Tasmanian Certificate of Education

ENVIRONMENTAL SCIENCE
and SOCIETY

Senior Secondary

Subject Code: ESS315114

External Assessment

2015

PART 1

Time: 36 minutes

On the basis of your performance in this examination, the examiners will provide a result on the following criterion taken from the course statement:

Criterion 2  Develop, interpret and evaluate experiments and practical activities

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<tr>
<th>Section Total</th>
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<td>/33</td>
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Pages: 8
Questions: 4

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CANDIDATE INSTRUCTIONS

You MUST make sure that your responses to the questions in this examination paper will show your achievement in the criteria being assessed.

Answer ALL questions. Answers must be written in the spaces provided on the examination paper.

You should make sure you answer all parts within each question so that the criterion can be assessed.

This examination is 3 hours in length. There are five booklets.

It is recommended that you spend approximately 36 minutes in total answering the questions in this booklet.

The 2015 External Examination Information Sheet for Environmental Science and Society can be used throughout the examination.

All written responses must be in English.
Question 1

Earlier this year, a taskforce titled ‘Saving Our Species’ collaborated in a ten-year research project to help close gaps in the knowledge about the interactions of feral cats and native species. The proposed research area in Tasmania was in the Midlands and their initial research question was ‘Can native species avoid feral cats if we provide better ground cover for them?’

(a) Formulate a hypothesis from this research question. (3 marks)

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(b) Using your knowledge of scientific method and baseline studies, discuss in detail three difficulties that researchers are likely to encounter in gathering valid data in this instance. (6 marks)

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Question 2

Treatments to boost the productivity of potatoes, one of the state’s biggest vegetable exports, has resulted in field trials of several treatments of different organic and inorganic fertilizers which are showing positive initial growth results. The hypothesis the researchers are testing is ‘Some types of fertilizers will promote greater crop productivity than others’.

(a) From the hypothesis above state the:

(i) dependent variable
.................................................................................................................................................. (1 mark)

(ii) independent variable
.................................................................................................................................................. (1 mark)

(b) Field trials are always difficult to control simply because they are conducted in the open, rather than a controlled laboratory environment. For this research project, state four variables which need to be controlled. (2 marks)

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(c) For one of the variables stated above, outline how not controlling it may alter the results of the experiment. (2 marks)

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Question 2 continues.
Question 2 (continued)

(d) This experiment lacks a specific control group. Explain carefully how valid results may still be obtained without having a 'no treatment' control group. (2 marks)

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(e) State results which would **support** and **negate** (not support) the hypothesis. (2 marks)

**Support:** ..............................................................................................................................................................
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**Negate:** .............................................................................................................................................................
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(f) Apart from repeats or replicates of the experiment, what else could further assist researchers in obtaining greater crop productivity? (2 marks)

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Question 3

Forestry Tasmania currently has a ‘Giant Tree’ register of Eucalypts which it started in 2002. The largest of these trees are in the Southern Forests near the Styx Valley in wet eucalypt forest. Forestry Tasmania currently use a remote sensing technique called ‘LIDAR’, which measures light reflected from a laser in a small aircraft to determine the height of specific trees in the forest below.

Explain four advantages of using LIDAR remote sensing technology rather than people on the ground for this type of biotic survey. (4 marks)

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Question 4

A recent Water and Sewerage State of the Industry Report states that environmental compliance with set levels of pollutants in effluent released from sewerage treatment plants lags behind mainland counterparts, with the environmental impact of waste water on the state’s rivers and coastal waters a serious concern.

Name four substances you think are most likely to be causing the high levels of pollution in the effluent and explain why each one is a problem. (8 marks)

Substance 1: ..........................................................................................................................
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Substance 2: ..........................................................................................................................
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Substance 3: ..........................................................................................................................
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Substance 4: ..........................................................................................................................
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On the basis of your performance in this examination, the examiners will provide a result on the following criterion taken from the course statement:

Criterion 5  Demonstrate knowledge and understanding of ecological processes.
CANDIDATE INSTRUCTIONS

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Question 5

Below is a generalised food web showing the organisms in a soil community.

Soil community food web

Birds

Earthworms

Spiders

Echidnas

Predatory nematode worms

Ants

Earwigs

Smooth nematode worms

Protozoa

Round nematode worms

Fungi

Bacteria

Plants

Organic matter

(a) What is the ultimate source of energy for the soil community? (1 mark)

(b) Which trophic level is occupied by the herbivores? (1 mark)

(c) Name three carnivores in this food web. (1 mark)

(d) Is there an omnivore in this soil community? If so, name it. (1 mark)

(e) Write a food chain containing six organisms from this food web. (2 marks)

Question 5 continues.
(f) Sketch and label a likely biomass pyramid for the soil community. (3 marks)

(g) Would a productivity (energy) pyramid for the soil community be a similar shape to your pyramid of biomass, or be inverted? Explain. (2 marks)

(h) Comment on the unusual role of the decomposers (bacteria and fungi) in this food web compared to other food webs you have studied this year. (2 marks)

(i) Name another food web community where bacteria and fungi perform a similar role. (1 mark)
Question 5 (continued)

(j) Describe carefully the movement of carbon atoms in the soil community from the producers to top level consumers. (4 marks)

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Question 6

The table below shows the Tasmanian population from 2008–2014.

**Tasmanian total population (to the nearest hundred) 2008–2014**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total population</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>501 700</td>
</tr>
<tr>
<td>2010</td>
<td>507 600</td>
</tr>
<tr>
<td>2012</td>
<td>512 400</td>
</tr>
<tr>
<td>2014</td>
<td>515 000</td>
</tr>
</tbody>
</table>

Tasmania also has the slowest growth rate (0.04%) and the highest percentage of older persons than any other state.

Using your knowledge of factors which influence population change, discuss reasons why the Tasmanian population growth is so low. (4 marks)

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Question 7

Both rainbow and brown trout are not species native to Tasmania, but were introduced from freshwater rivers and lakes in England and Scotland. They have thrived in the Central Highland lakes and other freshwater lakes and rivers in Tasmania and are the basis of successful recreational and commercial fisheries.

Comment on both biotic and abiotic factors of the Tasmanian Central Highland lakes and/or other freshwater lakes and rivers in the Tasmania environment that have contributed to the trout population being so successful. (5 marks)

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Question 8

Ecologists made the following observations of the feeding habits of a number of insectivorous birds living in a woodland community. Using your knowledge of niches and the data in the table below, answer the following questions.

<table>
<thead>
<tr>
<th>Bird</th>
<th>Food</th>
<th>Where obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree Creeper</td>
<td>Insects (especially ants)</td>
<td>Crevices in tree trunk; moves up trunk</td>
</tr>
<tr>
<td>Varied sitella</td>
<td>Insects</td>
<td>Crevices in tree trunk; moves down trunk</td>
</tr>
<tr>
<td>Crested shrike tit</td>
<td>Insects (especially grubs)</td>
<td>Tears bark off tree trunk, removes insects from under bark</td>
</tr>
<tr>
<td>Spotted pardalote</td>
<td>Insects</td>
<td>In leafy foliage</td>
</tr>
<tr>
<td>Superb fairy-wren</td>
<td>Insects</td>
<td>In thick shrubs</td>
</tr>
<tr>
<td>Yellow thornbill</td>
<td>Insects</td>
<td>On ground</td>
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</tbody>
</table>

(a) Briefly describe how competition for food resources is minimised between the spotted pardalote and the yellow thornbill. (2 marks)

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(b) Do the tree creeper and the varied sitella occupy the same niche? Explain. (2 marks)

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Question 9

Recent studies at the University of Tasmania have looked at the interactions of the Tasmanian Devil and feral cats in areas where both species are found. Devil Facial Tumour Disease (DFTD) is largely responsible for recent declines in the Tasmanian Devil population.

One study region (Early DFTD region) had fewer devils because it was from where DFTD was first discovered (1966) and was compared to an area where DFTD arrived in the year 2000 (Mid DFTD region) having more devils.

Data recording feral cat activity at varying times of the day in both study regions is displayed below. The shaded area in the graphs show the spotlight survey times.

![Early DFTD region graph]

![Mid DFTD region graph]

Question 9 continues.
Question 9 (continued)

Using your knowledge of species interactions, explain the reason for the change in the data for the **two** regions.

(4 marks)
Tasmanian Certificate of Education

ENVIRONMENTAL SCIENCE and SOCIETY

Senior Secondary

Subject Code: ESS315114

External Assessment

2015

TIME

PART 3

36 minutes

On the basis of your performance in this examination, the examiners will provide a result on the following criterion taken from the course statement:

Criterion 6 Demonstrate knowledge and understanding of changes to ecosystems, locally and globally.

<table>
<thead>
<tr>
<th>Section Total</th>
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<tr>
<td>/34</td>
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Question 10

Weeds, such as ragwort, are growing better and still adapting two hundred years after their first introduction into Australia from Europe. The weeds seem to have kept the capacity to change long after their initial introduction.

(a) Explain why many introduced plant species are still able to thrive long after their introduction into a new environment. (3 marks)

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Many introduced animal species, such as rabbits, have thrived in spite of physical control methods (shooting, trapping) and biological control agents (myxomatosis and calicivirus).

(b) Explain why introduced animal species are still able to thrive long after their introduction into a new environment. (3 marks)

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Question 11

The state’s Fire Management Council has recently implemented a new fuel reduction policy, with burn-off targets of up to 60 000 hectares (which comprises up to 5% of the state’s arable land) annually. This strategic plan uses computer modelling to plan burns rather than just burning land at random.

(a) (i) Using your knowledge of the impact of fire in areas where eucalypts (sclerophyll forest) are found, explain the benefits of having a managed fire regime. (3 marks)

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Question 11 (continued)

Some forest types, such as the cool-temperate rainforest found in Tasmania, do not, however, respond well to fire.

(b) Can a rainforest community survive a severe bushfire? Explain. (4 marks)

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Question 12

Many local councils in Tasmania are well prepared to deal with climate change according to CSIRO’s Marine and Atmospheric Research Division.

Discuss three of the most likely impacts of climate change on coastal communities in 
Tasmania. (6 marks)
Question 13

*Nothofagus* is a genus of trees/shrubs with several species. It is represented in Tasmania by *N. cunninghamii*, a rainforest species, and *N. gunnii*, a deciduous species common in the Central Plateau and the west.

*Nothofagus* is currently distributed in the environments illustrated below.

![Present distribution of Nothofagus species](image)

Fossils of *Nothofagus* can also be found in the land mass in Antarctica, which is presently covered with ice or snow for most of the year.

Considering the present distribution of *Nothofagus*, explain why *Nothofagus* fossils are present in Antarctica and why living plants are not found in this place today. (4 marks)

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Question 14

The graph below shows the area (in millions of square kilometres) of the Arctic ice shelf from 1960, when observations began, to the present, as well as climate model predictions of the likely area of ice shelf into the next century.

(a) Describe the overall trend displayed in the graph. (1 mark)

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(b) Approximately which year is the Area of Arctic ice shelf first predicted to be ‘nearly ice free’? (1 mark)

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(c) What are the main causes for the loss of size of the Arctic ice shelf? (3 marks)

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Question 14 continues.
Question 14 (continued)

Whilst Antarctica has a continental landmass under the ice, the Arctic does not; it is literally a large iceberg.

(d) Predict some of the likely impacts for animals such as walrus and polar bears, and other communities of organisms who live on the Arctic ice shelf, if there are successive years with ‘nearly no ice’. (4 marks)

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On the basis of your performance in this examination, the examiners will provide a result on the following criterion taken from the course statement:

**Criterion 7** Demonstrate knowledge and understanding of how humans depend and impact on ecosystems.
CANDIDATE INSTRUCTIONS

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**Question 15**

Fish is an excellent food source, but regular consumption of species high in mercury can be hazardous to your health.

Average Mercury levels in commercial fish and shellfish (1990–2010)

(a) What is the concentration of mercury in? (1 mark)

(i) halibut .................................................................

(ii) tilefish .................................................................

(b) Explain why filter-feeders, such as scallops and oysters, contain such low concentrations of mercury. (2 marks)

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Question 15 continues.
Question 15 (continued)

(c) Explain how the larger predatory species, such as swordfish and shark, contain such high levels of mercury. 

Despite the potential risk to human health, many species of shark are commercially fished and sold in fish markets, mostly being consumed as ‘flake’ in fish and chip shops.

(d) Describe two strategies employed by fisheries and/or food standards authorities to ensure that shark flesh with high mercury levels is not eaten by consumers. 

For Marker Use Only
Question 16

Analysis of data collected by a global network of sensing stations has revealed that the amount of atmospheric hydrogen chloride - an ozone depleting chemical - in the stratosphere has been rising since 2007, despite the drop in use of CFCs since the introduction of the Montreal Protocol nearly thirty years ago.

(a) Explain the impacts of ozone depletion in the Earth’s atmosphere. (3 marks)

(b) Give a reason for the recent rise in levels of ozone-depleting substances in the stratosphere. (2 marks)
Question 17

Based on reports from government agencies and representatives from the aquaculture industry, concerns about the decline in water quality, particularly lower dissolved oxygen levels, in Macquarie Harbour have been raised in the Tasmanian parliament. Recent increases in the number of salmon pens in the harbour are claimed to have been a major contributor to the low dissolved oxygen levels.

(a) As Macquarie Harbour is a natural environment, list four factors which may naturally contribute to seasonal lowering of the dissolved oxygen level. (2 marks)

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(b) Explain clearly why the salmon pens may contribute to a lowering of the dissolved oxygen level in Macquarie Harbour. (2 marks)

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(c) Explain other possible impacts in Macquarie Harbour from the increase in the number of salmon pens. (2 marks)

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Question 18

Pollution by plastic in packaging and disposable products is a global problem.

(a) Explain how the rise in plastic pollution may be considered a ‘Tragedy of the Commons’. (2 marks)

(b) Which two countries generate the least quantity of packaging per person? (1 mark)

(c) Which two countries recycle the highest proportion of the packaging they produce? (1 mark)

For Marker Use Only

Kg per person

Packaging production and recycling in selected European countries

Kg per person

Ireland France Italy Netherlands Germany Luxembourg Denmark United Kingdom Spain Belgium Austria Portugal Sweden Greece Finland European Union (28)

Question 18 continues.
Question 18 (continued)

Analyse the data from the graph below to answer the following questions.

Total annual and projected output of mismanaged plastic waste by coastal populations, top-ranked countries by billions of dollars

(d) Which two countries in 2010 were the greatest polluters of plastic? (1 mark)

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(e) Suggest why China and India are projected to have the greatest proportional increase in plastic pollution. (2 marks)

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Question 18 continues.
Apart from recycling, briefly describe two other developments which could reduce the amount of plastic pollution in the environment. (2 marks)

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Question 19

Explain the role of oceans in influencing the Earth’s climate. (4 marks)

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Tasmanian Certificate of Education

ENVIRONMENTAL SCIENCE
and SOCIETY

Senior Secondary

Subject Code: ESS315114

External Assessment

2015

PART 5

Time: 36 minutes

On the basis of your performance in this examination, the examiners will provide a result on the following criterion taken from the course statement:

Criterion 8 Demonstrate knowledge and understanding of principles for the ecologically sustainable management of the environment.

<table>
<thead>
<tr>
<th>Section Total</th>
<th>/34</th>
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</table>

Pages: 12
Questions: 4

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Question 20

There have been several renewable energy alternatives over the past few years to reduce the domestic consumption of energy generated from coal-fired power stations.

(a) Discuss two alternatives which have achieved this, describing how they reduce domestic energy consumption. (4 marks)

(b) Briefly discuss two management strategies that have been used in successfully promoting the use of these alternatives. (2 marks)
Question 21

The government currently has plans to rezone parts of the existing Tasmanian Wilderness World Heritage Area (TWWHA), reclassifying wilderness areas as remote recreational zones. This would allow greater air and water access, low scale tourism ventures such as building of huts and basic accommodation, but also access to select specialty species timber logging.

Discuss arguments for and against reclassifying parts of the TWWHA. (10 marks)

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Question 22

Green developments that aim to be climate-friendly may be hurting some of the world’s most vulnerable people, according to a survey of Ugandan villagers affected by carbon-offset projects.

Conclusions drawn from a study of a European carbon-offset company dismissed the company’s claim that the carbon trading represented a ‘win-win’ for both rural communities and the environment.

Firsthand accounts from Uganda reveal that villagers have experienced forced evictions, restricted access to land and food, in addition to loss of livelihood. The company plans to have tree farms on the villagers’ farmland.

The company currently holds licences on over 10 000 hectares of uncleared land in Uganda alone, with additional landholdings in neighbouring Mozambique.

In the extract of an article above, consider the ecologically sustainable development principles of:

- Intergenerational equity
- Intragenerational (social) equity
- Precautionary and anticipatory principle
- Conservation of biodiversity and ecological integrity
- Efficiency of resource use
- Pricing of environmental values and natural resources

Discuss how five principles of ecologically sustainable development have either been upheld or not upheld in this situation. (10 marks)

Question 22 continues.
Question 23

A private company has lodged an application with the local government and the Mount Wellington Management Trust to build a cable car to the top of Mount Wellington, an iconic tourist destination near Hobart. The Mount Wellington Trust is responsible for the management of the area. The cable car would start at the foot of the mountain at the Cascade Brewery site (also a popular tourist destination) and terminate in a large restaurant/cafe with extensive visitor interpretation areas and internal and external viewing platforms.

The reserve in which Mount Wellington is sited is vast, a refuge for wildlife, birds and cool climate and sub-alpine vegetation.

Access to the mountain is currently only by a steep walking track, or private or chartered vehicle. Apart from the access road, developments include a few bushwalking/day shelters, TV towers and a small building at the summit. The area is a haven for rock climbers and bushwalkers.

The project has been criticised for being a purely commercial venture and that it would impact greatly on the biodiversity, aesthetics and natural heritage values of the area.

Describe what should be included in the new management plan for the area should the cable car be built. (8 marks)

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Question 23 continues.
Question 23 (continued)

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## SOME COMMON TERMS EXPLAINED:

<table>
<thead>
<tr>
<th>Term</th>
<th>Explain</th>
<th>List</th>
<th>Identify</th>
<th>Measure</th>
<th>Outline</th>
<th>Predict</th>
</tr>
</thead>
<tbody>
<tr>
<td>Account</td>
<td>explain</td>
<td></td>
<td></td>
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<tr>
<td>Analyse</td>
<td>examine data mathematically to gain understanding of the data</td>
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<tr>
<td>Calculate</td>
<td>to find the answer using mathematics</td>
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<tr>
<td>Compare</td>
<td>give an account of similarities and difference between two factors</td>
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<tr>
<td>Construct</td>
<td>represent information in a graphical form</td>
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<tr>
<td>Deduce</td>
<td>reach a conclusion from the information given</td>
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<tr>
<td>Describe</td>
<td>give a detailed account including all relevant information</td>
<td></td>
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<tr>
<td>Design</td>
<td>produce a plan</td>
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<tr>
<td>Discuss</td>
<td>give an account including a range of arguments, assessment of the importance of various factors or a comparison of alternatives</td>
<td></td>
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<tr>
<td>Distinguish</td>
<td>give the difference between two or more different items</td>
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<tr>
<td>Draw</td>
<td>represent by means of pencil lines – include labels (unless told not to) - not to be confused with Draw a Conclusion</td>
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<tr>
<td>Estimate</td>
<td>find an approximate value</td>
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<tr>
<td>Evaluate</td>
<td>assess the limitations and implications</td>
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</tbody>
</table>
## Summary of types of graphs

<table>
<thead>
<tr>
<th>Nature of Independent variable</th>
<th>Nature of Dependent variable</th>
<th>Type of Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data continuous Individual readings</td>
<td>Data continuous Individual readings</td>
<td>Line graph</td>
</tr>
<tr>
<td>Data continuous No independent variable identified</td>
<td>Data continuous No dependent variable identified</td>
<td>Scatter graph</td>
</tr>
<tr>
<td>Data discontinuous Data grouped into non-numerical categories</td>
<td>Dependent variable measured or counted</td>
<td>Bar / Column graph</td>
</tr>
<tr>
<td>Data continuous Data grouped into numerical size / sample intervals</td>
<td>Dependent variable counted</td>
<td>Histogram</td>
</tr>
</tbody>
</table>

## Analysing trends in graphs

- **Analyzing** — Mathematically modifying data to highlight important data and identify trends in the variables.
- **Correlating** — Describing trends in one variable as another variable changes.
- **Interpretation** — Understanding what conclusions can be drawn from the data.

### Analysing Trends

- **a** Slope: constantly rising  
  Interpretation: variable X causes variable Y to increase regularly
- **b** Slope: constantly declining  
  Interpretation: variable X causes variable Y to decrease
- **c** Slope: constantly level  
  Interpretation: variable X causes no change in variable Y
- **d** Slope: rising then plateaus out  
  Interpretation: variable X causes variable Y to increase initially, then has no effect
- **e** Slope: rises, peaks, then declines  
  Interpretation: variable X causes variable Y to increase, then to decrease
- **f** Slope: becomes steeper and steeper  
  Interpretation: variable X causes variable Y to rise exponentially
CRITERION 2 – Develop, interpret and evaluate experiments

Your hypothesis should
1. be feasible (i.e. be sensible and based on scientific concepts)
2. be a statement (not a question)
3. be based on observations
4. involve one independent and one dependent variable in a cause-and-effect relationship
5. be testable and measurable in a way that demonstrates cause and effect

Experimental Design
State the hypothesis to be tested (unless already stated)
1. State the independent variable and how it is manipulated
2. State the dependent variable and how it is measured
3. Describe the procedure clearly in a step-by-step fashion which could be easily followed in a laboratory or the field.
   ▪ Indicate sample sizes, quantities of materials and time involved. Indicate how many replicas there are (if needed).
   ▪ Describe which variables are controlled and how. Say why fixed variables are needed. Include factors relevant for the organism – biotic, and those abiotic relevant in the environment
   ▪ What is the control group in the experiment and why is it needed.
4. How are the results analysed
5. Indicate any repetitions of the experiment

If required:
6. State what results would support the hypothesis and what results would not support the hypothesis
7. Discuss any foreseeable problems in conducting the experiment.
   ▪ variables difficult to control, sample size issues, ethical issues, animal vs human experimentation/environmental impacts etc.

Unfixed / uncontrolled variables
The impact of unfixed/uncontrolled variables can be reduced by
   ▪ using a large sample size, but this will depend on whether the organism is a plant or animal etc
   ▪ randomly assigning organisms to treatment groups or
   ▪ matching groups for similar factors

Also ethical aspects need to be considered:

Trial experiments conducted in a confined situation (laboratory/greenhouse) need to precede field investigations. If the results of these are positive, small scale field investigations are then carried out.

Unlike laboratories and greenhouses, experiments carried out in the field/environment contain many unfixed/uncontrolled variables.

In such cases the experimenter may record relevant information that may explain observed differences in treatment results. While this provides greater certainty/reliability, greater caution is needed in interpreting results.

Distinction between a replica and a repeat
   ▪ A replica is multiple identical groups within the one experiment.
   ▪ A repeat is doing the experiment again in a future time.

Sampling techniques
   ▪ Transects
   ▪ Quadrats
   ▪ Surveys

“Cause”

INDEPENDENT VARIABLE (IV)
the thing that the experimenter deliberately varies

“Effect”

DEPENDENT VARIABLE (DV)
the thing that the experimenter measures
Testing abiotic factors

Temperature: how hot or cold a substance is. The temperature of a water body directly affects many physical, biological and chemical characteristics. Temperature directly affects the metabolic rate of plants and animals. Aquatic species have evolved to live in water of specific temperatures.

**What factors affect temperature?**

Water temperature varies in response to:

- air temperature
- exposure to sunlight and amount of shade
- turbidity of the water, which is often a result of erosion in the catchment
- groundwater inflows to the waterbody
- discharge of warmed water from industry and power plants, or cold water from dams
- vegetation
- type, depth and flow of waterbody

Turbidity: opacity or muddiness caused by particles of extraneous matter; not clear or transparent. Suspended material can be particles of clay, silt, sand, algae, plankton, micro-organisms and other substances. Turbidity affects how far light can penetrate into the water. It is not related to water colour: tannin-rich waters that flow through peaty areas are highly coloured but are usually clear, with very low turbidity.

**What factors affect turbidity?**

Turbidity is affected by:

- rainfall and catchment runoff
- catchment soil erosion
- bed and bank erosion
- bed disturbance, e.g. by introduced fish species such as carp
- waste discharge
- storm water
- excessive algal growth
- riparian vegetation
- floodplain and wetland retention and deposition
- flow
- waterway type
- soil types
- salinity.

**Electrical conductivity:** the property of a substance which enables it to conduct (carry) electricity. Salty water conducts electricity more readily than purer water. Therefore, electrical conductivity is routinely used to measure salinity. The types of salts (ions) causing the salinity usually are chlorides, sulphates, carbonates, sodium, magnesium, calcium and potassium.

**What factors affect electrical conductivity?**

Electrical conductivity in waterways is affected by:

- geology and soils
- land use, such as agriculture (irrigation), urban development (removal of vegetation, sewage and effluent discharges), industrial development (industrial discharges)
- flow (electrical conductivity is generally lowest during high flows and increases as flows decrease, with extreme levels occurring during droughts)
- run-off
- groundwater inflows
- temperature
- evaporation and dilution.

**pH:** a measure of acidity (or alkalinity).

**What factors affect pH?**

A wide variety of factors may have an effect on the pH of water. These include:

- source of the water
- rainfall
- time of day
- water temperature
- amount of algal or plant growth in the water
- geology and soils, e.g. acid sulfate soils
- discharges of industrial wastes
- disturbance of acid sulfate soils due to agriculture, urban development or mining
- atmospheric deposition (acid rain, dry particle deposition)
- burning of fossil fuels by cars, factories and smelters
- photosynthesis and respiration
- salinity

**Dissolved oxygen:** a measure of the quantity of oxygen present in water. Oxygen is essential for almost all forms of life.

**What factors affect dissolved oxygen?**

- water temperature
- photosynthesis by aquatic plants
- respiration by aquatic plants and animals
- breakdown of organic materials in the water
- water movement and mixing
- flow (discharge)
- salinity
- altitude
- depth
- daily and seasonal cycles
- presence of nutrients
- chemicals in the water
- thermal contamination
- removal of vegetation

**Phosphorus** a mineral nutrient that is essential for all forms of life. The phosphorus found in a form called phosphate (chemical formula, $PO_4^{3-}$). It is naturally derived from the weathering of rocks and the decomposition of organic material, but it can also enter waterbodies in runoff or discharges - soil and fertiliser particles can carry phosphorus, and sewage is also rich in phosphorus.
Phosphates available to plants and animals are called orthophosphates, and exist in waterbodies as dissolved and particulate (suspended) and colloidal forms.

**What factors affect phosphate?**
Phosphate concentrations in water are affected by:
- rock type and geology
- soil type
- seasonal conditions
- animal and human wastes
- phosphate-containing fertilisers
- disturbed land
- urban run-off, which usually contains it

**Nitrogen** an element that is essential for all forms of life
The most common nitrogen compounds are ammonia (NH$_3$), nitrate (NO$_3$) and nitrite (NO$_2$). They occur in dissolved, particulate and gaseous forms.
Present in freshwaters at higher concentrations than phosphate. Although both nutrients are required for plant growth, phosphate is considered to be the limiting factor in freshwater. In saltwater ecosystems, however, nitrogen is much less abundant, and it becomes the nutrient that limits algal growth.

**What factors affect nitrogen?**
Nitrogen is actually measured by the concentration of nitrate (NO$_3$). The main factors affecting nitrates are:
- rock type and geology
- soil types
- vegetation
- seasonal conditions
- animal and human wastes (sewage)
- decomposing plants and animals
- nitrogen-containing fertilisers
- industrial discharges
- run-off

**Abiotic factors affecting the environment**
Consists of non-living component of the environment as shown below. All these need to be considered in the adaptation of organisms

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<table>
<thead>
<tr>
<th>Pressure:  altitude effects, oxygen levels</th>
<th>Physical characteristics of the environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil type: pH, nutrient levels</td>
<td></td>
</tr>
<tr>
<td>Wind: speed, direction, exposure</td>
<td></td>
</tr>
<tr>
<td>Light: intensity, direction, day length</td>
<td></td>
</tr>
<tr>
<td>Water: salinity, humidity, pH, O$_2$ and CO$_2$ levels</td>
<td></td>
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</tbody>
</table>
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CRITERION 5 – Ecological processes

Ecology The study of living organisms in the natural environment. How they interact with one another and how the interact with their nonliving environment.

Ecosystem Community + Abiotic environment, interacting

Community All the populations of the different species living and interacting in the same ecosystem.

Species A group of organisms that can breed to produce fully fertile offspring.

Populations A group of organism of the same species which live in the same habitat at the same time where they can freely interbreed.

Biodiversity The total number of different species in an ecosystem and their relative abundance.

Habitat The characteristics of the type environment where an organism normally lives. (e.g. a stony stream, a temperate woodland)

Niche Habitat + role + tolerance limits to all limiting factors

Generalist and specialist species

Limiting factor Too much or too little of any abiotic factor can limit or prevent growth of a population, even if all other factors are at or near the optimal range of tolerance.

Biotic factors Consists of living and once living biological components – plants, animals and microbes. Also include dead organisms, dead parts of organisms, and the waste products of organisms

ZONE OF TOLERANCE Each population in an ecosystem has a range of tolerance to variations in its physical and chemical environment. Individuals within a population may also have slightly different tolerance ranges for a factor due to genetic variation, health and age.
Systems
A system is defined as “an assemblage of parts and their forming a functioning whole” A system can be living or nonliving.

Components of systems
Storages – or stores of matter and energy
Flows – into, through and out of the system
Inputs – matter or energy entering system
Outputs – matter or energy entering system
Processes – which transfer or transform energy or matter from storage to storage

A comparison between natural, agricultural and urban systems

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>input</th>
<th>output</th>
<th>Level of recycling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural</td>
<td>Light** Organic matter* Water** Mineral salts** Fertilisers* Pesticides*</td>
<td>Heat* Organic matter** Water** Soil particles** Nutrients**</td>
<td>some</td>
</tr>
<tr>
<td>Urban</td>
<td>Light* Organic matter** Water*** Mineral salts* Fuel*** Industrial raw materials***</td>
<td>Heat*** Water*** Industrial and household wastes*** CO2***</td>
<td>little</td>
</tr>
</tbody>
</table>

The asterisks represent proportions of matter: *least, **intermediate, ***most

Types of systems
Open system – exchanges matter and energy with its surroundings. Eg all ecosystems are open

Closed system – exchanges energy but no matter with its environment. Very rare in nature. Earth can be thought of as “almost closed”

Example of a system - soil

Feedback systems
Any process that increases or decreases a change to a system

Positive feedback
Feedback loop that causes a system to change further in the same direction

Negative feedback
Feedback loop that causes a system to change in the opposite direction from which it is moving.
Eg population regulation around the carrying capacity
Energy and organisms

Autotrophs / Producers
Organisms which can synthesise their own complex, energy rich, organic molecules from simple inorganic molecules (e.g. green plants synthesis sugars from CO$_2$ and H$_2$O)

Heterotrophs / Consumers
Organisms who must obtain complex, energy rich, organic compounds form the bodies of other organisms (dead or alive).

Detritivores
Heterotrophic organisms who ingest dead organic matter. (e.g. earthworms, woodlice, millipedes) but do not decompose it into inorganic matter

Decomposers
Heterotrophic organisms who secrete digestive enzymes onto dead organism matter and absorb the digested material. (e.g. fungi, bacteria) completely breakdown the organic molecules into inorganic molecules → make matter available to producers - i.e. responsible for the recycling of matter in the ecosystem

Food webs
(i) First Order (Primary) Consumers – feed off producers (herbivores)
(ii) Second Order (Secondary) Consumers – eat first order consumers (carnivores)
(iii) Third Order (Tertiary) Consumers – eat second order consumers
(iv) Top Consumer/Carnivore – not usually eaten by other organisms (e.g. man, shark, bald eagle, crocodile, lion)

Trophic level 4 – carnivore (tertiary consumer)
Trophic level 3 – carnivore (secondary consumers)
Trophic level 2 – herbivore (primary consumers)
Trophic level 1 – producer

ECOLOGICAL PYRAMIDS
As you go up a food chain, the number of individuals at each level (usually) decreases. Due to energy losses at each level, each individual needs to consume a large number of the individuals below.

Pyramid of numbers shows the number of organisms in a food chain. Such pyramids can be almost any shape depending on the biomass of the organisms at any trophic level

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<tbody>
<tr>
<td>10</td>
<td>100</td>
<td>10,000</td>
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</tbody>
</table>

Pyramid of Biomass
Use total weight (dry mass) of organisms at each level - takes into account both numbers and mass

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<tbody>
<tr>
<td>2C</td>
<td>1C</td>
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Both pyramids of numbers and biomass can be inverted

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<tbody>
<tr>
<td>1C</td>
<td>P</td>
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</table>

Pyramid of Energy - total energy at each level

<p>| |</p>
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<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>1C</td>
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</table>

Each level must be no more than 10% of previous

Interactions among organisms in ecosystems

<table>
<thead>
<tr>
<th>Type of interaction</th>
<th>Species A</th>
<th>Species B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predator Prey</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Herbivory</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Mutualism</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Commensalism</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Competition</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Parasitism</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

Key
+ benefits , - harmed (may not mean death) 0 not affected
ENERGY FLOW

First law of thermodynamics
Energy is neither created nor destroyed. Energy is transformed from one form to another through the food chain.

Second law of thermodynamics
Energy conversions are never 100% efficient ie energy is lost as energy is passed from one trophic level to the next. is a one-way flow

Source of energy sun → light energy

Photosynthesis
Complex process that takes place in cells of green plants.

Carbon dioxide + water → Glucose + oxygen

Respiration
Aerobic respiration – produces a lot of energy in cells by using oxygen

Glucose + oxygen → Carbon dioxide + water

Anaerobic respiration – produces very little energy due to lack of oxygen. Used by some decomposers

BIOGEOCHEMICAL CYCLES
- cannot create/destroy atoms → there is a finite (fixed) amount of matter in our biosphere. (assume that earth is a closed system – with no losses/gains of matter)
- recycling of matter by decomposers
- nutrient matter cycles

Carbon cycle

Nitrogen cycle

Phosphorus cycle
POPULATION

measured as a rate – e.g. no. per 100,000

\[ r = (b - d) + (i - e) \]

growth rate
birth rate
death rate
immigration rate
emigration rate

In Ideal conditions – J curve

- a “doubling” of numbers in a set time period
  e.g. bacteria, human world population.

- not sustainable in the long term - population either
  “crashes” OR external factors regulate the growth rate

In reality – S curve

FACTORS WHICH AFFECT CARRYING CAPACITY / POPULATION SIZE

ABIOTIC FACTORS – DENSITY INDEPENDENT

e.g. temperature, humidity, rainfall, light intensity, sunlight hours, size of area, presence of trace elements, soil type may have a direct effect on the population – e.g. sunlight hours effects amount of P/S and ∴ plant growth

OR

an indirect effect – e.g. sunlight hours → P/S → plant growth → kangaroo population

BIOTIC FACTORS – DENSITY DEPENDENT

The impact of other organisms can be identified in two types of competition:

- **INTRASPECIFIC COMPETITION** – competition between members of the same species

- **INTERSPECIFIC INTERACTIONS** – competition between members of different species

NATURAL SELECTION

A species is a population of organisms that can potentially interbreed under natural conditions to provide fertile offspring.

Hybrids are offspring produced from parents of different species. They are sterile (can’t reproduce). Examples include zebroids (zebra and horse), mules (donkey and horse)

When a habitat selects certain organisms to live and reproduce and others to die that population is said to be undergoing natural selection.

Natural Selection - beneficial characteristics that can be inherited are passed down to the next generation, and unfavourable characteristics that can be inherited become less common in the population.

- Acts upon a whole population – the gene pool - not on an individual during its lifetime.

Environmental resistance

Abiotic & biotic factors acting to limit population growth.

If a population overshoots its carrying capacity, negative feedback occurs (in the form of more deaths and fewer births due to lack of food) to reduce the population.
El Niño and La Niña
The seasonal changes in the heating and cooling of sea surface temperatures tend to follow a fairly predictable pattern
- **El Niño** refers to the extensive warming of the central and eastern Pacific that leads to a major shift in weather patterns across the Pacific. In Australia (particularly eastern Australia), El Niño events are associated with an increased probability of drier conditions.

- **La Niña** refers to the extensive cooling of the central and eastern Pacific Ocean. In Australia (particularly eastern Australia), La Niña events are associated with increased probability of wetter conditions.

The effects of El Niño and La Niña are at their greatest between December and April. A La Niña event often, but not always, follows a period of El Niño, and vice versa.
TASMANIAN FORESTS
Three major types of forest groups in Tasmania

**Dry Sclerophyll**
- open canopy
- little understorey
- many grasses
- short sharp prickles

**Wet Sclerophyll**
- open canopy
- dense understorey
- fewer mosses and ferns

**Rainforest**
- closed canopy
- thin understorey
- many mosses, lichens, ferns

Forest structures in the southwest since last fire

![Diagram of forest structures]

**Interactions determining vegetation type**

![Diagram of interactions]

- **man's influence**
- **climatic variables**
- **soil fertility**
- **vegetation**
- **fire frequency**
- **animals**
- **man**

**Table:**

- **Sedge land edge**
  - Sapling regrowth
  - Wet Scrub understorey
  - Spar growth
  - Wet sclerophyll understorey
  - Submature stand
  - Wet Sclerophyll and young rainforest understorey
  - Mature stand rainforest understorey
  - Overmature stand rainforest understorey
  - Rainforest

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>25</th>
<th>50</th>
<th>90</th>
<th>150</th>
<th>300</th>
<th>400+ Years since last fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedge land edge</td>
<td>0</td>
<td>400</td>
<td>180</td>
<td>80</td>
<td>25</td>
<td>0</td>
<td>Eucalypt stems per acre</td>
</tr>
</tbody>
</table>
The Greenhouse Effect

Origins of greenhouse gases:

- Photosynthesis in forests and grasslands removes carbon dioxide (CO₂) from the atmosphere.
- Car exhaust emissions contain much CO₂ released to the atmosphere.
- Combustion of fossil fuels by industrial plants releases large amounts of CO₂.
- Ruminant fermentation produces methane (CH₄) which cattle release into the atmosphere. Intensive cattle ranching increases CH₄ release at the expense of CO₂ uptake by photosynthesis.
- Aerosol propellants contain chlorofluorocarbons (CFCs) which are 10³ x worse than carbon dioxide as greenhouse gases.
- Anaerobic fermentation in swamps and paddy fields produces CH₄. Inorganic fertilizers cause release of nitric oxide (NO).

The Sun, at a temperature of 6000 °C, emits radiation which is mostly in the visible band.

About 10% of the solar energy is reflected back to space by the Earth's atmosphere.

About 83% of the solar energy penetrates the atmosphere, warms the Earth's surface and is re-emitted in the infrared range.

About 7% of short wavelength radiation helps to generate ozone.

Some of the Earth's infrared emissions are re-reflected back to the Earth's surface → warming, particularly by H₂O (absorbs and re-emits radiation at 4–7 μm) and CO₂ (absorbs/re-emits at 13–19 μm), but most escapes back to space through a 7–13 μm 'window'.

The greenhouse gases close this window and thus allow the Earth's own infrared radiation to warm its surface.

On the + side:
- More atmospheric CO₂ and higher temperature at Earth's surface
- More rapid photosynthesis
- More food

Global warming (observed increase in temperature since 1900 = 0.6 °C):
- Climatic extremes: altered temperature gradients → cyclones. Heavier rain as water evaporates quicker.
- Rising sea levels: melting of polar ice and thermal expansion of seas.
- Crop losses: drier weather in most fertile areas → lower yields of staple crops.
- Species migrations: pests/disease vectors could extend their ranges.

But on the − side:

All living organisms release carbon dioxide by respiration – the additional greenhouse gases contributed by humans (anthropogenic contributions) include methane and CFCs in addition to greater quantities of carbon dioxide.
Enhanced greenhouse effect

<table>
<thead>
<tr>
<th>Gas:</th>
<th>Source:</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water vapour</td>
<td>Oceans, lakes, rivers, reservoirs. Humans have</td>
<td>Water vapour is the most abundant GHG. Increased temperature caused</td>
</tr>
<tr>
<td></td>
<td>little impact upon levels.</td>
<td>by other GHGs is amplified by the resulting increase in water vapour</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(positive feedback).</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>Burning of fossil fuels, and forests,</td>
<td>The greatest opportunity humans have of reducing the enhanced</td>
</tr>
<tr>
<td></td>
<td></td>
<td>greenhouse effect is to reduce their emissions of CO₂.</td>
</tr>
<tr>
<td>Methane (CH4)</td>
<td>Fossil fuel industry, agricultural livestock,</td>
<td>Emissions can be reduced by capturing and using CH₄ from fossil</td>
</tr>
<tr>
<td></td>
<td>landfill refuse sites, anaerobic wetlands (</td>
<td>fuel industries and landfill sites and reducing numbers of livestock.</td>
</tr>
<tr>
<td></td>
<td>including rice fields)</td>
<td></td>
</tr>
<tr>
<td>Nitrous oxide</td>
<td>Nitrate fertilisers, transport and power stations</td>
<td>Approximately 6%.</td>
</tr>
<tr>
<td></td>
<td>(combustion).</td>
<td></td>
</tr>
</tbody>
</table>

The table below lists the characteristics of species predicted to be most and least at risk from climate change

<table>
<thead>
<tr>
<th>Species least at risk</th>
<th>Species most at risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad range of</td>
<td>Narrow range of</td>
</tr>
<tr>
<td>physiological tolerance</td>
<td>physiological tolerance</td>
</tr>
<tr>
<td>to factors such as</td>
<td></td>
</tr>
<tr>
<td>temperature, water</td>
<td></td>
</tr>
<tr>
<td>availability and fire</td>
<td></td>
</tr>
<tr>
<td>High degree of</td>
<td>Low genetic variability</td>
</tr>
<tr>
<td>variability in the</td>
<td></td>
</tr>
<tr>
<td>physical appearance</td>
<td></td>
</tr>
<tr>
<td>of individuals and</td>
<td></td>
</tr>
<tr>
<td>genetic variability</td>
<td></td>
</tr>
<tr>
<td>Short life cycles and</td>
<td>Long life cycles and</td>
</tr>
<tr>
<td>high fertility</td>
<td>low fertility</td>
</tr>
<tr>
<td>Good dispersal</td>
<td>Poor dispersers</td>
</tr>
<tr>
<td>capacity</td>
<td></td>
</tr>
<tr>
<td>Broad geographic range</td>
<td>Narrow geographic range</td>
</tr>
</tbody>
</table>

Biodiversity

Types of biodiversity
1. Genetic: the variety of genetic information contained in all of the individual plants, animals and microorganisms that inhabit the earth - genetic diversity occurs within and between the populations of organisms that comprise individual species as well as among species
2. Species: the variety of species on earth
3. Ecosystem: the variety of habitats, biotic communities and ecological processes.

These three levels of diversity are interrelated and interdependent (e.g. a population of a species is thoroughly dependent on its habitat for survival, and a functioning ecosystem is dependent on the complex of species that comprises it).

Processes that threaten biodiversity
- loss of habitat, fragmentation, degradation
- introduced species
- overexploitation of plant and animal species
- pollution of soil, water and atmosphere
- global climate change

Conservation categories
- **Extinct** – no individuals alive
- **Extinct in the wild** – no individuals alive in the wild, but may occur in captivity of some description
- **Critically endangered** – extremely high risk of extinction in the immediate future
- **Endangered** - extremely high risk of extinction in the near future
- **Vulnerable** – not endangered but facing very high risk of Extinction in the medium term future.
- **Conservation dependent** – not vulnerable but needs a conservation program to survive or will move into one of the other categories
- **Data deficient** – insufficient information to make a direct or indirect assessment of its extinction risk based on its distribution or population status
- **Low risk** – not in any danger
TRAGEDY OF THE COMMONS
Depletion or degradation of a potentially renewable resource to which people have free and unmanaged access. Eg oceans, atmosphere, fisheries in international oceans.

ECOSYSTEM SERVICES
The role of ecosystems in providing humans with services from the ecosystems:

<table>
<thead>
<tr>
<th>PROVISIONING SERVICES</th>
<th>REGULATING SERVICES</th>
<th>CULTURAL SERVICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products obtained from ecosystems</td>
<td>Benefits obtained from regulation of ecosystem processes</td>
<td>Non-material benefits obtained from ecosystems</td>
</tr>
<tr>
<td>Food</td>
<td>Climate regulation</td>
<td>Spiritual and religious</td>
</tr>
<tr>
<td>Freshwater</td>
<td>Disease regulation</td>
<td>Recreation and ecotourism</td>
</tr>
<tr>
<td>Fuelwood</td>
<td>Water regulation</td>
<td>Aesthetic</td>
</tr>
<tr>
<td>fibre</td>
<td>Water purification</td>
<td>Inspirational</td>
</tr>
<tr>
<td>Biochemicals</td>
<td>Pollination</td>
<td>Educational</td>
</tr>
<tr>
<td>Genetic resources</td>
<td>***</td>
<td>Sense of place</td>
</tr>
<tr>
<td>***</td>
<td>***</td>
<td>Cultural heritage</td>
</tr>
</tbody>
</table>

SUPPORTING SERVICES
Services necessary for the production of all other ecosystem services:

- Soil formation
- Nutrient cycling
- Primary production

ECOLOGICAL FOOTPRINTS
Ecological footprint - the amount of productive land appropriated on average by each person (in the world, a country, etc) for food, water, transport, housing, waste management, and other purposes
Global hectare - (acre) is one hectare (2.47 acres) of biologically productive space with an annual productivity equal to the world average.

POLLUTION
The presence of a substance in the environment that prevents the functioning of natural processes and produces undesirable environmental and health effects ie any undesirable change in the chemical, physical or biological characteristics of an ecosystem.

Primary pollutant - is one that is unchanged since production.

Secondary pollutant is created when a primary pollutant reacts with other forms of pollution or with an environmental component.

Synergy - the effect of pollutants is increased when it acts in combination with others

Antagonistic - Two pollutants that cancel each other

Sources of Pollution
- Point sources
  - Source of pollution with specific points of discharge
  - Examples; Factories, Sewage systems, Power plants, Coal mines, Oil wells
- Diffuse sources
  - Sources of pollution that are harder to identify
  - Examples; Agricultural runoff, Stormwater drainage, Acid rain

Toxic chemicals
Toxic chemicals are among the most serious types of pollutants. They may be man-made or naturally occurring. They can enter the air as gases or form suspended or dissolved solids in water. They cannot be buried safely in landfills as they may leach into ground waters or they may enter food chains when they are absorbed by producer organism.

Degradable pollutant – can be broken down by natural processes

Biodegradable pollutant - can be broken down living organisms

Persistent pollutant takes a long time to break down.

Non-degradable pollutant does not break down at all.

Hazardous waste – waste that poses a danger to human health eg: batteries, chemicals, paints solvents and pesticides.
Pathway through plants

Pathway through animals

BIOLOGICAL MAGNIFICATION
Some poisons (those that are not biodegradable) are not completely broken down and excreted by organisms → instead; they accumulate in tissues and are passed along a food chain

Atmospheric Pollution

Three factors determine level of air pollution
1. Amount of pollutants entering the air
2. of space into which the pollutants can spread out
3. Mechanisms that remove pollutants from the air

Particles - (or suspended particles) are small solid particles of dust (e.g. dust from a dirt road) or organic material (e.g. pollen), they also include liquid droplets such as tiny droplets of oils and tars (e.g. wood-smoke). Larger particles quickly fall out of the air due to gravity (this is referred to as 'dust fallout') but smaller particles (those less than about 0.1mm diameter, referred to as 'total suspended particles') may remain in the air for many hours.

PM$_{10}$ - is particulate matter (particles) less than 10 micrometres (µm) in diameter; these are tiny particles that are too small to see individually but if there are millions of them they become visible as smoke or mist.

PM$_{2.5}$ - is particulate matter (particles) less than 2.5 micrometres (µm) in diameter; they are of greatest concern to air pollution professionals because they penetrate deep into our lungs when we breathe and can carry toxic compounds that cause illness.

Primary pollutants
- Pollutants released directly into atmosphere mainly as a result of burning fuels and wastes
- Examples; Carbon monoxide (CO), Nitrogen oxides (NOx), Sulphur oxides (SOx), Lead (Pb)

Secondary pollutants
- Pollutants resulting from reactions of primary air pollutants in the atmosphere
- Examples; Ozone (O$_3$); Sulphuric acid; Nitric acid

Smog
- Industrial smog
  - Greyish mixture of moisture, soot, and sulphurous compounds. Occurs in industrial areas and where coal is a primary energy source
- Photochemical smog
  - Brownish haze that typically forms over large cities with lots of automobile traffic
Pollution of the atmosphere

**LEAD COMPOUNDS** may slow mental development. They are in 'anti-knock' additives in petrol, and are released into the atmosphere from exhaust gases. Now most cars use lead-free petrol.

**THE GREENHOUSE EFFECT MAY CAUSE GLOBAL WARMING**

Greenhouse gases include:
- Carbon dioxide released by combustion of fossil fuels
- **Methane** produced by ruminants - released from gut into atmosphere
- CFC's from aerosol propellants.

Heat cannot escape if the atmosphere contains high levels of these gases. The infra-red radiation is reflected back towards the Earth's surface.

There are good and bad results.
- **✓** more carbon dioxide and higher temperatures mean more photosynthesis and more food.
- **✗** global warming causes:
  - greater climatic extremes - high winds and heavier rains
  - rising sea levels due to melting of polar ice
  - crop losses as water evaporates from fertile areas
  - extended range of pests

**ACID RAIN**

Human activities release acidic gases
- Sulphur and nitrogen in fossil fuels are converted to oxides during combustion.
- More oxidation occurs in the clouds, and is catalysed by ozone and unburnt hydrocarbon fuels.
- The oxides dissolve in water, and fall as acid rain.

Acid rain causes problems
- Soils become very acidic. This causes leaching of minerals and inhibition of decay.
- Water in lakes and rivers collects excess minerals. This causes death of fish and invertebrates so that food chains are disrupted.
- Forest trees suffer starvation because of (a) leaching of ions (b) destruction of photosynthetic tissue.

Acid rain can be reduced
- reduce emissions from car exhausts with catalytic converters
- use 'cleaner' power sources e.g. hydro and nuclear power.

**ATMOSPHERIC OZONE IS ESSENTIAL** (but in the wrong place it can be harmful)

- High level ozone offers protection: ozone absorbs solar ultraviolet radiation which would reach the Earth's surface and cause:
  - sunburn
  - skin cancer
  - cataracts
  - mutations (damage to DNA)

- 'Holes' in the ozone layer have been detected over Antarctica and are thought to have been caused by chlorine from long-lived CFCs.

Human activities affect ozone levels.
- CFCs (chlorofluorocarbons) used in aerosols, refrigerator coolants, and expanded plastics decrease amounts of high level ozone.
- Fossil fuel combustion produces oxides of nitrogen which react with oxygen to increase amounts of low level ozone.

Low level ozone causes problems:
- acts as a greenhouse gas
- contributes to trapping of dust and smoke: smog
- causes irritation of eyes, throat and lungs
- damages mesophyll in leaves: reduction in crops.
Water Pollution

Biodegradable: a product in wastewater is biodegradable if it can easily be broken down or digested by, for example, sewage treatment.

Biomarker: any parameter that can be used to measure an interaction between a biological system and an environment agent, which may be chemical, physical or biological.

Biomonitoring: the use of living organisms to test the suitability of an effluent to be discharged into receiving waters and to test the quality of such waters downstream from a discharge.

Discharge: the volume of water that passes a given location within a given period of time.

Dissolved oxygen (DO): the oxygen dissolved in sewage, water, or other liquid, usually expressed in milligrams per litre or percent of saturation. It is the test used in BOD determination.

Dissolved solids: the total amount of dissolved material, organic and inorganic, contained in water or wastewater. Excessive dissolved solids make water unpalatable for drinking and unsuitable for industrial use. Measurements are expressed as ppm or mg/L.

Effluent: a liquid that has passed through a processing operation.

LC50: the concentration of a material in air that will kill 50 per cent of a group of test animals with a single exposure (usually 1 to 4 hours). The LC50 is expressed as parts of material per million parts of air, by volume (ppm) for gases and vapours, or as micrograms of material per litre of air (g/l) or miligrams of material per cubic meter of air (mg/m³) for dusts and mists, as well as for gases and vapors.

LD50: a single dose of a material expected to kill 50 per cent of a group of test animals. The LD50 dose is usually expressed as milligrams or grams of material per kilogram of animal body weight (mg/kg or g/kg). The material may be administered by the mouth or applied to the skin.

Water pollution: any physical or chemical change in surface water or groundwater that can harm living organisms or make water unfit for certain uses.
Pollution of water

**LEAD POLLUTION** - water pipes were traditionally made of lead. Lead dissolves into the water which flows through the pipes. Lead compounds are toxic and accumulate via food chains. Lead weights discarded by anglers also contribute to lead pollution.

**OIL POLLUTION** - oil tankers spill their contents, by accident or deliberately during cleaning, into the sea. The oil floats on the surface, causing
- death of seabirds since feathers lose their ability to insulate when they are coated with oil.
- fish are directly poisoned
- marine mammals are killed by eating poisoned food or by loss of fur's insulating capacity.

**PESTICIDES** - overuse of pesticides on agricultural land (e.g., to protect a crop from insects) or directly on water (e.g., to kill an aquatic stage of an insect) can raise pesticide levels. The pesticide levels are then amplified as they pass through food chains
- e.g., DDT concentration in parts per million:

WATER 0.02 → PLANKTON 5 → DAPHNIA 50 → STICKLEBACK 250 → GREBE 1500

At these concentrations the DDT is harmful and reduces breeding success.

**THERMAL POLLUTION** - industries/power stations use water as a coolant, then discharge the water into rivers.

Now has lower oxygen concentration as the capacity of water for dissolved oxygen decreases as temperature rises, and as fish and bacteria become more active and respire more. May have new species e.g., tropical fish, terrapins which may affect food chains.

**EUTROPHICATION** - nutrient enrichment of ponds, lakes and rivers is responsible for

- Biological Oxygen Demand

  - Input of raw sewage
  - Leaching of inorganic fertilisers from farmland

  \* NB The leaching of phosphates into ponds and rivers is at least as important as nitrates in causing eutrophication

- Aerobic organisms (fish and invertebrates) die from lack of oxygen.
- Aerobic decomposers (mainly bacteria) multiply and consume oxygen
- Large quantities of organic material
- Reduction of light for bottom-growing plants

**POSITIVE FEEDBACK**

- Algae and green plants use nutrients to multiply rapidly - algal bloom
- Die

B.O.D. is the mass of oxygen consumed by micro-organisms in a sample of water. It is determined by measuring oxygen concentration with an oxygen electrode before and after a period of microbial respiration. It indicates the oxygen not available to more advanced organisms.
## Major water pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Major Sources</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage</td>
<td>Various industries, household waste, dumping at sea</td>
<td>Kills aquatic life. Dangerous to human health causing a range of gastro-intestinal diseases</td>
</tr>
<tr>
<td>Heavy metals, (eg arsenic, cadmium, mercury)</td>
<td>Industry (e.g. chemical, metal), urban run-off, mining</td>
<td>Disease and contaminated fish. Passed through food chain to humans causing lung, heart and nervous disorders</td>
</tr>
<tr>
<td>Polychlorinated biphenyls (PCBs)</td>
<td>Industry (e.g. chemical, pulp paper, plastics)</td>
<td>Disease and contaminated fish and shellfish. Damage vital human organs</td>
</tr>
<tr>
<td>Radioactive waste</td>
<td>Nuclear power stations, dumping at sea</td>
<td>Contamination of water. Increased risk of cancer</td>
</tr>
<tr>
<td>Oil</td>
<td>Oil refineries, flushing of tankers, accidental spills</td>
<td>Kills birds and marine life. Poisonous to humans</td>
</tr>
<tr>
<td>Biocides (e.g. DDT, dieldrin)</td>
<td>Run-off from farmland</td>
<td>Persistent, pass through food chain to humans. May cause birth defects, cancer and other illnesses</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Fertilisers in run-off from farmland, sewage, animal waste</td>
<td>Increased algae in water, causing lack of oxygen. Aquatic life destroyed</td>
</tr>
<tr>
<td>Sediment</td>
<td>Soil erosion from cleared land</td>
<td>Blocks light needed by aquatic life. Pipes and drains become blocked, waterways become too shallow for boats and ships</td>
</tr>
<tr>
<td>Plastics</td>
<td>Household waste, litter, dumping</td>
<td>Destroys natural habitats, strangles and mutilates wildlife</td>
</tr>
<tr>
<td>Hot water</td>
<td>Power stations, various industries</td>
<td>Harms aquatic life, destroys natural habitats</td>
</tr>
<tr>
<td>Acid rain</td>
<td>Power stations, various industries, motor vehicles</td>
<td>Aquatic life killed, pipes corroded, illness in humans</td>
</tr>
</tbody>
</table>

## Major air pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Sources</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide</td>
<td>Motor vehicles, burning of fossil fuels</td>
<td>Blood absorbs carbon monoxide more readily than oxygen, reducing the amount of oxygen being carried through the body. Carbon monoxide can produce tiredness and headaches. People with heart problems are particularly at risk</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>Coal and oil burning power stations, mineral ore processing and chemical manufacture</td>
<td>Attacks the throat and lungs. People with breathing problems can suffer severe illness</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>Fuel combustion</td>
<td>Affects the throat and lungs</td>
</tr>
<tr>
<td>Volatile organic compounds</td>
<td>Motor vehicles, fuel combustion, solvent use</td>
<td>Some VOCs cause eye and skin irritation, headaches or nausea, while some are classed as carcinogens</td>
</tr>
<tr>
<td>Ozone</td>
<td>These chemicals are released by motor vehicles and industry.</td>
<td>Ozone attacks the tissue of the throat and lungs and irritates the eyes</td>
</tr>
<tr>
<td>Lead</td>
<td>Exhaust gases from motor vehicles that use leaded petrol, smelters.</td>
<td>Particles containing lead in the air can enter the lungs. The lead can then be absorbed into the blood stream. Over a period lead can affect the nervous system and the body's ability to produce blood.</td>
</tr>
<tr>
<td>Particles</td>
<td>Motor vehicles, burning of plant materials, bushfires.</td>
<td>May cause breathing difficulties and worsen respiratory diseases. Some may contain cancer-producing materials</td>
</tr>
</tbody>
</table>
Ozone in the atmosphere is essential for life (but too much in the wrong place can be harmful).

Holes’ in the ozone layer: Measurements made by British scientists at Halley Bay, Antarctica, showed a thinning of the ozone layer caused by an accumulation of atmospheric chlorine during the winter months. The effect is partially reversed in the summer and may be peculiar to the Antarctic, but is seen as a warning that we must reduce production of long-lived CFCs.

Antarctica: ozone layer thinned over an area as large as the United States.

Tropospheric (low level) ozone causes problems
1. It acts as a greenhouse gas, absorbing and reradiating heat which raises the temperature at the Earth's surface.
2. As a result of 1, thermal inversion occurs—a layer of warm air traps cool air (containing dust and smoke) close to the Earth causing smog.
3. It causes irritation of eyes, throat and lungs and may cause death in sufferers from respiratory ailments as breathing is impaired.
4. It severely damages the photosynthetic mesophyll layers of plants by forming powerful oxidizing free radicals: this may lead to a 10% reduction in crop production.

Human activities generate ozone in the troposphere

\[ \text{Fossil fuel combustion} \rightarrow \text{NO}_2 \]

\[ \text{NO}_2 \xrightarrow{\text{sunlight}} \text{NO} + \text{O} \]

\[ \text{O} + \text{O}_2 \rightarrow \text{O}_3 : \text{OZONE} \]

* This occurs more rapidly in the presence of unburned hydrocarbons.

Human activities reduce ozone in the stratosphere

CFCs (chlorofluorocarbons) used in:
- refrigerator coolants;
- aerosols;
- expanded plastics.

Atmospheric chlorine

\[ \text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2 \]

\[ \text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2 \]

i.e. ozone levels are depleted.
Chlorine is released to degrade further ozone molecules.
Managing ecosystems: fish farming
maximises profit by minimising environmental resistance

**SPECIES** - the ‘farmed’ species must
- grow well under captive conditions
- accept prepared i.e. non-living food
- have a high conversion ratio i.e. convert food → flesh efficiently
- ideally be able to complete its life cycle i.e. breed under captive conditions
- not be particularly susceptible to disease.
It is usually expensive to provide these conditions so the product should command a high price. For this reason the main farmed species in Britain are members of the Salmon family.

**FRY PRODUCTION**
- Fish are spawned under artificial conditions - often in aquaria and often under the influence of reproductive hormones.
- Fry are ‘grown on’ to a size at which they can be released
  - control temperature (higher temperature, rapid growth)
  - high oxygen levels with aerators
  - growth hormones may be added to water
- Fry of **uniform size** are released into the farming pens. This reduces the chance of the fish eating each other!

**SUSPENDED NET**
- keeps out **aerial predators** such as cormorant, heron and osprey.

**PREPARED FOOD**
- dried, in pellet form, for convenience of transport from site of production and for measured delivery to fish.
- usually made from ‘trash fish’ which is marine fish caught in nets but not used for human consumption – very high in protein (rapid growth rate) but very expensive.
- may include colouring agent (turns fish pink – favoured by consumers) and **antibiotic** (disease control).

**HANGING NET**
- keeps out **aquatic predators** such as otter and pike
- keeps out other fish and so reduces competition for the pelleted food.

**DISEASE CONTROL**: close confinement makes fish more likely to suffer from disease (spread is much easier)
- dose water with **dichlorvos** which kills fish lice.
- dose water with **fungicide** to prevent fungal infection of skin and gills.
- add **antibiotic** to food to control bacterial infections.

**PROBLEMS AND ENVIRONMENTAL CONCERNS**
- very high food costs.
- poor control of temperature and oxygen availability in large outdoor farming pens.
- much more research necessary to obtain highest yields - particularly important are selective breeding programmes to develop new fish varieties with improved growth rates and conversion ratios.
- pollution by pesticides since these compounds may kill organisms which are foods for ‘wild’ species.
- excess food and fish faeces create nutrient rich environment below netted area → growth of bacterial population → increased biological oxygen demand.

In developed countries intensive fish farming is so costly that it should be seen as adding variety to the diet rather than being a source of cheap, plentiful protein.
**IDEAL RELATIONSHIP BETWEEN PEST AND ITS CONTROL AGENT**

The pest species becomes the prey of the control agent; it is the target in the system of biological control.

Control agent is a natural predator on the prey pest species - population increases as the predator breeds.

Introduction of control agent: must be a population large enough to control the pest before it causes too much damage.

Pest population falls due to predation by control agent.

Population size above which the pest is economically harmful: often determined by the expected yield and potential value of the crop.

Population of control agent falls because of food shortage caused by a reduction in prey (pest) numbers.

A dynamic equilibrium is set up in which a moderate residual population of the control agent is able to permanently restrict the population of the pest. NB the pest species must not be entirely eliminated or the control agent will die out and a further introduction will be necessary to prevent re-establishment of economically damaging pest populations.

**BUT THERE HAVE BEEN FAILURES!**

Hawaiian cane toads introduced into Queensland, Australia, to control the greenback beetle, a pest on sugarcane, are now a serious threat to Australian wildlife. The toad eats many native insects and worms - displaces native frogs and toads from breeding pools - poisons larger animals which try to eat it because its skin is extremely toxic.

Cats and stoats introduced to offshore islands of Britain and New Zealand to limit population of rodents which threatened rare ground-nesting birds found that the chicks of the ‘protected’ birds were easier to catch than the rats were!

**NEVERTHELESS, COMPARED WITH CHEMICAL CONTROL, THERE ARE CERTAIN ADVANTAGES OF BIOLOGICAL PEST CONTROL...**

<table>
<thead>
<tr>
<th>SPECIFICITY</th>
<th>BIOLOGICAL CONTROL</th>
<th>CHEMICAL CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>'ACCUMULATION' IN Ecosystems</td>
<td>None</td>
<td>Concentrations may increase along food chains</td>
</tr>
<tr>
<td>PERMANENCE OF CONTROL</td>
<td>Good, but small numbers of pests must be tolerated</td>
<td>Requires regular reaplication</td>
</tr>
<tr>
<td>DEVELOPMENT OF PEST</td>
<td>Very rare</td>
<td>Common, requiring ever-increasing 'dose'</td>
</tr>
<tr>
<td>RESISTANCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COST IN FINANCIAL TERMS</td>
<td>Initially may be high, but very low in the long-term</td>
<td>May be very high, restricting use to wealthy nations</td>
</tr>
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</table>

**PRINCIPLE TECHNIQUES IN BIOLOGICAL CONTROL**

1. Use a herbivore to control a weed species e.g. *Cactoblastis* larvae on prickly pear.
2. Use a carnivore to control an herbivorous pest e.g. hoverfly larvae on aphids.
3. Use a parasite to control its host e.g. *Encarsia*, a parasitic wasp, on the greenhouse whitefly, *Trialeurodes vaporariorum*.
4. Disrupt the breeding cycle of a pest if it mates only in its life e.g. release of irradiation-sterilised males of the screw worm fly, a flesh eating parasite of cattle.
5. Control of pest behaviour e.g. sex attractant pheromones are used to attract apple codling moths into lethal traps.

**BIological pest control** depends on an understanding of the relationship between populations of predators and their prey.
PROBLEMS WITH INSECTICIDES: these arise since the principal idea behind chemical control is to kill as many of the pests as possible — the effects on harmless or beneficial organisms were not studied or were ignored.

1. Direct killing: accidental misuse of toxic chemicals may cause death in humans or in domestic animals.

2. Non-specificity: non-target species, particularly natural predators of the pest species, may be killed by some wide-spectrum insecticides, e.g. large doses of dicofol killed many birds as well as the Japanese beetle pest which was the intended target organism.

3. Pest resistance: genetic variation means that each pest population contains a few resistant individuals. The pesticide eliminates the non-resistant forms and thus a resistant population is selected for and may quickly develop (since many pests reproduce rapidly).

4. Pest replacement: most crops are susceptible to attack by more than one species — a pest complex and the use of a pesticide to eliminate one species may simply allow another species to assume major pest proportions (since a pesticide may be more deadly to one species than another).

5. Pest resurgence: non-specific pesticides may kill natural predators as well as pests — a small residual pest population may now multiply without check, creating a worse problem than initially was present.

6. Bioaccumulation of toxins: pesticides or their products may be toxic:
   a. they may seriously affect micro-organisms and thus alter decomposition in soils;
   b. they may pass along food chains, becoming more concentrated in organisms further up the chain.

e.g. DDT used as an insecticide accumulates in the fatty tissues of carnivorous animals, inhibiting cytochrome oxidase and limiting reproductive success (especially thin eggs in birds of prey).

![Chemical pest control diagram]

Chemical pest control may involve the use of:
- herbicides — for control of weeds;
- insecticides — for control of insects;
- fungicides — for control of fungi;
- molluscicides — for control of slugs and snails.

HERBICIDES may be:
1. Pre-emergent, i.e. applied before emergence of crop.
   a. Contact herbicides, e.g. Paraquat, which kill all above-ground parts of all plants.
   b. Residual herbicides, e.g. Linuron, which bind to soil particles and kill weed seedlings as they emerge.

Pre-emergent herbicides can be non-selective and are ideal for clearing ground prior to cultivation.

2. Post-emergent is applied to both crop and weed, and therefore must be selective. Many, such as 2,4-D, are growth regulators.

Systemic herbicides, such as glyphosate, are absorbed by weeds and translocated to the meristems where they typically act by inhibition of cell division.

![Phytoplankton food chain]

Relative DDT concentration along an aquatic food chain.
Criterion 8 - Principles for the ecologically sustainable management of the environment

ECOLOGICALLY SUSTAINABLE DEVELOPMENT
A sustainable society is one in which all human activity takes place and is maintained over time within the limits of the earth to provide the necessary resources for survival (particularly food) and assimilate waste.

A sustainable society allows the human members to meet their own needs without compromising the needs of other species and future generations of humans.

PRINCIPLES OF SUSTAINABLE DEVELOPMENT
Ethical considerations

Intergenerational Equity - It is important that future generations of humans have supplies of important resources and that they are not required to clean up the environmental disasters of the past.

Intra-generational Equity – The resources of the planet should meet the needs of all humans and all human should have access to clean water, clean air, and basic food materials, fibres for clothing, building materials and other basic human requirements.

Ecological Integrity - It is important that all the ecosystems be able to continue to function. The biodiversity of ecosystems must be maintained as well as the habitat necessary for them to survive.

Strategies
Precautionary & Anticipatory Principles – These should apply to all new developments. The development should only be allowed if it can be proved beyond doubt that it will not harm the environment.

Full Cost Pricing - In the use of natural resources all values should be considered in the price not just the financial values. The user pays principle should always apply. The cost of cleaning up pollution should also be included in the price – the polluter pays principle.

Efficient Use of Resources - The use of non-renewable resources should be decreased and the use of renewable resources increased. Reusing and recycling should be encouraged.

APPROACHES TO SUSTAINABLE DEVELOPMENT
Education
Establishing community based programs that involve the public in environmental management. Damage already done can be repaired and future problems can be avoided. This approach is less expensive and helps create an environmental ethic in the community. Waterwatch, Coastcare and Landcare are good examples of this approach.

Economic
This approach uses economics to encourage good environmental practice. Green Economics consists of a group of strategies that would promote this concept.

Green Economic Strategies include:
• The Polluter Pays Principle
• Full-cost Pricing / user pays principle
• Economic incentives
• Economic Disincentives
• Tradable/Marketable Permits
• Market Forces
• Accounting for environmental assets
• Mandatory renewable energy targets (MRETs)

Two approaches to improved environmental control

<table>
<thead>
<tr>
<th>Market based approach</th>
<th>Government control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td>Flexible – allows least cost method of production. Encourages development of new anti-pollution strategies</td>
<td>Equitable – all producers have to reduce environmental impact</td>
</tr>
<tr>
<td>Popular with industry – remain in control</td>
<td>Easier to implement higher standards as technology and awareness improve.</td>
</tr>
<tr>
<td>Prices good regulators – profits hurt when wrong decisions made</td>
<td>Public acceptance and understanding</td>
</tr>
<tr>
<td>Dynamic – can be adjusted to meet improved standards</td>
<td>Mechanisms in place</td>
</tr>
<tr>
<td>Saves costs</td>
<td></td>
</tr>
</tbody>
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Examples

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxes –fuel / carbon taxes</td>
<td>Environmental standards – usually set by EPA</td>
</tr>
<tr>
<td>Improved property rights – transferable water rights in Murray Darling Basin, which increases the value of water and reduces wasteful irrigation practices.</td>
<td>Licences – pollution control permits,</td>
</tr>
<tr>
<td>Tradable emission permits – used to reduce emissions in some places</td>
<td>Regulations – refundable deposits in SA, lead free petrol, emission control on cars</td>
</tr>
</tbody>
</table>

Realistic pricing - user pays
An externality is a cost that can be passed on to someone else and is therefore not considered in the cost/benefit analysis i.e. milk processors are not required to pay for the disposal of the milk cartons, the local council meets this cost. In full cost pricing this cost would be included in the price of a carton of milk.

An opportunity cost is the cost of a lost opportunity e.g. if you log a forest you can’t make money from it from ecotourism and as such is an opportunity cost.

Legislation

In Australia there are three levels of government: Commonwealth/Federal, State and Local (councils).

Governments produce environmental laws that essentially provide a set of rules governing human interactions with the environment. They provide a legal framework to prohibit activities that cause harm (eg the Federal Ozone Protection Act regulates the release of ozone depleting gases, and the Tasmanian Environmental Management and Pollution Control Act sets guidelines for sewerage treatment and discharge of effluent). Legislation can be used to assist decision making to ensure only sustainable developments progress (eg the Federal EPBC act is used to assess significant projects during the approvals process). Legislation can also be used to support conservation and positive interactions with the environment (eg the Tasmanian National Parks and Reserve Management Act sets out the guidelines for allocating and managing land within out state reserves).

Legislation is often tied with economic incentives and disincentives to encourage or discourage certain activities.

International agreements are proposed and adopted through a governing body (in most cases this is the United Nations) and examples include: CITES, Montreal Protocol, IWC, Law of the Sea, World Heritage Convention, Ramsar Convention, CCAMLR

**MANAGEMENT TOOLS**

**E.I.A./E.I.S.**

An Environmental Impact Assessment is required for all major projects. It allows us to predict the impact of a development on the environment, manage our resources more effectively and improve our decision making.

An EIA examines the likely impact on the environment of a project and examines the social and economic impacts as well as the impact on the biophysical environment. The biophysical impact must consider the effects on soil, the air and the water as well as the living organisms.

An EIA links together three groups- the developer, the community and the decision makers. The developer initiates the project and must try to minimise the impact of the project on the environment. The community should have their concerns addressed in the design of the project and in the final decision about the project. The decision makers can use the EIA to determine if the project should go ahead.

**STEPS IN THE EIA PROCESS**

1. Initiate - the developer initiates the projects and identifies the type of assessment that should be made.
2. Identify the issues - advice is sought from industry, the community and from governments as to what issues should be addressed in the EIA.
3. Develop Alternatives - including different locations, different designs and always the alternative to ‘do nothing’.
4. Predict the likely impact and identify the type of study that should be made.
5. Evaluate the alternatives to make the best decision.
6. EIS - a formal document is completed and presented.
7. Make a decision based on the document. If the answer is “Yes” to the proposal, conditions may be applied.
8. Monitor the projects to see if any conditions have been met, if the predicted impacts occur and to help future decision making.
MANAGEMENT PLANS
What they are
Management plans are one of several management tools that can be used to promote sustainable development and reduce the impact of human activities on the environment. They are more commonly used for projects and activities that are already in use rather than new projects.

How they are developed:

- identification of stakeholders
- vision statement
- description and mapping of resources
- valuing of resources
- determine legal restrictions
- selecting appropriate technology
- ongoing monitoring
- evaluating the management plan
- suggest various options

A management plan should include:

- A description of the area and its significance in the region. A map of the area should be included and it should include access points and services available.
- Information about the legal status of the area and any relevant legislation (both state and federal) should be noted.
- The values of the area should be identified and the stakeholders identified. A consultation process with the stakeholders should be established.
- A list of management objectives should be created.
- A baseline study should be designed to document the biotic and abiotic factors relevant to the area. Special note should be made of threatened or endangered species.
- A vision statement should be prepared. Major threats should be identified and a recovery plan should be included if necessary. What human amenities are required should be identified. The vision statement should show how the area should look after a period of time.
- An ongoing plan for monitoring should be created and a consultation committee established.

Managing Biodiversity

- Conservation reserves eg National Parks, Marine protected areas - Protection of natural and scenic areas of national or international significance for scientific, educational and recreational use.
- The National Reserve System is underpinned by a scientific framework to ensure that Australia progressively extends protection to examples of all our ecosystems.

The scientific framework has a clear objective: to develop a 'comprehensive, adequate and representative' system of protected areas - commonly referred to as the 'CAR' reserve system. Specifically CAR means:

- Comprehensive: the inclusion in the National Reserve System of examples of regional-scale ecosystems in each bioregion
- Adequate: the inclusion of sufficient levels of each ecosystem within the protected area network to provide ecological viability and to maintain the integrity of populations, species and communities
- Representative: the inclusion of areas at a finer scale, to encompass the variability of habitat within ecosystems

- Corridors – connect fragmented habitats
- Translocation – transfer of plants or animals from one part of their range to another
- Reintroduction – of plants and animals that have been raised in captivity to replace those that have become locally extinct
- Biodiversity hotspots – concentrating efforts on protecting significant hotspots where significant biodiversity is under immediate threat.
- Rehabilitating and restoring –
- Quarantine

Quarantine
**BARRIERS TO SUSTAINABLE DEVELOPMENT**

**Global economic system**

The economies of the MEDC's (more economically developed countries) are often quite different to the economies of the LEDC's (less economically developed counties).

The economies of the MEDC’s are usually based on one of two models, regulated economies or market economies. Some economies are a mixture of the two.

Australia has a market economy where the prices of goods and services is determined by their value in the market. In the past there was some degree of regulation in the Australian economy but much of this has been removed since the 1980s.

The prices of goods and services are determined by a principle called the Law of Supply and Demand. If the supply is less than the demand the price goes up and if demand is less than the supply the price goes down.

All economies are based on some type of capital. This can be natural capital (natural resources). Agricultural capital, manufactured capital or human capital. Most of the MEDC’s have considerable manufactured capital and/or human capital and the LEDC’s have only natural or agricultural capital. The poorest nations may have little capital of any kind.

**GDP / GNP**

Economists use terms such as GDP (gross domestic product) and GNP (gross national product) to describe the health of an economy.

GDP refers to the amount of good and services produced and consumed by an economy.

GNP refers to the goods and services produced and consumed plus the amount imported and exported. Nations with a high GDP and GNP usually have a high standard of living.

Almost all nations trade goods and services with other nations. Goods purchased from other countries are called imports and those sold to other countries are called exports. If the value of the goods imported is greater than the goods exported then the country is said to have a trade deficit. The value of natural resources and agricultural products is often much less than the value of manufactured goods.

GDP and GNP say little about the health of the environment. There is a general trend that the higher a countries GDP and GNP the larger is its ecological footprint- the more resources it consumes and the more pollution it creates.
GLOSSARY OF ENVIRONMENTAL SCIENCE TERM

**Abiotic factor:** nonliving components of the ecosystem, including chemical and physical factors.
**Acid deposition:** rain or snow that has a lower pH than precipitation from unpolluted skies.
**Acid mine drainage:** sulfuric acid that drains from mines, especially abandoned underground coal mines. Created by the chemical reaction between oxygen, water, and iron sulfides found in coal and surrounding rocks.
**Active solar:** capturing and storage of the sun’s energy through special collection devices (solar panels) that absorb heat and transfer it to air, water, or some other medium, which is then pumped to a storage site usually a water tank) for later use. Contrast with passive solar.
**Adaptation:** a genetically determined structural or functional characteristic of an organism that enhances its chances of reproducing and passing on its genes.
**Agricultural society:** a group of people living in villages or towns and relying on domestic animals and crops grown in nearby fields.
**Albedo:** a measure of the reflectivity of the earth’s surface.
**Algal bloom:** rapid growth of algae in surface waters due to increase in inorganic nutrients, usually either nitrogen or phosphorus.
**Alien species:** any species introduced into or living in a new habitat. Also known as exotic.
**Anthropogenic:** created by humans.
**Aquaculture:** cultivation of fish and other aquatic organisms in freshwater ponds, lakes, or other bodies of water.
**Aquifer:** underground layer of porous material containing water (ground water).
**Asbestos:** A naturally occurring silicate fibre. Useful in society as an insulator. It is deadly to breathe even in small amounts. Causes diseases such as mesothelioma, asbestosis and lung cancer.
**Asbestosis:** lung disease characterised by build up of scar tissue in the lungs. Caused by inhalation of asbestos.
**Atmosphere:** layer of air surrounding the earth.
**Atom:** a basic unit of matter consisting of a nucleus of positively charged protons and uncharged neutrons, and an outer cloud of electrons orbiting the nucleus.
**Autotroph:** An organism that can produce its own food.
**Bacteria:** A group of single-celled organisms, each surrounded by a cell wall and containing circular DNA. Responsible for some diseases and many beneficial functions, such as decay of organic materials and nutrient recycling.
**Biological or biochemical oxygen demand (BOD):** measure of oxygen depletion of water (largely from bacteria decay) due to presence of biodegradable organic pollutants. Gives scientists an indication of how much organic matter is in water.
**Bioconcentration:** ability of an organism to selectively accumulate certain chemicals, elements, or substances within its body or within certain cells.
**Biodegradable:** Able to be broken down by microorganisms.
**Biogas:** a gas containing methane and carbon dioxide. Produced by anaerobic decay of organic matter, especially manure and crop residues.
**Biochemical cycle:** complex cyclical transfer of nutrients from the environment to organisms and back to the environment. Examples include the carbon, nitrogen, and phosphorus cycles.
**Biological control:** use of naturally occurring predators, parasites, bacteria, and viruses to control pests.
**Biological extinction:** disappearance of a species from part or all of its range.
**Biological magnification:** (biomagnification) build up of chemical elements or substances in organisms in successively higher trophic levels.
**Biomass:** the dried weight of all organic matter in the ecosystem. Any form of organic material (from both plants and animals) from which energy can be derived.
**Biomass pyramid:** see pyramid of biomass.
**Bioturbation:**One of several immense terrestrial regions, each characterised throughout its extent by similar plants, animals, climate and soil type.
**Biosphere:** all the life supporting regions (ecosystems) of the earth and all the interactions that occur between organisms and between organisms and the environment.
**Biotic factor:** The biological component of the ecosystem, consisting of population of plants, animals, and micro-organisms in complex communities.

**Cancer:** Uncontrolled proliferation of cells in humans and other living organisms. In humans, includes more than 100 different types afflicting individuals of all races and ages.
**Carbon Cycle:** The cycling of carbon between organisms and the environment.
**Carcinogen:** A chemical or physical agent that causes cancer to develop, often decades after the original exposure.
**Carrying capacity:** Maximum population size that a given ecosystem can support for an indefinite period or on a sustainable basis.
**Catalyst:** Substance that accelerates chemical reactions but it is not used up in the process. Enzymes are biological catalysts. Also see catalytic converter.
**Catalytic converter:** Device attached to the exhaust system of automobiles and trucks to rid the exhaust gases of harmful pollutants.
**Cellular respiration:** Process by which a cell breaks down glucose and other molecules to acquire energy.
**Chlorofluorocarbons:** Organic molecules consisting of chlorine and fluorine covalently bonded to carbon. Previously thought to be inert, but now known to destroy the stratosphere’s ozone layer.
**Chlorophyll:** Pigment of plant cells that absorbs sunlight, thus allowing plants to capture solar energy.
**Clear-cutting:** (also clear-felling) Removal of all trees from a forested area.
**Climate:** The average weather conditions: temperature, solar radiation, precipitation, and humidity.
**Climax community or ecosystem:** See mature community.
Closed system: A system that can exchange energy, but does not exchange matter, with the surrounding environment.

Coastal wetlands: Wet or flooded regions along coastlines, including mangrove swamps, salt marshes, bays, and lagoons.

Coliform bacterium: Common bacterium found in the intestinal tracts of humans and other species. Used in water quality analysis to determine the extent of faecal contamination.

Combustion: Burning.

Commensalism: Relationship between two organisms that is beneficial to one and neither harmful nor helpful to the other.

Commons: Any resource used in common by many people, such as air, water, and grazing land.

Community: Also called a biological community. The populations of plants, animals, and micro-organisms living and interacting in a given locality.

Competition: Vying for resources between members of the same or different species.

Composting: Aerobic decay of organic matter to generate a humus-like substance used to supplement soil.

Conservation: A strategy to reduce the use of resources, especially through increased efficiency, reuse, recycling, and decreased demand.

Consumer (or consumer organism or heterotroph): An organism in the ecosystem that feeds on autotrophs and/or heterotrophs.

Contour farming: Soil erosion control technique in which row crops (corn) are planted along the contour lines in sloping or hilly fields rather than up and down the hills.

Control group: In scientific experimentation, a group that is untreated and compared with a treated, or experimental, group.

Cost-benefit analysis: Way of determining the economic, social, and environmental costs of a proposed action.

DDT: Dichlorodiphenyltrichloroethane. An insecticide used to control a variety of insect pests, but now banned because of its persistence in the environment and its ability to bioaccumulate.

Debt for Nature: Wealthier nations cancel the debts for poorer communities if they will protect their natural ecosystems.

Decibel (db): A unit to measure the loudness of sound.

Decomposer: Also micro consumer. An organism that breaks down nonliving organic material. Bacteria and Fungi are decomposers and should not be confused with detritivores.

Decomposer food chain: A specific nutrient and energy pathway in an ecosystem in which decomposer organisms (bacteria and fungi) consume dead plants and animals as well as animal wastes. Also called detritus food chain.

Deep Ecology: Recognises the right of all organisms to exist. Humans are no more important than other organisms.

Deforestation: Destruction of forests by clear cutting.

Demographic transition: A phenomenon witnessed in populations of industrialising nations. As industrialisation proceeds and wealth accumulates. Crude birth rate and crude death rate decline, resulting in zero or low population growth.

Demography: The science of population.

Denitrification: The breakdown of nitrates by bacteria.

Desert: Biome located throughout the world. Often found on the downwind side of mountain ranges. Characterised by low humidity, high summertime temperatures, and plants and animals especially adapted to lack of water.

Desertification: The formation of desert in arid and semi-arid regions from overgrazing, deforestation, poor agriculture practices, and climate change. Found today in Africa, the Middle East, and the South-western United States.

Detoxification: Rendering a substance harmless by reacting it with another chemical, chemically modifying it, or destroying the molecule through combustion or thermal decomposition.

Detritus: Any organic waste from plants and animals.

Detritus Feeder: Organisms in the decomposer food chain that feed primarily on organic waste (detritus) such as fallen leaves.

Detritus food chain: See decomposer food chain.

Developed Country: A convenient term that describes industrialised nations, generally characterised by high standard of living, low population growth rate, low infant mortality rate, high per capita income, urban population, and low illiteracy.

Developing country: Same as less developed country.

Dioxin: A large group of highly toxic, carcinogenic compounds containing some herbicides (2,4-D and 2,4,5-T) and Agent Orange.

Diversity: A measure of the number of different species in an ecosystem.

DNA (deoxyribonucleic acid): A long-chained organic molecule that is found in chromosomes and carries the genetic information that controls cellular function and is the basis of heredity.

Doubling time: The length of time it takes some measured entity (population) to double in size at a given growth rate.

Ecological niche: see niche

Ecological system: See Ecosystem

Ecologically Sustainable Development: Development which meets the needs of the present generation without compromising the needs of future generations and other species.

Economic externality: A cost generally passed on to the general public and tax payers.

Ecosphere: See biosphere

Ecosystem: Short for ecological system. A community of organisms occupying a given region within a biome. Also, the physical and chemical environment of that community and all the interactions between organisms and between organisms and their environment.
Ecosystem stability: Dynamic equilibrium of the ecosystem. Also a characteristic of ecosystems causing them to return to their previous state (resilience) and their resistance to change (inertia).

Ecotone: Transition zone between adjacent ecosystems

Element: A substance, such as oxygen, gold, or carbon, that is distinguished from all other elements by the number of protons in its atomic nucleus.

Emigration: Movement of people out of a country to establish residence elsewhere.

Endangered Species: A plant, or micro-organism that is in immediate danger of biological extinction. See threatened and rare species.

Energy: The capacity to do work. Found in many forms, including heat, light, sound, electricity, coal, oil, gasoline.

Energy Pyramid: See pyramid of energy

Entropy: A measure of disorder. The second law of thermodynamics applied to matter says that all systems proceed to maximum disorder.

Environment: All the biological and non-biological factors that affect an organisms life.

Environmental control (of pests): Methods designed to alter the abiotic and biotic environment making them inhospitable or intolerable. Examples include increasing crop diversity, altering time of planting, and altering soil nutrient levels.

Environmental impact statement (EIS or ES): Document prepared primarily to outline potential impacts of projects.

Environmental Resistance: Abiotic and Biotic factors that can potentially reduce population size.

Environmental science: The interdisciplinary study of the complex and interconnected issues or population, resources and pollution.

Estuary: Coastal regions such as inlets or mouths of rivers where fresh and salt water mix.

Ethanol: Grain alcohol, or ethyl alcohol, produced by fermentation of organic matter.

Eukaryotes: The first aerobic cells complete with nuclei and energy releasing organelles.

Eutrophication: Accumulation of nutrients in a lake or pond due to human or natural activities.

Evolution: A long term process of change in organisms caused by random genetic changes that favour the survival and reproduction of the organisms possessing the genetic change. Through evolution, organisms become better adapted to their environment.

Experimental group: in scientific experimentation, a group that is treated and compared with an untreated, or control group.

Exponential curve: see J curve

Extinct species: Has completely disappeared.

Feral: a domestic animal or plant that has gone wild.

Food Chain: A flow diagram showing the movement of matter and energy from one organism to another.

Food web: Shows the feeding relationships in a community.

Fossil Fuels: Fuels derived from once living organisms.

Frontier mentality: A mind that views humans as “above” all other forms of life rather than as an integral part of nature and sees the world as unlimited supply or resources for human use regardless of the impacts on other species. Implicit in this view are the notions that bigger is better, continued material wealth will improve life, and nature must be subdued.

Gaia Hypothesis: Term coined by James Lovelock to describe the Earth’s capacity to maintain the physical and chemical conditions necessary for life.

Galaxy: Grouping of billions of stars, gas, and dust, such as the Milky Way galaxy.

GDP: Gross Domestic Product. Indicates the amount of goods and services used by a society.

Genetic engineering: The transfer of genes from one organism to another.

Geothermal energy: Energy derived from the earth’s heat that comes from decay of naturally occurring radioactive materials in the earth’s crust, magma, and friction caused by movement of tectonic plates.

Global Warming: An increase in the average temperature of the Earth.

GNP: See Gross National Product.

Grasslands: Biome found in both temperate and tropical regions and characterised by periodic drought, flat or slightly rolling terrain, and large grazers that feed off the lush grasses.

Grey-air cities: Older industrial cities characterised by predominantly sulfur dioxide and particulate pollution.

Grazer food chain: A specific nutrient and energy pathway starting with plants that are consumed by grazers (herbivores).

Greenhouse Effect: Mechanism that explains atmospheric heat trapped like the glass in a greenhouse, permitting visible light to penetrate but impeding the escape of infrared radiation, or heat.

Gross National Product (GNP): Total national output of goods and services valued at market prices, including net exports and private investment.

Gross Primary Productivity: The total amount of sunlight converted into chemical-bond energy by a plant.

Groundwater: Water below the Earth’s surface in the saturated zone.

Habitat: The specific region in which an organism lives.

Hard path: A term coined by Amory Lovins to describe large, centralised energy systems such as coal, oil, or nuclear power, characterised by extensive power distribution, central control, and lack of renewability.

Hazardous waste: Any potentially harmful solid, liquid, or gaseous waste product of manufacturing or other human activities.

Herbicide: Chemical agent used to control weeds.

Herbivore: Heterotrophic organism that feeds exclusively on plants.

Heterotroph: An organism that feeds on other organisms such as plants and animals. It cannot make its own foodstuffs.

Hot-rock zones: Most widespread geothermal resource. Regions where bedrock is heated by underlying magma.

Humus: Mixture of decaying organic matter and inorganic matter that increases soil fertility, aeration, and water retention.

Hydroelectric power: Electricity produced in turbines powered by running water.

Hydrological cycle: The movement of water through the environment from atmosphere to Earth and back again.

Hydrosphere: The watery portion of the planet. Contrast with atmosphere and lithosphere.

Hypothesis: Tentative explanation for a natural phenomenon, testable by experiment.

Immigration: Movement of people into a country to set up residence there.

Indoor air pollution: Generally refers to air pollutants in homes from internal sources such as smokers, fireplaces, wood stoves, carpets, panelling, furniture, foam insulation, and cooking stoves.

Industrial smog: Air pollution from industrial cities (grey-air cities), consisting mostly of particulates and sulfur oxides.

Industrial society: Group of people living in urban or rural environments that are characterised by mechanisation of industrial production and agriculture. Widespread machine labour causes high energy demands and pollution. Increasing control over natural processes leads to feeling that humans are separate from nature and superior to it.

Infrared radiation: Heat, an electromagnetic radiation of wavelength outside the red end of the visible spectrum.

Inland wetlands: Wet and flooded regions along inland surfaces waters. Includes marshes, bogs, and river outflow lands.

In-migration- Movement of people into a state or region within a country to set up residence.

Inorganic fertiliser: Synthetic plant nutrient added to the soil to replace lost nutrients. Major components include nitrogen, phosphorus, and potassium.

Insecticide: One form of pesticide used specifically to control insect populations.

Intergenerational equity: The idea that future generations should inherit a planet that has not been polluted or depleted of its natural resources.

Interspecific competition: Competition between members of different species.

Intrageneral (social) Equity: The idea that all humans have equal rights to the resources of the Earth.

J curve: A graphical representation of exponential growth.

Joules: The units in which work and heat are measured.

Keystone species: Critical species in an ecosystem whose loss profoundly affects several or many others.

KiloWatt: One thousand watts. See Watt.

Kinetic energy: The energy of objects in motion.

Legume: Plants (eg peas and beans) that have a symbiotic relationship with nitrogen fixing bacteria.

Less developed country: Term describing the non-industrialized nations, generally characterised by low standard of living, high population growth rate, high infant mortality, low material consumption, low per capita energy consumption, low per capita income, rural population, and high illiteracy.

Light Year: Astronomical unit that measures the distance that light can travel in a year.

Limiting Factor: A chemical or physical factor that determines whether an organism can survive in a given ecosystem.

Lithosphere: The outermost shell of the Earth.

Macronutrient: A chemical substance needed by living organisms in large quantities (for example, carbon, oxygen, hydrogen and nitrogen).

Management Plan: Plan that have been developed to guide the present and future land/water management of an area.

Mariculture: Cultivation of fish and other aquatic organisms in salt water (estuaries and bays).

Mature Community: A community that remains more or less the same over a long period of time. Climax stage of succession. Also called a climax community.

Mature Ecosystem: An ecosystem in the climax age of succession, characterised by high species diversity and high stability. Contrast with immature ecosystem.

MegaWatt: Measure of electrical power equal to a million watts. See Watt.

Mesothelioma: A tumour of the lining of the lung caused by asbestos.

Migration: Moment of people across state and national boundaries to set up new residence. See immigration, emigration, in-migration and out migration.

Mineral: A chemical element (e.g. gold) or inorganic compound (e.g. iron ore) existing naturally.

Minimum tillage: Reduced ploughing and cultivating of cropland between and during growing seasons to help reduce soil erosion and save energy.

Monoculture: Cultivation of plant species such as wheat over a large area making it highly susceptible to disease and insects.

Mutation: In general, any damage to the DNA and chromosomes.

Mutualism: relationship between two organisms that is beneficial to both.

Natural Gas: Gaseous fuel containing methane and lesser amounts of other burnable organic gases such as propane and butane.

Natural resource: see resource.

Natural selection: Process in which slight variations in organisms (adaptations) are preserved if they are useful and help the organism to better respond to its environment.

Negative feedback: Control mechanism present in the ecosystem and all organisms. Information in the form of chemical, physical and biological agents influences processes, causing them to shut down or reduce their activity.

Net Primary Productivity: Gross Primary Productivity minus the energy plants use during cellular respiration.

Niche: Also called an ecological niche. An organism’s role in a community.

Nitrogen cycle: The cycling of nitrogen between organisms and the environment.
**Nitrogen fixation:** Conversion of atmospheric nitrogen (a gas) into nitrate and ammonium ions (inorganic form), which can be used by plants.

**Nitrogen oxides:** Nitric oxide (NO) and nitrogen dioxide (NO₂), produced during combustion when atmospheric nitrogen (N₂) combines with oxygen.

**Nonpoint source:** (of pollution) Diffuse source of pollution such as an eroding field, urban and suburban lands, and forests.

**Non-renewable resource:** Resource that is not replaced or regenerated naturally within a reasonable period (fossil fuel, mineral)

**Nuclear power (or energy):** Energy from the fission or fusion of atomic nuclei.

**Old growth forest:** Ancient forests with trees often 150 to 1000 or more years old.

**Omnivore:** An organism that eats both plants and animals.

**Open system:** A system that freely exchanges energy and matter with the environment.

**Opportunity Cost:** Money lost when an opportunity is lost. E.g. A tree sold for wood chips can’t be used the make furniture.

**PCBs:** see polychlorinated biphenyls.

**Perennial:** A plant that grows from the same root structure year after year (for example, rose bushes).

**Permaculture:** A method off sustainable agriculture which encourages biodiversity.

**Permafrost:** Permanently frozen ground found in the tundra.

**Pesticide:** A general term referring to a chemical, physical, or biological agent that kills organisms we classify pests, such as insects and rodents.

**Petroleum:** A viscous liquid containing numerous burnable hydrocarbons. Distilled into a variety of useful fuels (fuel oil, gasoline, and diesel) and petrochemicals (chemicals that can be used as a chemical feedstock for the production of drugs, plastics, and other substances).

**pH:** Measure of acidity on a scale from 0 to 14, with pH 7 being neutral, numbers greater than 7 being basic, and numbers less than 7 being acidic.

**Photochemical oxidants:** Ozone and a variety of oxygenated organic compounds produced when sunlight, hydrocarbons, and nitrogen oxides react in the atmosphere.

**Photochemical reaction:** A chemical reaction that occurs in the atmosphere involving sunlight or heat, pollutants, and sometimes natural atmospheric chemicals.

**Photochemical smog:** A complex mixture of photochemical oxidants and nitrogen oxides. Usually has a brownish-orange colour.

**Photosynthesis:** A two-part process involving (1) the capture of sunlight and its conversion into cellular energy and (2) the production of organic molecules such as glucose and amino acids from carbon dioxide, water, and energy from the sun.

**Photovoltaic cells:** Thin wafer of silicon or other material that emits electrons when struck by sunlight, thus generating an electrical current. Also solar cell.

**Pioneer community:** The first community to become established in a once-lifeless environment during primary succession.

**Plankton:** free floating micro-organisms. May be phytoplankton -plants or zooplankton - animals.

**Point source (of pollution):** Easily discernible source of pollution such as a factory.

**Pollution:** Any physical, chemical, or biological alteration of air, water, or land that is harmful to living organisms.

**Polychlorinated biphenyls (PCBs):** Group of at least 50 organic compounds, used for many years as insulation in electrical equipment. Capable of biological magnification. Disrupts reproduction in gulls and possible other organisms high on the food chain.

**Population:** A group of organisms of the same species living with a specified region.

**Population control:** In human populations, all methods of reducing birth rate, primarily though pregnancy prevention and abortion.

**Population crash:** Sudden decrease in population that results when an organism exceeds the carrying capacity of its environment.

**Population growth rate:** Rate at which a population increases on a yearly basis, expressed as a percentage.

**Population histogram:** Graphical representation of population by age and sex.

**Positive feedback:** Control mechanism in ecosystems and organisms in which information influences some process, causing it to increase.

**Potential energy:** Stored energy.

**Precipitation:** Water falling from the sky as rain, snow or ice.

**Predator** An organism that actively hunts its prey.

**Prey** Organism (e.g. deer) attacked and killed by predator.

**Primary air pollutant:** A pollutant that has not undergone any chemical transformation; emitted by either a natural or an anthropogenic source.

**Primary consumer:** First consuming organism in a given food chain. A grazer in grazer food chains or a decomposer organism or insect in decomposer food chains. Belongs to the second tropic level.

**Primary succession:** The sequential development of biotic communities where none previously existed.

**Primary treatment (of sewage):** First step in sewage treatment to remove large solid objects by screens (filters) and sediment and organic matter in settling chambers.

**Producer (autotrophic or producer organism):** One of the organisms that produces the organic matter cycling though the ecosystem. Producers include plants and photosynthetic algae.

**Productivity:** The rate of conversion of sunlight by plants into chemical-bond energy (covalent bonds in organic molecules).

**Pyramid of biomass:** Graphical representation of the amount of biomass (organic matter) at each tropic level in an ecosystem.
**Pyramid of numbers:** Graphical representation of the number of organisms of different species at each trophic level in an ecosystem.

**Radioactive waste:** Any solid or liquid waste material containing radioactivity. Produced by research labs, hospitals, nuclear weapons factories, and fusion reactors.

**Radioactivity:** Radiation released from unstable nuclei.

**Real price (or cost):** The price of a commodity or service in fixed dollars, that is, the value of a dollar at an earlier time. Helpful way to determine whether a resource has experienced a real increase in cost or whether higher costs are simply due to inflation.

**Reclamation:** As used here, the process of returning land to its prior use. Commonly to convert deserts, wetlands and other areas into habitable, productive land.

**Recycling:** A strategy to reduce resource use by returning used or waste materials from the consumption phase to the production phase of the economy.

**Relative humidity:** The amount of moisture in a given quantity or air divided by the amount the air could hold at that temperature. Expressed as a percentage.

**Renewable source:** A resource replaced by natural ecological cycles (water, plants, animals) or natural chemical or physical processes (sunlight, wind).

**Reserve:** Deposit of energy or minerals that is economically and geologically feasible to remove with current and foreseeable technology.

**Resource (in general):** Anything used by organisms to meet their needs, including air, water, minerals, plants, fuels, and animals.

**Resource (as a measurement of a mineral of fuel):** Total amount of a mineral or fuel on Earth. Generally, only a small fraction can be recovered. Compare with reserve.

**Restoration ecology:** Study of restoring ecosystems to their natural state after human interference. Also called conservation biology.

**Risk acceptability:** A measure of how acceptable a hazard is to a population.

**Risk assessment:** The science of determining what hazards a society is exposed to from natural and human causes and the probability and severity of those risks.

**Risk probability:** The likelihood of a hazardous event will to occur.

**Risk severity:** A measure of the total damage a hazardous event would cause.

**Salinisation:** Deposition of salts in irrigated soils, making soil unfit for most crops. Cause by rising water table due to inadequate drainage of irrigated soils.

**Saltwater intrusion:** Movement of saltwater from oceans or saltwater aquifers into freshwater aquifers, caused by depletion of freshwater aquifers of low predication or both.

**Sanitary landfill:** Solid waste disposal site where garbage is dumped and covered daily with a layer of dirt to reduce odours, insects and rats.

**Sclerophyll:** Plants with hard leathery leaves that contain oils.

**Scrubber:** Pollution control device that removes particulates and sulfur oxides from smokestacks

**Secondary consumer:** Second consuming organism in food chain. Belongs to the third trophic level.

**Secondary pollutant:** A chemical pollutant from a natural or anthropogenic sources that undergoes chemical changes as a result of reacting with another pollutant, sunlight, atmospheric moisture, or some other environmental agent.

**Secondary succession:** The sequential development of biotic communities occurring after the complete or partial destruction of an existing community by natural or anthropogenic forces.

**Secondary treatment (of sewage):** After primary treatment, removal of biodegradable organic matter from sewage using bacteria and other microconsumers in activated sludge or tickle filters.

**Selective cutting:** Restricted removal of trees. Especially useful for mixed hardwood stands. Contrast with clear-cutting and shelter-wood cutting.

**Sewage treatment plant:** Facility where human solid and liquid wastes from homes, hospitals, and industries are treated, primarily to remove organic matter, nitrates, and phosphates.

**Shelterbelts:** Rows of trees and shrubs planted alongside fields to reduce wind erosion and retain snow to increase soil moisture. May also be used to reduce heat loss from wind and thus conserve energy around homes and farms.

**Shelter-wood cutting:** Three-step process spread out over years: (1) removal of poor-quality trees to improve growth of commercially valuable trees and allow new seedlings to become establishes, (2) removal of commercially valuable trees once seedlings are established, and (3) cutting remaining mature trees grown from seedlings.

**Slash-and burn agriculture:** Farming practice in which small plots are cleared of vegetation by cutting and burning. Crops are grown until the soil is depleted; then the land is abandoned. This allows the natural vegetation and soil to recover.

**Sludge:** Solid organic material produced during sewage treatment.

**Smelter:** A factory where ores are melted to separate impurities from the valuable minerals.

**Smog:** Refers to a greyish haze (combination of smoke and fog) found in industrial cities.

**Soft path:** A term coined by Amory Lovins to describe such practices as conservation, efficient use of energy, and renewable energy systems such as solar and wind. Characterised by high labour intensity, decentralised energy production, and small-scale technology.

**Soil horizon:** Layers found in most soils.

**Solar collector:** Device to absorb sunlight and convert it into heat.

**Solar energy:** Energy derived from the sun (heat) and natural phenomena driven by the sun (wind, biomass, running water).

**Spaceship earth:** Metaphor introduced in the 1960s to foster a greater appreciation of the finite nature of Earth’s resources and the ecological cycles that replenish oxygen and other important nutrients.
**Speciation**: Formation of new species.

**Species**: A group of plants, animals, or micro-organisms that have a high degree of similarity and generally can interbreed only among themselves.

**Species diversity**: Measure of the number of different species in a biological community.

**Star**: Spherical cloud of hot gas, such as the sun, fuelled by nuclear fusion reactions in its core.

**Synergism**: An effect whereby two substances together have a greater impact.

**Technological fix**: A purely technological answer to a problem.

**Temperate deciduous forest**: Biome located in the eastern United States, Europe, and north eastern China below the taiga. Characterised by deciduous and non-deciduous trees, warm growing season, abundant rainfall, and a rich species diversity.

**Temperature inversion**: Alteration in the normal atmospheric temperature profile so that air temperature increases with altitude rather than decreases.

**Terracing**: Construction of small earthen embankments on hilly or mountainous terrain to reduce the velocity of the water flowing across the soil and thus reduce soil erosion.

**Tertiary treatment (of sewerage)**: Removal of nitrates, phosphates, chlorinated compounds, salts, acids, metals and toxic organic after secondary treatment.

**Thermal pollution**: Heat added to air or water that adversely affects living organisms and may alter climate.

**Thermodynamics**: The study of energy conversions. See the first and second laws of thermodynamics.

**Toxin**: A chemical, physical, or biological agent that causes disease or some alteration of the normal structure and function of an organism. Impairments may be slight or severe. Onset of effects may be immediate or delayed.

**Transpiration**: Escape of water from plants through pores (stomata) in the leaves.

**Tree farms**: Private forests devoted to maximum timber growth and relying heavily on herbicides, insecticides and fertilisers.

**Trophic level**: Describes the position of the organism in the food chain.

**Tropical rain forest**: Lush forest near the equator with high annual rainfall, high average temperature a notoriously nutrient poor soil. Possibly the richest ecosystem on Earth.

**Tundra (alpine)**: Life zone found on mountain tops. Closely resembles the arctic tundra in terms of precipitation, temperature, growing season, plants and animals. Extraordinarily fragile.

**Tundra (arctic)**: First major life zone or biome in south of North Pole.

**Ultraviolet (UV) light or radiation**: Electromagnetic radiation from sun and special lamps. Causes sunburn and mutations in bacteria and other living cells.

**Waste-to-energy plant**: Incinerator for rubbish that produces small amounts of electricity from heat given off by combustion.

**Water cycle**: See hydrological cycle.

**Water-logging**: High water table causing saturation of soils due to poor soil drainage and irrigation. Decreases soil oxygen and kills plants.

**Watershed**: Land area drained by a given stream or river.

**Water table**: Top of the zone of saturation.

**Watt**: Unit of power indicating rate at which electrical work is being performed.

**Wave power**: Energy derived from sea waves.

**Wetlands**: Land areas along fresh water (inland wetlands) and salt water (coastal wetlands) that are flooded all or part of the time.

**Wilderness**: An area where the biological community is relatively undisturbed by humans. Seen by developers an untapped supply of resources such as timber and minerals, seen by environmentalists as a haven from hectic urban life, and an area for reflection and solitude.

**Wind energy**: Energy captured from the wind to generate electricity or pump water. An indirect form of solar energy.

**Wind generators**: Windmills that produce electrical energy.

**Zero population growth**: A condition in which population is not increasing; the population growth rate is zero.