A local ecosystem

Part 1: Abiotic and biotic factors
You are about to start a module on ‘A local ecosystem’. In this first part of the module you will be looking at the living and the non-living parts of the ecosystem and how we measure them.

You will need the following items for the practical exercises in this part.
- a 4 metre length of string
- four wooden pegs or a quadrat

In this part you will be given opportunities to learn to:
- compare the abiotic characteristics of aquatic and terrestrial environments
- identify the factors determining the distribution and abundance of a species in each environment
- examine trends in population estimates for some plant and animal species within an ecosystem.

In this part you will be given opportunities to:
- process and analyse information obtained from a variety of sampling studies to justify the use of different sampling techniques to make population estimates when total counts cannot be performed

We live in a world of finite resources. We have used the natural environment of the Earth as if we are the only species to have the right. Our increasing population has stretched the Earth’s resources to a point where we must look at our uses of the environment and ensure that our activities are sustainable. We would like future generations to have equal access to the natural resources of the Earth.

In this module of your Biology course, you will be looking at your own local ecosystem. It is here that you can have the most effect. You will be able to draw on your existing knowledge of a local ecosystem and expand your understanding of biological concepts. An important part of this work is to carry out a field study. Throughout the unit you will carry out exercises that will prepare you for this activity. When you are about to do an activity that forms part of your field study you will see this icon.

Have a look at the field study scaffold that is included with this week’s work. This scaffold helps to set out the written report in a scientific style. You will be filling in the tables of the report as you go through the module.

Start thinking about an area that you can study. Choose one that is convenient for you and one that is safe to visit. Write a short paragraph describing your initial thoughts of this local ecosystem.

_________________________________________________________

_________________________________________________________

_________________________________________________________

_________________________________________________________

_________________________________________________________
What is an ecosystem?

Let’s start with a definition of an ecosystem.

An ecosystem is made up of groups of organisms and the non-living environment interacting together as a complex self-sustaining natural system.

The four important points of this definition are
• groups of organisms
• the non-living environment
• interacting together
• self-sustaining.

We study ecosystems because they allow us to investigate major interactions, cycles and living populations. However you might notice that the most difficult part of this definition is the term self-sustaining. There is always a degree of interaction between ecosystems. Some examples of ecosystems are rainforests, heathland, grassland, mangrove swamps, ponds, lakes, forests, and deserts. The photographs below show examples of different ecosystems.

Heathland
Look closely at the photographs above. Each has a group of organism that are interacting together with the non-living environment and they are mostly self-sustaining.
Your backyard can be considered an ecosystem especially if you don’t add extra water and fertiliser.

A small backyard pond

The photograph above shows a small backyard pond. It has a group of organisms living in it and it is interacting with the non-living environment. It is self-sustaining. It therefore fits the definition of an ecosystem. This would make a suitable small ecosystem to study. When deciding on your study area consider the possibility of working on a small ecosystem as well as the more obvious larger ecosystems.

**Biotic and abiotic factors**

Another way of naming the organisms and the non-living environment is with the terms *biotic* and *abiotic*.

You may recall the terms biotic and abiotic (‘a’ means ‘without’) from your previous studies. If not try to predict the meaning of the terms in the space below.

Biotic: ____________________________________________________________

Abiotic: ____________________________________________________________
Answer: Biotic: the living organisms in the ecosystem, such as plants and animals
Abiotic: the non-living part of the ecosystem for example, soil, light, heat, and air.

The environment of any organism consists of both biotic and abiotic factors interacting.

Let’s have a look at more examples of biotic and abiotic factors.

Here is a list of some abiotic and biotic factors of ecosystems.

- Chemical factors – water, oxygen, nitrogen, carbon dioxide, pH, salinity
- Physical factors – light, temperature, humidity, tide, wind
- Plants – grasses, algae, shrubs, trees
- Animals – micro-organisms, fish, birds, reptiles, mammals
- Fungus – yeast, mushrooms, toadstools
- Bacteria – Rhizobium sp, Escherichia coli

Place these factors into the table to indicate whether they are biotic or abiotic. The first one is done for you.

<table>
<thead>
<tr>
<th>Biotic</th>
<th>Abiotic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>salinity</td>
</tr>
</tbody>
</table>

Answers: Abiotic: Chemical (water, oxygen, nitrogen, carbon dioxide, pH, salinity) and physical factors (light, temperature, humidity, tide, wind) Biotic: Plants, animals, fungus, bacteria.
By now, you will have a good understanding of what biotic and abiotic factors are. Think about your local ecosystem study and list some of the biotic and abiotic factors that you could look for on the lines below.

Abiotic: _________________________________________________
________________________________________________________
________________________________________________________
________________________________________________________

Biotic: __________________________________________________
________________________________________________________
________________________________________________________
________________________________________________________

Below is a drawing showing some of the factors within a pond ecosystem.

The drawing shows biotic and abiotic factors. Indicate with a tick in the table below whether they are biotic or abiotic.
<table>
<thead>
<tr>
<th>Feature</th>
<th>Biotic</th>
<th>Abiotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>air and water temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>water plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>water beetle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dissolved oxygen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>microscopic algae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>water bird</td>
<td></td>
<td></td>
</tr>
<tr>
<td>frog</td>
<td></td>
<td></td>
</tr>
<tr>
<td>presence of water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dragonfly</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Answers: Abiotic: Air and water temperature, pH, light, dissolved oxygen, presence of water
Biotic: Fish, water plants, water beetle, microscopic algae, water bird, frog, dragonfly.

Other abiotic factors in this pond are:
- **viscosity**  ‘thickness’ of the medium
- **buoyancy**  upthrust of the medium
- **pressure**  weight of medium pressing down
Abiotic factors of ecosystems

We can divide ecosystems into two basic types, aquatic (water) and terrestrial (land). As is often the case in Biology when we make a sweeping distinction there are always exceptions to the rule. There are ecosystems that are difficult to classify as terrestrial or aquatic such as mangrove swamps and rock platforms.

As you have seen, important abiotic factors are:
- water and dissolved ions
- light
- temperature
- pH
- gases such as oxygen and carbon dioxide
- viscosity
- buoyancy
- pressure
- salinity

Now you will examine how each of these is different in a terrestrial and aquatic environment.

Living on land has many challenges. Firstly there is the problem of support. In an aquatic ecosystem the buoyancy (uplift) of water means that aquatic animals and plants do not need a rigid support system. A water plant has less supporting tissue than a land plant. The backbone of a land mammal is greater than a similarly sized aquatic mammal.

Water is more viscous (thicker) than air. If you have walked through water you would have found it hard going compared to walking through air. Aquatic animals have a streamlined shape to overcome the viscosity of water.

The next challenge is obtaining water. Water is necessary for life. In the aquatic environment the organism is surrounded by water, while on land this may be in short supply. The amount of water is dependent on rainfall, wind, temperature, and humidity. Many terrestrial animals have adaptations to overcome the lack of water in their ecosystems.

Temperature varies greatly in a terrestrial environment, during the day, through the seasons, as well as with altitude and latitude. In an aquatic environment the changes in temperature are less. Large bodies of water
experience small changes in temperature. A small puddle or a rock pool would have a greater range of temperature as they heat up during the day.

Water transfers heat faster than air. When swimming you will notice how cold you get after a period of time in water. This is why divers wear wet suits. Aquatic mammals have blubber to retain the heat in their bodies.

**Pressure** is not a problem for terrestrial animals. If you climb a mountain, you do have to take into account both the reduction in oxygen and the reduction in air pressure. In the aquatic environment there are rapid increases in pressure with depth. Even if you go to the bottom of a diving pool you can feel the effect of pressure on your ears. Organisms need special adaptations to survive the pressure in the depths of the ocean.

*Light* and *gases* are more readily available in the terrestrial environment than in the aquatic environment. There is no shortage of carbon dioxide and oxygen in the terrestrial ecosystem but in water a shortage of oxygen can be a problem. In water, the amount of oxygen that is available depends on water temperature and whether the water is fresh or salt. As the temperature of water increases, the amount of dissolved oxygen decreases. There is often more oxygen at the surface of water than at the bottom. Light is reduced as you go deeper in water both in quantity and quality.

The **pH scale** is a measure of the acidity of a substance. Most organisms live in a neutral pH of around 7. Acid rain on land and the effect of acid sulfate soils on water can produce conditions that can kill organisms.

**Summary of abiotic factors of terrestrial and aquatic ecosystems**

<table>
<thead>
<tr>
<th>Abiotic factor</th>
<th>Terrestrial</th>
<th>Aquatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>water and ions</td>
<td>Varies greatly from deserts to swamps. Some soils are rich others, poor.</td>
<td>Readily available</td>
</tr>
<tr>
<td>light</td>
<td>Readily available</td>
<td>Intensity and wavelength varies with depth of the water</td>
</tr>
<tr>
<td>temperature</td>
<td>Very varied both as you move through the seasons and through latitude and altitude</td>
<td>Less variation in oceans, decreases with depth</td>
</tr>
<tr>
<td>gases (oxygen and carbon dioxide)</td>
<td>No shortage of gases Availability decreases with altitude.</td>
<td>Oxygen availability is low and gas solubility decreases with an increase in temperature</td>
</tr>
<tr>
<td>viscosity</td>
<td>Less than water</td>
<td>High viscosity</td>
</tr>
<tr>
<td>buoyancy</td>
<td>Little support from the air</td>
<td>Water supports body weight</td>
</tr>
<tr>
<td>pressure</td>
<td>Decreases with altitude</td>
<td>Greatly increases with increasing depth</td>
</tr>
</tbody>
</table>
Biotic factors of an ecosystem

You have examined some of the abiotic factors of an environment. Now you will focus on the biotic factors.

Animal and plant species are not found scattered randomly throughout the environment. Each species has a preferred part of the ecosystem. This distribution of animals and plants is dependent on the conditions that prevail. To survive in any ecosystem an organism must be adapted to cope with the physical conditions. A fish cannot survive for long out of water. A rainforest plant cannot survive long in a desert environment. A desert or an estuary has extreme conditions that few species can live in while a forest has many different species competing for resources. The distribution of an organism depends on the requirements for living that each species possess.

Abundance is a term used to describe how many organisms are in the population at a certain time and in a certain place.

Populations will increase in number until they are confronted by a limiting factor. Limiting factors include:

- lack of space
- predators
- disease
- competition for food between members of the same species
- competition from members of other species
- physical factors (weather conditions).

For each limiting factor there is a zone of optimum characteristic. This is the preferred zone for an organism. Moving away from the optimum, there is a zone where the organism would be under stress. Further from the preferred zone there is death or avoidance. For example, many organisms have a preferred temperature. Most of the organisms would be found in the area with the optimum temperature. There would be some living on the fringes with limited survival. This would decide the distribution (range) of the species. The distribution of a species is where it is found. A species can have a high abundance and a small distribution, an example in the garden might be high numbers of stinkbugs on a citrus tree. Alternatively, the distribution can have low abundance but a large distribution—for example, small numbers of blue whales in the ocean.
The abundance of a species is often not a random occurrence. It is a result of the abiotic and biotic factors interacting in the ecosystem.

**Distribution and abundance**

To illustrate this you will focus on examples from a terrestrial and an aquatic ecosystem that show how abiotic factors determine the distribution and abundance of a species.

**Terrestrial environment**

The example that you will study is the distribution and abundance of plants in a rainforest and in the marine ecosystem.

**Photosynthesis** is the source of energy for most ecosystems.

Plants capture sunlight through chlorophyll molecules and use this energy to drive the series of chemical reactions that split water and form carbohydrates. It is these carbohydrates that all animals use as a source of energy input for the process of **respiration**.

To carry out photosynthesis a plant requires carbon dioxide, water, light and mineral ions. Usually carbon dioxide, light and mineral ions are easily
obtained from the terrestrial environment. The limiting factor is often water. In this example of a rainforest light may be the limiting factor.

If you have ever visited a rainforest you will know that it is dark and damp. There is plenty of water and carbon dioxide and there is a cycling of mineral ions. The struggle for existence is seen in the competition for light. In the canopy, trees have access to light and grow rapidly. On the forest floor the light reaching the plants is filtered by the leaves above. The plants at ground level use different photosynthetic pigments to the plants of the canopy. In the canopy the main pigment used is chlorophyll a. In the understorey the main pigment used is chlorophyll b. The forest floor in a rainforest is often fairly bare. If you look at the plants that grow on the forest floor you will notice they have large dark leaves. These are designed to capture as much of the available light as possible. If a tree falls allowing light to reach the forest floor there is a rapid growth of plants to use the available light. Light is the limiting factor for plants growing on the floor of a rainforest.

In the table on the next page is a summary of the abiotic factors in a rainforest.
Summary of abiotic conditions in a rainforest

<table>
<thead>
<tr>
<th>Part of rainforest</th>
<th>Light (as %)</th>
<th>Wind (km/hr)</th>
<th>Humidity (as %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest floor</td>
<td>0</td>
<td>0</td>
<td>98</td>
</tr>
<tr>
<td>Understorey</td>
<td>15</td>
<td>6</td>
<td>80</td>
</tr>
<tr>
<td>Sub-canopy</td>
<td>50</td>
<td>10</td>
<td>70</td>
</tr>
<tr>
<td>Canopy</td>
<td>100</td>
<td>18</td>
<td>65</td>
</tr>
</tbody>
</table>

From the information above describe the different conditions that occur at the four levels of a rainforest in terms of light, wind and humidity.

Forest floor: ______________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________

Understorey: ______________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________

Sub-canopy: ______________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________

Canopy: _________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________

Check your answers.
The abiotic conditions that occur in a rainforest control the distribution of plants in that environment. Many plants grow as epiphytes. This means that they grow on another plant. They are adapted to low light. Examples of epiphytes are orchids and ferns. Bird’s nest fern (*Asplenium australasicum*) is a shade tolerant species that is found in the branches of trees in rainforests.

![Bird’s nest fern (*Asplenium australasicum*)](image)

**Aquatic environment**

In an aquatic environment the majority of plants are microscopic algae called *phytoplankton*. These plants form the basis of life in the oceans. Plants capture sunlight through chlorophyll molecules and use this energy to drive a series of chemical reactions that split water and combine with CO₂ to form carbohydrates.

Plants in an aquatic environment have plenty of water, mineral ions and carbon dioxide. Their main limiting factor is light. As you go deeper into the ocean, two things happen to the light:

- The amount of light or the intensity of the light decreases.
- Different wavelengths of light are absorbed.

If you have ever gone underwater, you will know that as you go deeper the amount of light at the surface quickly begins to diminish. If you were to go deep enough you would reach a point where no light penetrates. At this point plants can no longer carry on photosynthesis.
This is reflected in the distribution of phytoplankton. Phytoplankton are found in the surface waters of the oceans to a depth of about one hundred metres. Some algae have been recorded at depths of 150 metres but their rate of growth is slow.

The depth to which plants can grow in aquatic environments is determined by the light penetration. The light has to be sufficient to allow photosynthesis to occur. Different species of plants require different amounts of light.

To illustrate this you will draw a graph of photosynthetic rate against light intensity. Below are some guidelines for drawing a graph.

**Drawing a graph**

Data can be presented in different ways to make interpretation easier. Tables are useful to bring information into an ordered form. Graphs are useful to give a visual representation. Choosing the correct graph type can make the information easier to understand.

A line graph is used when one of the variables (the independent variable) affects the other, the dependent variable. The independent variable is often time. In the example below, the independent variable is time and the dependent variable is the population.
Hints on drawing a graph

Look at the graph above and tick off the following points below to make sure that the graph is drawn correctly:

1 Labelling is important. Make sure the graph has a title and that both axes are named and include the units that were used for measurement. The axes should be linear.

2 Unless asked to, do not extrapolate (add extra numbers beyond the graph that you have not measured).

3 If there is a direct relationship between the two variables and there are no outlying points, then draw a line through the points.

4 If the points are scattered but there is an overlying relationship, use a line of best fit.

5 The independent variable should go on the horizontal (x) axis.

6 The dependent variable should be on the vertical (y) axis.

Now it’s your turn.

Graphing exercise

Graph the relationship between light intensity and the rate of photosynthesis from the table below.

Light intensity vs photosynthetic rate

<table>
<thead>
<tr>
<th>Light intensity (Units of light intensity)</th>
<th>Rate of photosynthesis (mm³CO₂/cm²/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>80</td>
</tr>
<tr>
<td>7</td>
<td>80</td>
</tr>
</tbody>
</table>
Graph showing rate of photosynthesis against light intensity

From your graph at what light level does the rate of photosynthesis level off?

Drawing a graph is a useful skill. Scientists use computer programs to draw graphs for their research reports but understanding how to draw a graph by hand is still useful.

You have examined the distribution of plants in two different environments. In both the aquatic and terrestrial environments you have seen that light can be the abiotic factor that determines distribution of plants. In the aquatic environment phytoplankton are found only in the surface waters where light is available for photosynthesis. In rainforests some plants can live on the shady forest floor or in the branches of trees because they can photosynthesise in reduced light conditions.

Each species inhabits an area that it can tolerate. Once conditions change past the level of tolerance, the species can no longer live in that area.

If you look around a garden you will notice that certain plants grow only in certain areas. Some plants live in full sun; others are found in damp shady areas for example, mosses.
Moss plants with spore capsules growing in a damp part of the garden

If you want to find slaters or worms, you need to look in dark shady areas. These animals will actively avoid areas of full sunlight.

Have a break now and go outside and see if you can find an example of a plant and animal that is found only in a particular part of the garden. Examine the plants. Look for any evidence that the plants have been eaten and look for diseases such as spots and galls. You thought about an area to study at the start of this module. Go back now and read what you wrote and decide if your choice was appropriate.
Ecosystem measurement

While it is useful to list the biotic and abiotic factors of the ecosystem a major part of this module is how to measure the abiotic and biotic factors.

**Measuring abiotic factors**

When you investigate your local ecosystem, you will have to measure some of the abiotic factors. The photograph below shows a datalogger.

An example of a datalogger attached to a graphic calculator

A datalogger is a useful instrument that you can take on a field study. It will gather data that can be taken back to a computer and analysed.
The datalogger can have different probes attached. Each probe collects data on a specific feature. Most dataloggers can have several probes to collect data simultaneously. For example, you could program your datalogger to measure the abiotic factors:

- water temperature
- dissolved oxygen
- pH.

The datalogger can gather information as often as you like. You can leave the datalogger in your ecosystem collecting data while you are away. A datalogger makes it easy to collect data on abiotic factors. Other methods of gathering information on abiotic factors will be discussed later in the unit.

When recording abiotic data it is important to record the units of measurement. Without the correct units the results are meaningless.

### Measuring biotic factors

#### Sampling

When studying a population it is important to determine the size of the population (abundance) and the distribution (range) of the population. How can we measure a population?

The answer is not to count every individual but to sample the population.

> A population can be defined as the number of organisms living in a certain area at a certain time.

#### Justification for using sampling

The numbers of organisms in a population is always changing. Although we talk about an ecosystem being balanced, we should be thinking in terms of a dynamic (changing) equilibrium. The numbers of organisms in an ecosystem would be changing each time that an organism had a meal.

It is important to be able to monitor the fluctuating numbers in a population. As it is nearly impossible to count every organism in an
ecosystem, there are several methods that are used to estimate the population. Sampling is carried out when it is not possible to count every individual in a population. A small area is counted in detail and then multiplied to get an estimate for the whole area.

**Methods of sampling**

We will look at the following methods of sampling

- transects (lines)
- random quadrat (squares)
- capture/recapture (capture-marking-recapture).

**Transects**

A **transect** is a straight line. Usually a string is laid across an area and the organisms along the line are recorded. A transect is used to sample plant populations but can also be useful for animals especially if they are attached to one spot, for example, barnacles on a rock platform.

![Barnacles and Nodilittorina (Small periwinkle)](image.jpg)

The organisms that lie on the transect line or string are recorded. There are three ways of recording the organisms along the transect:

- Points are marked off at regular intervals and the organisms that touch the string at that point are recorded.
- Continuous sampling along a transect records every organism that touches the string.
- The transect can be a designated width either side (for example, a 1 metre strip) of the line transect.

Transects are particularly good for studying the changing distribution of plants. As the abiotic factors change so does the vegetation. A transect is a good way of monitoring the change.

Example of point sampling

Example of continuous sampling

Another example of using the transect method is spotlighting along a track for possums and gliders.
Random quadrats

This is a useful method for estimating the numbers of plants. It suits any population that does not move around. If you wanted to estimate the number of dandelion plants on an oval, it would be a waste of time to physically count every plant. To overcome this problem you can make an estimate using a quadrat (pronounced kwod-rat).

As the name suggests, a quadrat is usually a square but it can be any shape. A good size is a metre by a metre. The size depends on the organisms that you are counting. You can make one of these with four wooden stakes and some string.

A quadrat is placed randomly in an area and the number of organisms is counted in the square. This is then repeated several times and an average is taken. Then the size of the whole area is measured and multiplied by the average from the quadrat results. The quadrats are placed at random. You can count the actual numbers of each plant or work out a percentage cover for each species. It is necessary to take enough samples to have a reasonable estimate of the population.

Sample size

When studying an area you have to make a decision on

- the size of your quadrat
- the number of quadrats that you take.
The more quadrats that you take, the more accurate your results will be—but the effort to take the sample increases. There has to be a balance between the two, effort and accuracy. In the field, you can pre-sample to decide on the best size for a quadrat. If you try different-size quadrats, you can test for any significant difference between the sizes. This will help you to decide on the best quadrat size.

Before you start counting you have to decide on the criteria for counting.
• You can count the organisms that are completely within the quadrat.
• Only count along two edges of the quadrat.
• Count an organism if any part of it lies within the quadrat.

Here are three quadrats taken from a lawn. Count the number of small plants in each and record in the table below.

<table>
<thead>
<tr>
<th>Quadrat</th>
<th>Number of plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>quadrat 1</td>
<td></td>
</tr>
<tr>
<td>quadrat 2</td>
<td></td>
</tr>
<tr>
<td>quadrat 3</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td></td>
</tr>
</tbody>
</table>

Answer: 5, 8, 10, 23
Average

Work out the average by dividing the total number by the number of samples.

Average = \( \frac{23}{3} = 7.7 \) plants per square metre.

The total area of the three samples is 3 square metres. The total number of plants is 23. Therefore, the average is 23 divided by 3, which is 7.7. Therefore, there are 7.7 plants per square metre.

If the entire lawn measured 10 metres by 10 metres, the total area for the lawn would be \( 10 \text{ m} \times 10 \text{ m} = 100 \text{ sq metres} \)

If the average per square metre was 7.7, for the whole lawn you would estimate that there were;

\( 7.7 \times 100 = 770 \) small plants

This is an estimate for the number of small plants for example, dandelions in the lawn.

Practical activity

Now I want you to carry out the above experiment.

Estimating using the random quadrat method

You will need a 4 metre length of string and four wooden pegs or a quadrat.

If you have a garden available, use the lawn for the following practical.

1. Select at random a spot on the lawn. You can do this by throwing a stick over your shoulder and starting one of your corners of the quadrat from where the stick lands.

2. Select a plant that you can recognise, such as dandelion, bindi-eye, clover. (It doesn’t matter if you don’t know the name just as long as you can recognise it.)

3. Make your quadrat using the four pegs and the string. A good size is a metre x a metre but a smaller quadrat is acceptable. Whatever size you use, make sure that you can work out the area of your quadrat.

4. Count the number of your chosen plants in the square.

5. Repeat so that you have 10 measurements.

6. Work out the average number of your plant in your samples.
<table>
<thead>
<tr>
<th>Quadrat number</th>
<th>Number of plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>

Total number of plants = 
Average number = \[\text{ } \] / 10
This gives you the density of your plants.

7 You can now work out the total number of plants in the lawn by multiplying the density by the total area. Measure or estimate the size of your area (multiply the length by the breadth).

Length of area =
Width of area =

Area in square metres =
Multiply the area by the average number of plants in a quadrat.
This will give you an estimate of your chosen plant.

Chosen plant per square metre =
Write an experimental report on this practical exercise. Include in the conclusion of the report how good an estimate you have made. You may like to use the format for your report that is on the next page.
Report Title

Write a name for the experiment

Aim:

What did you set out to achieve?

Method:

What you actually did.

Results:

What did you find out?

Conclusion:

Did you achieve your aim?
**Percentage cover**

In some cases when you are investigating an ecosystem it is more useful to record the percentage cover rather than the actual number of organisms. A very small but dense plant is very difficult to count.

Again you can use a quadrat to estimate the abundance of this type of plant or animal. This time the quadrat is divided into a grid using string.

To work out the percentage cover you have to count the number of squares that are covered by the plant. If the plant doesn’t cover an entire square, you have to estimate the percentage of squares covered.

Work out the percentage cover of the small plant from the following plan diagram.

![Small plant diagram](image)

total number of squares =

number of squares covered =

percentage cover = \( \frac{\text{number of squares covered}}{\text{total number of squares}} \times 100 \)

= x 100

= %
Check your answer.

Capture/recapture

While it is relatively easy to count the number of trees in an area, counting animals presents different problems. Animals move around. If you sat and counted animals you could easily be counting the same animal more than once. By tagging and marking animals it is possible to work out an estimate of the population. During this module the term capture/recapture will be used. You should be aware that the term capture/tag/recapture can also be used.

Fish not only move around but also are difficult to see from the surface. If you caught every fish in an area you would know the population exactly, but you would have many dead fish. Using capture/recapture, large numbers of fish can be tagged and then released back into the population. If you know how many fish you have tagged, you can work out the total number of fish by looking at the number you recapture each time.

For example, in a lake 30 fish are tagged and then released. After time for the fish to disperse the fish are recaptured. If there are 10 tagged fish out of every one hundred fish caught, the total number in the population can be estimated using the following formula:

Population size = \( \frac{\text{number of animals tagged} \times \text{number of animals recaptured}}{\text{average number of tagged animals recaptured}} \) or \( N = \frac{M \times n}{m} \)

where

\( N \) = the population size
\( M \) = number of captured tagged and released organisms
\( m \) = the average number of tagged animals recaptured
\( n \) = number sampled the second time (tagged and untagged)

\( N = \frac{30 \times 100}{10} = \frac{3000}{10} = 300 \) fish in the total population
There are problems with this method. If you are not careful with your tagging method you could cause the death of the animals that you tag. The tag may make the animal more likely to be caught by a predator. This could then affect your result. When using traps to catch small mammals such as marsupial mice some of the animals become trap-shy and will not return to be captured. Others ‘enjoy’ the experience and return often to take the bait offered.

Other examples of tagging methods are leg bands on birds, paint spots on shellfish, colouring fur, and ear tags.

For the next activity you will need:

- two colours of beads or lollies, approximately thirty of one colour and ten of the other
- a container to hold them

**Practical activity**

**Model of capture/recapture**

**Aim**

The aim of this experiment is to model the method of capture/recapture.
Method

To do this you will need to collect two sets of different-coloured beads, buttons or lollies. You will need 10 of one colour (this represents the tagged animals) and about 30 of the other colour (untagged animals).

Place the beads into a container together and make sure they are mixed up. Next draw out 10 beads and record how many of colour 1 you have in your sample. Return them and then repeat your sampling so that you have ten samples.

Results

Record the results in the table below.

<table>
<thead>
<tr>
<th>Number of first colour</th>
<th>Number of second colour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

Population size = \( \frac{\text{number of animals tagged} \times \text{number of animals recaptured}}{\text{average number of tagged animals recaptured}} \) or

\[ N = \frac{M \times n}{m} \]

where

\( N = \text{the population size} \)
Part 1: Abiotic and biotic factors

\[ M = \text{number of captured tagged and released organisms} \]
\[ m = \text{the average number of tagged animals recaptured} \]
\[ n = \text{number sampled the second time (tagged and untagged)} \]

• Calculate the average number of the first colour.

To do this add the total of each colour and then divide by ten.

Total of first colour = 

Average of first colour \((m)\): \(\frac{\text{total of first colour}}{10} = \)

• Calculate the total population using the formula.

\[ N = \frac{M \times n}{m} \] where

Where \( M = 10 \)
\[ n = 10 \]

• Count the actual number of beads to check your estimate.

**Conclusion**

How close were you to the correct answer? ________________

________________________________________________________________________________________

If you weren’t close can you think of any reasons why? _____________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

Name an animal population you could count by this method. ______

________________________________________________________________________________________

________________________________________________________________________________________

Could you count a plant by this method? ________________

Answer Exercise 1.3

For a look at some virtual environments go to the Biology Website under the heading Virtual ecosystems.

http://www.lmpc.edu.au/science
Advantages and disadvantages of sampling methods

The main advantage of a sampling method is that often it would be impossible to count every organism in a population. Even in the cases when it would be possible to count every individual, it would be time-consuming and expensive to do. It could also be a disruptive process to a population.

The disadvantages to this method are that the accuracy can never be 100%. Some methods of sampling lead to the death of the organism thus the act of sampling can have an effect on the population. Organisms move out of the area that you are sampling and would therefore never be recaptured.

Draw a table showing the advantages and disadvantages of sampling methods. Use the information above and try to think of some other disadvantages. Think about your own experiences and add these as well.

<table>
<thead>
<tr>
<th>Advantages of sampling</th>
<th>Disadvantages of sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From the table you have created, write an exposition.

The title of the exposition will be that sampling is a good method of estimating population numbers. Following there is a scaffold for an exposition. Use this or if you feel confident write an exposition without the scaffold.

**Exposition scaffold**

The function of exposition is to influence or persuade the reader.

**State your position:**

Sampling is a good method of estimating a population when total counts cannot be performed.
Examining trends in a population

When you examine trends in a population you can see if the population is increasing or decreasing. An example of a population that has shown varying trends is a species of fish called gemfish. During the 1970’s the gemfish fishery was developed. Throughout the decade the number of fish caught increased. Gemfish was a popular and inexpensive fish to buy during this period. Gemfish were caught while they were aggregating for
migration and spawning. They are a large fish that grows to a length of 1.3 metres.

The catch peaked at over 5000 tonnes per year but falling catch rates and fish sizes made it necessary to set a zero total allowable catch (TAC) in 1993. This stopped all fishing for this species. The population is slowly recovering but is thought to be 40% of the level it was during the 1970s.

This example shows how important it is to examine population trends.

Animals are not the only organisms that show trends in population estimates within an ecosystem. An example of a plant that has shown trends in population estimates are seagrasses. These plants are unusual because they live in saltwater but they are not algae. They are flowering plants. The population estimates of seagrasses are based upon their distribution. By mapping seagrasses on the coast of NSW it is possible to see that there has been a reduction over time in the population of these plants. Aerial photographs are a good way of estimating the population and recording differences over time.

Answer Exercise 1.4

Optional

In the syllabus, you are asked to examine trends in population estimates for some plant and animal species within an ecosystem.

The local area that you are studying changes during the year and changes with time. If you could study the same area in twenty years time, you would find differences. At different times of the year, you would find different organisms present. For example, some insects have breeding cycles that only occur during the summer.

This could be your open-ended investigation for the Preliminary course. Estimate a population in your local area and then return and repeat the sampling later.
An ecosystem is made up of groups of organisms and the non-living environment interacting together as a complex self-sustaining natural system. It is made up of abiotic (non-living) and biotic (living) factors.

Examples of abiotic factors are:

- Chemical factors – water, oxygen, nitrogen, carbon dioxide, pH, salinity
- Physical factors – light, temperature, humidity, tide, wind.

Examples of biotic factors are:

- Plants – grasses, algae, shrubs, trees
- Animals – micro-organisms, fish, birds, reptiles, mammals
- Fungus – yeast, mushrooms, toadstools
- Bacteria – *Rhizobium* sp, *Escherichia coli*

Distribution and abundance of organisms are controlled by the biotic and abiotic factors. Measuring abiotic factors can be done with a datalogger. Measuring biotic factors is done by sampling. Methods of sampling are transects, quadrats and capture/recapture. There are advantages and disadvantages to using sampling. Monitoring trends in populations is an important activity.
Characteristics of a rainforest

From the information above describe the different conditions that occur at the four levels of a rainforest in terms of light, wind and humidity.

**Forest floor**  High humidity 98%, low light 0% and no wind 0%.

**Understorey**  Receives 15% of light, the wind is low at 6 km/hr and the humidity is high at 80%.

**Sub-canopy**  A reasonable amount of light, 50%, high wind at 10 km/hr and a lower humidity of 70%.

**Canopy**  Very high light 100%, high wind 18 km/hr and low humidity 65%.

**Percentage cover**

Rough estimate

total number of squares = 10 x 10 = 100

number of squares covered = 3 + 2 + 2.5 + 4 = 11.5

percentage cover = \( \frac{\text{number of squares covered}}{\text{total number of squares}} \times 100 \)

= \( \frac{11.5}{100} \times 100 \)

= 11.5 %
Environmental factors

Exercise 1.1

Aquatic and terrestrial ecosystems have different abiotic characteristics. Choose three of the following and say how they are different in the two environments: light, temperature, viscosity, buoyancy, water and ions, pressure, gases.

_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
Exercise 1.2

a) When ecologists study a population of plants or animals they often want to know the abundance of the population being studied. This is especially true when studying endangered species. Different methods of sampling are used to estimate populations. Name three methods of sampling and then justify the use of sampling to make population estimates.

b) You are studying a rock platform and it is your job to estimate the number of barnacles on the rock platform. You take 10 quadrats randomly and get the following results:

2, 4, 19, 3, 8, 6, 10, 7, 8, 9.

If the rock platform is 10 000 square metres in area, what is your estimate for the population of barnacles?
Exercise 1.3

Capture/recapture

An ecologist wants to know the possum population in a nearby eucalyptus forest. She captures 30 possums and tags them. She releases them and after a two-week period she takes 3 samples of 20 possums. The results of the re-sampling are below

<table>
<thead>
<tr>
<th>Sample</th>
<th>Tagged possums</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

a) Calculate the size of the total population.

Predict what would happen if you:

i resample immediately

ii wait a year to resample
b) List four ways to tag an animal.

________________________
________________________
________________________
________________________

c) On a rock platform an ecologist wants to estimate the number of barnacles per square metre. Ten random quadrats were selected and counted. The results are below.

<table>
<thead>
<tr>
<th>Quadrat</th>
<th>No of barnacles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>114</td>
</tr>
<tr>
<td>6</td>
<td>32</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>

Work out the density per square metre (average).
Exercise 1.4

A fish species is commercially harvested. The following statistics for the population were gathered.

**Gemfish catch/year**

<table>
<thead>
<tr>
<th>Year</th>
<th>Gemfish (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>500</td>
</tr>
<tr>
<td>1977</td>
<td>700</td>
</tr>
<tr>
<td>1978</td>
<td>750</td>
</tr>
<tr>
<td>1979</td>
<td>2000</td>
</tr>
<tr>
<td>1980</td>
<td>2100</td>
</tr>
<tr>
<td>1981</td>
<td>5100</td>
</tr>
<tr>
<td>1982</td>
<td>4500</td>
</tr>
<tr>
<td>1983</td>
<td>4500</td>
</tr>
<tr>
<td>1984</td>
<td>4000</td>
</tr>
<tr>
<td>1985</td>
<td>3200</td>
</tr>
<tr>
<td>1986</td>
<td>2900</td>
</tr>
<tr>
<td>1987</td>
<td>500</td>
</tr>
<tr>
<td>1988</td>
<td>0</td>
</tr>
</tbody>
</table>

Examine the trend in the population estimate. Would you suggest that the fishing of this species should continue? Explain.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Graph the table of gemfish catch.