The Study of an Ecosystem

(Prescribed Activities)

IDENTIFY ANY FIVE FAUNA AND ANY FIVE FLORA USING SIMPLE KEYS. IDENTIFY A VARIETY OF HABITATS WITHIN THE SELECTED ECOSYSTEM

Materials/Equipment
Hand lens
Forceps
Ruler
Suitable container(s)
Identification keys

Procedure
1. Familiarise yourself with all procedures before starting.
2. Name the selected ecosystem.
3. Draw a map/sketch or give a written description of the selected ecosystem.
4. Identify any five fauna in the selected ecosystem, using an identification key.
5. Note the habitat in which each organism was found.
6. Note an adaptation of any organism.
7. Record results.
8. Repeat this procedure to identify any five flora in the selected ecosystem.
9. Carefully return any collected fauna to where they were found.

Result

Map/sketch/written description of selected ecosystem:

Identified organisms:

(a) Fauna

Organism name	Habitat	Adaptation

(b) Flora

Organism name	Habitat	Adaptation

Conclusion/Comment

SKILL ATTAINMENT

Identify any five fauna and any five flora using simple keys. Identify a variety of habitats within the selected ecosystem

Name: ________________________________ Class: ____________ Date: ___________

Did you…	*With how much help..* *a lot*	*a little*	*none*
Following instructions			
Familiarise yourself with all procedures before starting	☐	☐	☐
Follow instructions step by step	☐	☐	☐
Listen to the teacher's instructions	☐	☐	☐
Correct manipulation of apparatus			
Use identification keys to identify fauna	☐	☐	☐
Use identification keys to identify flora	☐	☐	☐
Use the hand lens	☐	☐	☐
Use the ruler	☐	☐	☐
Handle the organisms with care	☐	☐	☐
Observation			
Notice the effect of using the hand lens	☐	☐	☐
Observe features of the fauna	☐	☐	☐
Observe features of the flora	☐	☐	☐
Note the habitats of the fauna	☐	☐	☐
Note the habitats of the flora	☐	☐	☐
Appreciate the importance of the identification keys	☐	☐	☐
Observe a variety of habitats	☐	☐	☐
Note an adaptation of any organism	☐	☐	☐
Recording			
Write up the procedure	☐	☐	☐
Draw a map/sketch or give a written description of the selected ecosystem	☐	☐	☐
Tabulate results	☐	☐	☐
Interpretation			
Draw reasonable conclusions from your observations and results	☐	☐	☐
Application			
Become aware of any other application(s) of what you learned in this activity	☐	☐	☐
Organisation			
Exercise caution for your personal safety and for the safety of others	☐	☐	☐
Work in an organised and efficient manner	☐	☐	☐
Label as appropriate	☐	☐	☐
Work as part of a group or team	☐	☐	☐
Carefully return any collected fauna to where they were found	☐	☐	☐
Leave the area as you found it	☐	☐	☐

Background information

Identification keys

Identification keys are essential tools used by biologists in ecological studies to help identify organisms. Keys are usually printed on paper, sometimes with illustrations and are the starting point for obtaining information about a given taxon (a particular group of organisms, e.g. family or genus). Most keys are arranged to present the user with a series of choices that describe the features of the specimen.

There are two main types of key: dichotomous (branching) and multi-access (multiple entry) keys. Completely dichotomous keys are made up of a series of steps, consisting of pairs of descriptions called couplets. At each couplet, the user selects the description that best matches the organism being identified and this points to the next couplet. This process continues until one of the chosen descriptions results in a name for the specimen. Some keys may have more than one choice at some of the points. In such keys the statements normally begin with general features and become progressively more specific with each choice made.

Multi-access keys work by eliminating all taxa except the one that matches the organism to be identified. They allow the user to start at any point, in any order, and identify the specimen by comparing the set of characters with a database of all potential species. The use of computers has made this type of key more practical and useful. In addition, these keys are useful in situations where important features of the specimen are difficult to observe or characters are unreliable or missing. As a result, some people find multi-access keys superior to dichotomous keys.

Fauna and Flora

Some common ecosystems include woodland, grassland, hedgerow, seashore and bog. Examples of fauna and flora found in these ecosystems are as follows:

ECOSYSTEM	FAUNA	FLORA
Woodland	Owl, woodlouse, springtail, deer, centipede.	Arum lily, oak tree, ivy, holly, moss.
Grassland	Slug, snail, earthworm, field mouse, spider.	Daisy, grass, dandelion, clover, plantain.
Hedgerow	Butterfly, wren, rabbit, hover fly, hedgehog.	Herb Robert, blackthorn, cow parsley, goose grass, hawthorn.
Seashore	Limpet, crab, dog whelk, blenny, starfish.	Sea lettuce, bladder wrack, spiral wrack, coral weed, oar weed.
Bog	Mayfly nymph, pond skater, frog, beetle, flatworm.	Sundew, lichen, ling heather, hummock *Sphagnum*, feather moss.

Advance preparation

- Refer to Fieldwork Checklist – Appendix 1.

Helpful hints

- Collect fauna using appropriate apparatus to help the identification process, e.g. use of a net.
- It is sufficient to identify some organisms to group level only e.g, spiders, , slugs.
- Hold small animals in a clear plastic container, not glass.
- Use a good quality hand lens, typically one with a 10x magnification.

- Take account of seasonal changes. There are many more plants and small animals evident in most ecosystems in the summer or early autumn. Some plants have more visible features necessary for identification in the spring and summer.
- Since a lot of organism identification tends to be done while sitting or kneeling, garden kneelers may be quite useful.
- When using a dichotomous key, always read both descriptions in the couplet even if the first one seems to be the logical one. If a choice is not clear, follow both options. If two answers are still possible, follow both alternative paths until an answer becomes clear.
- Avoid guessing the measurements of the specimen. Use a calibrated scale. A section of a metre stick may be photocopied onto an acetate sheet and held on a clipboard for easy access during fieldwork.

IDENTIFY AND USE VARIOUS APPARATUS REQUIRED FOR COLLECTION METHODS IN AN ECOLOGICAL STUDY

Suggested Materials/Equipment

Plastic bags	Insect net	Spade
Basins	Fish net	Cryptozoic trap
Specimen bottles	Plankton net	Mammal trap
Buckets	Sweep net	Pitfall trap
Forceps	Pooter	Beating tray
Baermann funnel	Scissors	Collection tray
Grapnel	Sieve	Trowel
Knife		

Procedure

1. Familiarise yourself with all procedures before starting.
2. Choose those items from the list appropriate to the ecosystem you are studying.
3. Name each piece of apparatus chosen.
4. Draw a sketch or give a written description of each piece.
5. Use each piece of apparatus appropriately.
6. Describe how you used each piece.
7. Record the type of organism collected by each piece.

Result

Identified collection apparatus

Name:

How used:

Type of organism collected :

Diagram/ Written Description

SKILL ATTAINMENT

Identify and use various apparatus required for collection methods in an ecological study

Did you…	*With how much help..* *a lot*	*a little*	*none*
Following instructions			
Familiarise yourself with all procedures before starting	☐	☐	☐
Follow instructions step by step	☐	☐	☐
Listen to the teacher's instructions	☐	☐	☐
Correct manipulation of apparatus			
Choose those items from the list appropriate to the ecosystem you are studying	☐	☐	☐
Use each piece of apparatus appropriately	☐	☐	☐
Observation			
Identify various apparatus	☐	☐	☐
Note the use of each piece of apparatus	☐	☐	☐
Recording			
Write up the procedure	☐	☐	☐
Name each piece of apparatus used	☐	☐	☐
Draw a labelled diagram or give a written description of each piece of apparatus used	☐	☐	☐
Interpretation			
Draw reasonable conclusions from your observations and results	☐	☐	☐
Application			
Become aware of any other application(s) of what you learned in this activity	☐	☐	☐
Organisation			
Exercise caution for your personal safety and for the safety of others	☐	☐	☐
Work in an organised and efficient manner	☐	☐	☐
Label as appropriate	☐	☐	☐
Work as part of a group or team	☐	☐	☐
Carefully return any collected fauna to where they were found	☐	☐	☐
Leave the area as you found it	☐	☐	☐

Background information

Since plants cannot move around, they are easier to find and collect than animals. Plants can be identified on-site using suitable keys. However, if absolutely necessary, plant parts such as leaves, flowers, seeds and fruit may be bagged, tagged and taken back to the laboratory for identification.
Unlike plants, most animals are highly mobile and present special challenges in terms of collection.

Apparatus used for collecting animal specimens

Baermann funnel: This method may be used to extract organisms, particularly nematodes from a soil sample. A muslin bag holds the soil sample which is suspended in water in a funnel. A light is switched on over the funnel. Both light and heat cause the organisms to move out of the muslin bag and into the bottom of the funnel where they are collected for examination and identification.
Tullgren funnel: This method is used to extract organisms from leaf litter or soil. The animals are driven out of the soil by heat from a lamp and fall through a wire gauze and are collected.
Grapnel: This is sometimes called a plant grab. It consists of a sturdy pole (e.g. a brush handle) which has a ring of backward-pointing barbs at one end. These are easily made from lengths of sturdy fence wire, about 30 cm long, which are bent into a 'V' which has a 20 cm arm (that is bound to the pole) and a 10 cm arm which acts as the barb. When the grab is plunged into aquatic vegetation the plants become entangled in the barbs and can be pulled onto dry land.
Insect net: Used for catching flying insects. The net part should be sufficiently long so that the mouth frame seals off the end of the net which contains the catch when the net is laid flat.
Fish net: This is a shallow, wide-mouthed net that is used for sampling in rock pools and ponds.
Plankton net: This net has a very fine nylon mesh which traps organisms such as small crustacea, some algae and protists. The net must be moved slowly through the surface of the water to allow the water to pass through the fine mesh. Small organisms are collected in the specimen tube at the end of the net.
Sweep net: This is a strong net which may be 'swept' through long grass or water. The net is then inverted onto a tray or into a bucket from where the organisms may be identified or transferred into a specimen bottle for identification in the laboratory.
Pooter: This apparatus comprises a specimen jar with a cover incorporating two plastic tubes. The operator sucks through one of the tubes and the small animals e.g. ants, greenflies are drawn into the specimen jar. The tube acting as the mouthpiece has a gauze filter at the end to prevent the animals being sucked into the operator's mouth.
Sieve: Many of the organisms that live in leaf litter can be extracted, without resorting to a Tullgren funnel, by using a sieve with a mesh size of about 5 mm. Use the sieve over a beating tray or a large sheet of paper.
Cryptozoic trap: This is basically a piece of wood or stone which is left on the ground. After a suitable interval, animals such as slugs, woodlice, centipedes and millipedes will be found underneath.

Small mammal trap: An example of such a trap is a Longworth trap which is used to trap small mammals such as wood mice and bank voles. It consists of a two-part aluminium box with a single entrance. Bedding is placed in the box along with suitable bait to lure the animal in. Once the animal is inside it usually trips a wire and the door closes firmly behind it.
Pitfall trap: A jam jar, paper cup or other suitable container is placed into a small hole in the ground. The container mouth must be level with the ground. The trap can be partially hidden with twigs or leaf litter or covered with a flat stone raised on small pebbles. Small arthropods fall into the trap.
Beating tray: This may be simply a white tray, cotton sheet or large piece of white chart paper. It is placed under a bush, tree branch or other foliage. The bush, tree branch or foliage is shaken suddenly and vigorously. Insects and other invertebrates fall onto the tray.
Settlement tray: This is used in freshwater. It consists of a shallow wooden frame which has a metal gauze or perforated zinc sheet bottom. The tray is placed on the bottom of a pond or stream and is covered with gravel or mud and is left in place for a month or more. It is then carefully removed and examined and the organisms which have settled on it are recorded.

Advance preparation

- Refer to Fieldwork Checklist – Appendix 1

Helpful hints

- Pooters with different coloured tubes or marked with different coloured tape could be used. This allows the mouthpiece to be instantly recognised by the operator.
- When setting pitfall traps, make sure there are no gaps between the rim of the trap and the edge of the hole.
- After collecting pitfall traps, fill in the holes with soil.
- When using a beating tray, it is important not to disturb the vegetation to be investigated until you are ready to apply the vigorous shake.
- When investigating a pond or stream, if a series of settlement trays are placed in position, and removed one at a time after increasing intervals of time, it will be possible to see the rate and order at which the organisms settle.
- When working in sea-water, do not use any apparatus that has aluminium parts, as these will rapidly corrode in this environment.
- A rake may be substituted for a grapnel.
- If a pitfall trap is being used for capture-recapture, bait could be used.
- When using a plankton net, it is necessary to draw it through the water for a distance of approximately 250m.
- When setting small mammal traps, ensure they are stable and the chamber is sloped to prevent water running in.
- Bedding and bait should be placed in small mammal traps. Bedding provides insulation and suitable types include clean dry hay, non-absorbent cotton wool, and shredded paper. Examples of bait may include seeds, nuts, and minced meat.

CONDUCT A QUANTITATIVE STUDY OF PLANTS AND ANIMALS OF A SAMPLE AREA OF THE SELECTED ECOSYSTEM

Because of the large variety of ecosystems and organisms available for study, many alternative quantitative study methods are possible.

(a) To calculate the frequency of an organism (suitable for plants and for sedentary and slow moving animals)

Materials/Equipment

Frame quadrat

Procedure

1. Familiarise yourself with all procedures before starting.
2. Select the sample area in the ecosystem and mark it off.
3. Decide on and record the organisms to be studied.
4. Throw a small object over your shoulder to select a random sample point. Place the quadrat at the random sample point.
5. Record the presence or absence of the named organisms within the quadrat.
6. Repeat for a number of throws.
7. Use the formula below to calculate frequency.
8. Tabulate results.
9. Transfer results to graph or bar chart.

Result

	Quadrat throw												
Organism Name	1	2	3	4	5	6	7	8	9	10	Total	Frequency	% Frequency

$$\textbf{Frequency} = \frac{\textbf{No. of quadrats containing organism}}{\textbf{No. of quadrats thrown}}$$

If percentage frequency is required use formula:

$$\% \text{ Frequency} = \text{Frequency} \times 100$$

Conclusion/Comment

(b) To calculate the percentage cover of an organism (suitable for most plants)

Materials/Equipment

Grid quadrat
Needle/pencil

Procedure

1. Familiarise yourself with all procedures before starting.
2. Select the sample area in the ecosystem and mark it off.
3. Decide on and record the organisms to be studied.
4. Throw a small object over your shoulder to select a random sample point. Place the quadrat at the random sample point.
5. Lower the needle at each sampling point and note the organism(s) hit.
6. Count and record the number of hits for each organism within the quadrat.
7. Repeat for a number of throws.
8. Use the formula below to calculate % cover.
9. Tabulate results.
10. Transfer results to graph or bar chart.

Result

	Quadrat throw												
Organism Name	1	2	3	4	5	6	7	8	9	10	Total Hits	Total Points	% Cover

$$\% \text{ Cover} = \frac{\text{No. of hits} \times 100}{\text{Total no. of points}}$$

Conclusion/Comment

(c) To calculate the population density of an organism (suitable for plants and for sedentary and slow moving animals)

Materials/Equipment

Frame quadrat

Procedure

1. Familiarise yourself with all procedures before starting.
2. Select the sample area in the ecosystem and mark it off.
3. Decide on and record the organisms to be studied.
4. Throw a small object over your shoulder to select a random sample point. Place the quadrat at the random sample point.
5. Count and record the number of the named organisms within the quadrat.
6. Repeat for a number of throws.
7. Calculate the average number of organisms per quadrat.
8. Calculate the number of organisms per m^2 (density).
9. Tabulate results.

Result

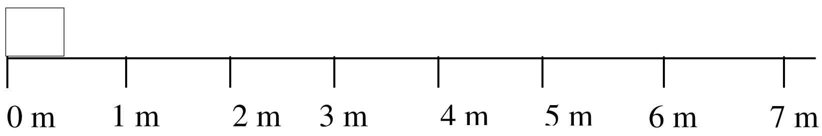
	Quadrat throw												
Organism Name	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total Number**	**Average No. per Quadrat**	**Density** (No. per m^2)

Conclusion/Comment

(d) To conduct a quantitative study of organisms along a belt transect (suitable for areas where there is an obvious environmental gradient or an unequal distribution of organisms)

Materials/Equipment

Tape measure (30 m)
2 tent pegs
Frame quadrat/grid quadrat and needle



Procedure

1. Familiarise yourself with all procedures before starting.
2. Select the sample area in the ecosystem and stretch the tape across it.
3. Fix the tape at either end with tent pegs so that it remains taut.
4. Decide on and record the organisms to be studied.
5. Place the quadrat at the 0 mark of the tape. Note and record either the % cover or the number of the named organisms in each quadrat.
6. Repeat at suitable intervals along the tape.
7. Tabulate results.
8. Transfer results to bar charts or belt transect diagram.

Result

Record % cover **or** number of a named organism in each quadrat along the transect											
	Position of quadrat on belt transect										
Organism Name	**0**										

If calculating the % cover using a grid quadrat and needle the following formula may be used

$$\textbf{\% Cover} = \frac{\textbf{No. of hits} \times \textbf{100}}{\textbf{No. of points on quadrat}}$$

Conclusion/Comment

(e) To calculate the population of an animal using the capture-recapture technique (suitable for mobile animals)

Materials/Equipment

Suitable markers

Procedure

1. Familiarise yourself with all procedures before starting.
2. Select the sample area in the ecosystem and mark it off.
3. Decide on the animal to be studied.
4. Search the area for the selected animal. Mark each animal found in a suitable way.
5. Count and record the number of animals captured and marked. Replace each animal where it was found.
6. Return to the area the following day. Search for animals in the same way. Count and record the total number of animals recaptured.
7. Count and record the number of marked animals in the recapture sample. Replace each animal where it was found.
8. Use the formula below to calculate the total number of animals in the sample area.

Result

Number of animals captured and marked on 1^{st} visit	
Number of animals captured on 2^{nd} visit	
Number of marked animals in the recapture sample	
Total population of animals	

$$\textbf{Total Population} = \frac{\textbf{No. captured and marked on } 1^{st} \textbf{ visit} \times \textbf{No. captured on } 2^{nd} \textbf{ visit}}{\textbf{Number of marked animals in the recapture sample}}$$

Conclusion/Comment

SKILL ATTAINMENT

Conduct a quantitative study of plants and animals of a sample area of the selected ecosystem

Name: ______________________________ Class: ___________ Date: __________

Select the appropriate skills according to the quantitative study conducted

Did you…	*With how much help..* *a lot*	*a little*	*none*
Following instructions			
Familiarise yourself with all procedures before starting	☐	☐	☐
Follow instructions step by step	☐	☐	☐
Listen to the teacher's instructions	☐	☐	☐
Correct manipulation of apparatus			
Mark out the area under study	☐	☐	☐
Select a random sample point	☐	☐	☐
Place the quadrat at the random sample point	☐	☐	☐
Repeat for a number of throws	☐	☐	☐
Lower the needle at each sampling point	☐	☐	☐
Fix the tape down at both ends	☐	☐	☐
Ensure that the tape was taut	☐	☐	☐
Place the quadrat at suitable intervals	☐	☐	☐
Use a suitable collecting method for the selected animal	☐	☐	☐
Mark each animal in a suitable way	☐	☐	☐
Observation			
Note all organisms in the quantitative study	☐	☐	☐
Count the number of the named organism	☐	☐	☐
Observe the distribution of organisms	☐	☐	☐
Recording			
Write up the procedure	☐	☐	☐
Record the organisms found	☐	☐	☐
Tabulate results	☐	☐	☐
Present results in a graphical or diagramatic form	☐	☐	☐
Interpretation			
Draw reasonable conclusions from your observations and results	☐	☐	☐
Application			
Become aware of any other application(s) of what you learned in this activity	☐	☐	☐
Organisation			
Exercise caution for your personal safety and for the safety of others	☐	☐	☐
Work in an organised and efficient manner	☐	☐	☐
Work as part of a group or team	☐	☐	☐
Carefully return any collected fauna to where they were found	☐	☐	☐
Leave the area as you found it	☐	☐	☐

Background Information

A quantitative study provides information on numbers of organisms present in an ecosystem. There are many different procedures used to carry out quantitative studies but some are more suited to a particular ecosystem than others.

The most accurate way to determine population size is by direct count of all the individuals present in an ecosystem but this is not always possible. However, a direct count is suitable for some populations e.g. oak trees or deer in a woodland.

Since it is not always feasible to count all the individuals of a species present in an ecosystem a technique known as sampling is used. Samples representative of the area being studied are chosen. Before sampling an ecosystem a suitable strategy should be decided on. How many samples should be taken? Where and when should they be taken?

Sampling can be divided into three main categories

i. Random sampling – overcomes the problem of hidden bias and ensures that each point within the study area has an equal chance of being sampled. This is suitable in some areas where there is no obvious environmental gradient e.g grassland.

ii. Systematic sampling – here samples are taken at regular intervals throughout the study area. This type of sampling is used where there is an obvious environmental gradient e.g. on a rocky seashore.

iii. Stratified sampling – used for small specialised habitats within the ecosystem e.g. areas of bracken in grassland or rock pools on a seashore.

(i) Random sampling

(a) Quadrats

A quadrat is a frame that forms a known area and can be of any regular shape. The most common are square-shaped. A quadrat is the usual sampling unit used for random sampling of plants or some slow moving or attached animals e.g. snails, barnacles. The purpose of using a quadrat is to enable comparable samples to be obtained from areas of consistent size and shape.

The size of the quadrat used depends on the size of the area being sampled. A quadrat frame such as $1m^2$ or $0.25\ m^2$ is used when sampling a grassland or the herb/ground layer of a woodland. However, if the woodland trees were to be included in the study then a $100m^2$ quadrat marked out with ropes would be more suitable. An optimum quadrat size is reached when 1% increase in size yields no more than a 0.5% increase in the number of species.

To obtain an accurate measure of population size a series of quadrat samples is required. A satisfactory minimum number of throws is reached when a 1% increase in the number of throws yields no more than a 0.5% increase in the number of species found.

True randomness is an important element when sampling in ecology, so instead of simply throwing a quadrat at random it is better to map the area and then to lay a numbered grid over the map. A random numbers table can then be used to select the squares to sample in.

Rules for inclusion must be decided before using the quadrat e.g. is an organism half in or half out included? It does not matter which you decide as long as the rules for inclusion are consistent throughout the study.

(b) Capture-Recapture

This is a method used in random sampling of moving animals. Changes in the abundance of animal populations are governed by four parameters – birth, death, immigration and emigration. Biologists require accurate information about abundance of animals to make decisions about animal conservation.

Animals may be marked in different ways e.g. leg bands for birds, ear tags or radio transmitters for mammals, fur clipping for small furry mammals such as mice, paint for shelled animals. Animals may be caught in a variety of ways depending on the animal e.g. snails by direct search, beetles by pitfall traps, grasshoppers by sweep nets.

Capture-recapture studies are based on assumptions such as:

1. The sample is representative of the population. The trapping techniques used must not favour one group versus another e.g. juveniles versus adults. All must have an equal chance of being caught.
2. The markers used do not affect the behaviour or fate of the marked individuals. Markers must not increase the predation on the marked individuals.
3. Marked animals distribute themselves equally throughout the population so that marked and unmarked animals have an equal chance of being caught.
4. Markers are not lost. If this happens the population will appear to be more abundant than it really is.

Certain factors should be kept constant throughout the investigation such as the size of the capture-recapture area, the time of day and the collecting method used.

(ii) Systematic sampling

This is when samples are taken at fixed intervals or continuously along a line called a transect. A transect (usually a tape measure) is set up across an area where there is a distinct environmental gradient or where there is an unequal distribution of organisms e.g. up a rocky seashore or through a hedgerow. Samples are then taken from either under the tape (line transect) or from a wider band beside the tape (belt transect).

A line transect is carried out by laying the line along the gradient identified. The species touching the line may be recorded along the whole length of the line (continuous sampling) or at suitable intervals.

When a wider band running through the ecosystem is being sampled then it is called a belt transect. A common way of achieving this is to use a quadrat beside the line transect and sample the organisms within the quadrat.

In some ecosystems e.g. a rocky seashore, it is important to conduct a profile transect along the transect line to investigate whether the topography has an effect on the distribution of the organisms.

The importance of systematic sampling is that it gives quite a lot of information on the distribution of the organisms within the selected ecosystem.

(iii) Stratified sampling

Stratified sampling is used where there are small areas within a larger ecosystem which are clearly different e.g. rock pools on the rocky seashore. Sampling would be carried out either randomly or systematically within each separate ‘stratum’ identified. This recognises major differences within communities before sampling begins.

Advance preparation

- Refer to Fieldwork Checklist – Appendix 1.

Helpful hints

- Mark off the sample area by using poles with string or flags or by other visible markers e.g. trees, paths, rocks.
- Although it is not truly random, for the purpose of a school study, it is sufficient to throw a small object over your shoulder to select a random sample point.
- Place the quadrat down carefully so that the animals are not disturbed enabling you to count them.
- The population density of earthworms and slugs can be studied using the quadrat method. Pour water onto the ground in the quadrat to get the slugs and earthworms to come to the surface where they can be seen and counted.
- % cover is a method very suitable for use when studying the dominant plant in an ecosystem or for animals either when individual organisms do not exist e.g. sponges or where individual organisms are hard to see e.g. barnacles.
- % cover may give a result greater than 100% unless the study is confined to the canopy organisms.
- A point frame can be used instead of a grid quadrat to measure % cover.
- If using a 0.5m x 0.5 m quadrat when calculating the population density of an organism - multiply the average number of organisms per quadrat by 4. If total population is required use the formula: Total Population = Population Density x Area of Ecosystem.
- Direct counting of smaller animals is also possible over the course of a year – set many traps e.g. pitfall traps or cryptozoic traps in the sample area and count the number of the named animals caught. Repeat this many times to validate your results.
- Two ropes marked at metre intervals and placed a distance apart e.g. one metre, can be used to make a belt transect. Each square metre can then be surveyed without the need for quadrat frames.
- When carrying out a belt transect the quadrat can be ‘rolled over’ within the belt giving continuous sampling or the quadrat can be placed at predetermined points e.g. every metre or at suitable intervals depending on the vegetation changes.
- On a belt transect the % cover may be done by visual estimate.
- When using a line transect or belt transect each group of students could study a five-metre section and collate all the results at the end.
- In the capture-recapture technique use poster paints to mark animals, as this paint will wear off after a short time.
- In the capture-recapture technique, animals should be marked discreetly so as not to increase their chances of being preyed upon.

INVESTIGATE ANY THREE ABIOTIC FACTORS PRESENT IN THE SELECTED ECOSYSTEM, AS LISTED
RELATE RESULTS TO CHOICE OF HABITAT SELECTED BY EACH ORGANISM IDENTIFIED IN THIS STUDY

Abiotic factors as listed in the syllabus:
pH, temperature (air and ground or aquatic), light intensity, water current, air current, dissolved oxygen, mineral content, percentage air in soil, percentage water in soil, percentage humus, salinity, degree of exposure and slope.

Materials/Equipment

Equipment to measure the chosen abiotic factors.

Procedure

1. Familiarise yourself with all procedures before starting.
2. Choose any three abiotic factors present in the selected ecosystem from the list above.
3. Measure the abiotic factors for the habitat of each of the identified organisms by using the appropriate equipment and following the relevant instructions.
4. Record results.
5. Relate results to the choice of habitat by commenting on the suitability of each habitat for the organism.

Result

		Abiotic factors and measurements		
Organism Name	**Habitat**			

Conclusion/Comment

SKILL ATTAINMENT

Investigate any three abiotic factors present in the selected ecosystem, as listed. Relate results to choice of habitat selected by each organism identified in this study

Name: ________________________________ Class: ____________ Date: ___________

With how much help...

Did you…	**a lot**	**a little**	**none**
Following instructions			
Familiarise yourself with all procedures before starting	☐	☐	☐
Follow instructions step by step	☐	☐	☐
Listen to the teacher's instructions	☐	☐	☐
Correct manipulation of apparatus			
Use each piece of apparatus appropriately	☐	☐	☐
Observation			
Observe the distribution of organisms in the ecosystem	☐	☐	☐
Observe a variety of habitats within the selected ecosystem	☐	☐	☐
Note the link between the abiotic factors and the organism's choice of habitat	☐	☐	☐
Recording			
Write up the procedure	☐	☐	☐
Tabulate results	☐	☐	☐
Interpretation			
Draw reasonable conclusions from your observations and results	☐	☐	☐
Application			
Become aware of any other application(s) of what you learned in this activity	☐	☐	☐
Organisat Organisation			
Exercise caution for your personal safety and for the safety of others	☐	☐	☐
Work in an organised and efficient manner	☐	☐	☐
Label as appropriate	☐	☐	☐
Work as part of a group or team	☐	☐	☐
Leave the area as you found it	☐	☐	☐

Background information

pH

Both in soil and water, pH affects plant growth. Each species grows best at a certain pH. Any departure from the optimum pH will have an adverse effect and may kill the plant. Plants such as bracken, gorse, heather, azalea, rhododendron, camellia, and oak only grow on acid soils (pH range 4.0 - 6.5). These plants are now known to be intolerant of calcium ions in the soil and may be known as **calcifuges** ("lime haters"). Plants that live in limestone soils (pH range 7.5 - 9.0) are known as **calcicoles** ("lime-tolerant")

Certain aquatic animals, such as the freshwater shrimp, can tolerate a wide range of pH. Others, such as planarian flatworms, caddis fly larvae and some damselfly nymphs are more abundant in alkaline, calcium-rich waters. Earthworms also prefer alkaline soils.

Marked changes in pH are ecological features in some areas e.g. woodland in Killarney National Park. The pH over the limestone areas is alkaline and one finds beech and ash. As the soil becomes acidic over the sandstone areas the flora changes and oak becomes the predominant tree species.

Within certain habitats there can also be marked changes in pH. Heathland fires significantly alter the surface pH by adding ash from the burnt stems and leaves of heather and other plants. Ash is extremely alkaline, at pH 10.0 - 11.5. The pH in the soil changes rapidly from 4.5 to about 9.0. For a few weeks after the fire pH falls slowly as alkaline salts are leached from the soil, stabilising at about 5.0 after eight weeks or so. It is thought that the high pH inhibits the germination of heather seeds until the acidic conditions are established.

Measuring pH: The pH of water samples can be measured directly using pH paper or a pH meter and a probe. To measure the pH of soil, take a sample of soil, place it in a measuring cylinder and add an equal volume of distilled water. Shake vigorously for about 10 minutes and then filter. (If clay particles are present, they can be flocculated by using barium sulphate solution instead of distilled water.) The pH of the filtrate is then measured.

Temperature (air and ground or aquatic)

Throughout northern Europe there is a seasonal variation in temperature closely linked to light intensity. There are also daily temperature and light cycles. In ecological studies, the precise temperature at any one moment is of little value. Of much greater significance are the diurnal (daily) and seasonal variations. Diurnal temperature is best measured with a max-min thermometer.

Temperatures at different heights of vegetation above ground level are also of considerable practical importance. Investigations have shown that at midday the foliage, together with the bare soil between plants, are the warmest places. At night the bare soil cools more rapidly. Therefore if vegetation is removed ground level temperature shows marked fluctuations, a factor that affects the rate of recolonisation.

Most plants photosynthesise between April and September, when the mean air temperature is above 8 ^{o}C. For the rest of the year they undergo changes that assist survival at low temperatures. Annual plants produce cold-resistant seeds, perennials shed their leaves and form buds or dormant underground storage organs.

The winter survival tactics shown by animals include cold avoidance and cold tolerance. Cold avoidance is shown by migratory birds and butterflies, whose annual migration to warmer climates ensure they never experience adverse weather

conditions. Cold tolerance is shown by insects - many insects enter a non-feeding stage to overwinter. Hedgehogs hibernate for the winter.
Temperature gradients are an important feature of ponds and lakes especially in summer. Such a gradient exists because warm water rises to the surface and cold water falls.

Measuring Temperature: Temperature can be measured using a standard mercury-in-glass or alcohol thermometer. Such a thermometer with a thickened bulb and in a protective case can be used in air, soil and water. Digital thermometers could be used to measure habitat temperatures instead of standard thermometers. Standard maximum/minimum thermometers can be used to measure the temperature range over a period of time which, for many investigations, is more important than a reading at any particular moment.

Light intensity

Sunlight is the source of energy that drives all ecosystems. Seasonal variation in light intensity affects plant productivity. Less than 0.25% of the total incident radiation on the earth is used by plants in the process of photosynthesis.
Many plants grow in direct sunlight, but most plants show some degree of shade tolerance.
Animals respond to changes in light intensity by modifying their behaviour, often moving away from or towards light.
Two aspects of light, its duration and its intensity, are generally important to ecological studies. The duration of daylight hours can be determined astronomically and is predictable for any location. Photoperiodism is a biological response to the changes in the ratio of light and dark in a 24 - hour period. Flowering plants may be divided into three categories:

a) Short day plants. These plants flower in early spring or autumn and require a dark period exceeding a certain critical length.
b) Long day plants. These plants require a period less than the critical period. They flower in summer.
c) Day-neutral plants. These plants are unaffected by photoperiod.

Some plants require only a single exposure to the critical day-night cycle in order to flower.
Examples of photoperiodic responses in animals are

a) Many small birds and mammals mate in spring and early summer due to increasing daylight.
b) Conversely, sheep and goats respond to shortening day length as they mate in late summer/early autumn.

Measuring light intensity: Light intensity can be measured at any particular time using **light meters**, such as those used by photographers. However, the readings may not be very useful because light levels fluctuate continuously. In addition, if light intensity is being studied in relation to the distribution of plants, it is more important to measure the light received over a relatively long period of time, because it is this which most affects plant performance. **Light probes** connected to a computer or data-logger can be used to take continuous measurements of light. Alternatively, it is possible to compare the amount of light received over a long period of time by using **light-sensitive paper**, such as ozalid paper used by printers. This gradually darkens on exposure.

Air current
Air movements may affect organisms indirectly, by evaporative cooling or by a change in humidity. It may also affect them by determining their shape; the development of branches and roots of trees in exposed areas. Wind is important for dispersal of seeds and spores.

When considering wind speed and direction, it is important to remember that for most ecological studies, degree of exposure is more important than wind speed at any one time. Degree of exposure is a function of wind frequency, speed, and direction**.**

Measuring air current: A wind vane measures direction and a anemometer measures wind speed.

Water current
A still body of water will inevitably be disturbed by various factors, which will affect the distribution of organisms in the water. Wind is considered to be the prime factor responsible for disturbing water, though changes in temperature can create convection currents where temperature is evened out across the body of water via this movement.

Still water communities can vary greatly in appearance, anything from a small temporary puddle to a large lake is capable of supporting life to some extent. The size and depth of a still body of water are major factors in determining the characteristics of that ecosystem.
One of the main differences between still water and running water communities is the fact that the water is moving at a particular velocity in running water communities. This can have great bearing on what organisms occupy the ecosystem and what particular ecological niches they can exist in. Running water can bring many factors into play affecting the lives of the organisms in this particular environment:

- Movement of minerals and stones caused by the velocity and volume of the water means the water bed is constantly changing. The faster and higher volume of water present will result in a direct increase in amount and size of particles shifted downstream.
- Standing waves are used by salmon at the bottom of waterfalls to spur them upstream. At the same time, they cause small air pockets, which results in a small habitat becoming available suited to particular organisms
- Erosion is caused by the running water breaking down the river bank and beds, causing the geography of the river to change over a long period of time. This means, for example, that hydroseres previously occupying the river bank may find themselves distanced from the running water and over time this would mean the overall ecosystem would change**.**

In general the diversity of plant species in a running water community is small compared to that of a still water community. Most plants have gone through evolutionary adaptations to cope with the force and different conditions that running water brings. As these conditions are more harsh for a typical species of plant, more notably larger plants, smaller species have found the conditions of the community more favourable. This is due to the fact that they are more flexible in regards to the physical conditions of the water. Algae can grow in all sorts of different places and surfaces, and therefore are a successful constituent of the running water ecosystem.

Most of these algae have developed evolutionary adaptations over time that prevent the water current sweeping them away.

Other animals have developed some of the following adaptations over time that help them cope with the conditions in hand:

- Suckers – These suckers attach themselves to a surface and can also assist movement in any direction.
- Hooks/Claws – These sharp objects can dig into any given object and allow the animal to cling to a position or claw their way around the surface.
- Body flattening – This adaptation can allow the animal in the water bear less of the brunt of the force of water moving downstream, therefore reducing it as an inhibitor of their movement. This also allows these animals to enter confined areas (such as under stones) that may present a useful environment for them to live in.
- Streamlining – This reduces the frictional forces between the flowing water and the streamlined animal.
- Flight – Some animals have adaptations allowing them to fly, removing themselves from the force of the current at ground level and enabling them to move upstream more easily if needs be.

  The simplest procedure to measure water current is to record the time taken for a floating object to travel a known distance. It is preferable to use an object which is mainly submerged to eliminate any wind effects.

  Formula: $\frac{\text{distance travelled by the object}}{\text{time taken to travel that distance}} = \text{Current (m/sec)}$

Dissolved oxygen

Oxygen concentration in water is a limiting factor for most aquatic organisms. Water always contains much less oxygen than atmospheric air e.g. at $0^{o}C$ water contains approximately 10 cm^3 /l dissolved oxygen. As the temperature rises, the concentration of dissolved oxygen falls and at $30^{o}C$ the level of dissolved oxygen is about 5 cm^3/l. An animal's requirement for oxygen increases as the temperature rises and it is not difficult to see why aquatic animals may experience stress during hot weather. Oxygen gradients exist in large ponds and lakes most of the year. Surface water, 100% saturated, may contrast greatly with the water at the bottom of the pond, which may be only 25% saturated.

Oxygen depletion may occur for any of the following reasons

a) In winter when the water is covered with ice.
b) In late summer when plants die back and microorganisms decompose dead leaves.
c) At any time if sewage or other organic effluents enter the water.

Measuring dissolved *oxygen*: a dissolved oxygen probe and meter or the Winkler method may be used to measure dissolved oxygen.

Mineral content

Inorganic ions constitute approximately 1% of an organism by weight, but they are essential for its health. When a mineral is in short supply or missing the organism develops deficiency symptoms.

Soil is tested by farmers and gardeners for the presence or absence of certain essential minerals, using soil test kits. Kits are available from garden centres. Minerals in soil become used up or leached away and may have to be replaced using fertilisers or by leaving the ground fallow for a season.
Different plant species have different mineral requirements and the distribution therefore depends on the mineral balance of a particular soil.

Percentage air in soil
The amount of air present in the soil depends on the structure of the soil and its water content. Waterlogged soils contain little oxygen. Low oxygen levels can cause anaerobic bacteria to thrive e.g. sulphur bacteria, which produce hydrogen sulphide (a gas toxic to many plants). Oxygen is needed by plants for the uptake of minerals by active transport from the soil.

Percentage water in soil
The water content of soils varies greatly. Any freely drained soil, which holds as much water as possible is said to be at field capacity. Addition of any more water which cannot drain away causes waterlogging and anaerobic conditions.
Some plants can tolerate waterlogged conditions. Many headed bog-cotton which inhabits bog pools has aerenchyma tissue which channels oxygen to the roots of the plant which allows it to penetrate to depths of 60cm into the waterlogged peat. Yarrow, which lives in drier soil, is a hemiparasite which lives off minerals and water from roots of other plants.

Percentage humus
A major component of soil is dead organic matter e.g. leaf litter. As it decomposes it forms a gelatinous brown-black material called humus. Humus is a colloidal acid substance, an immediate product in the decomposition of dead plants and animals. The presence of humus encourages plant growth for a number of reasons.

1. The moist sticky substance binds minerals together forming a crumbly, less compacted soil. This increases the air content of the soil and improves drainage.
2. Humus provides food for many invertebrates e.g. earthworms.
3. Humus and clay particles carry negative charges, which prevent positively charged ions from being washed out of the soil by rain (leaching).
4. Humus absorbs solar radiation because of its dark colour. Humus rich soils heat up quickly, promoting the germination of seeds and the growth of seedlings.

Salinity
The salt content (salinity) of a water body is one of the main factors determining what organisms will be found there. Thus fresh waters and saline waters are inhabited by quite different organisms. Plants and animals that live in or use freshwater generally have a salt content inside their cells that is greater than the water they inhabit or use. They tend to give off salts as waste products. Saltwater plants and animals have a salt content equal to or less than the salinity of the surrounding water, and thus have different mechanisms for maintaining their salt balance. In brackish waters we find plants and animals that can tolerate changes in salinity.

Intertidal organisms tolerate abrupt changes in salinity. When the tide is out, they may be soaked in fresh water from rain, when the tide returns, they quickly return to a salt-water environment. Water in tide pools may evaporate, concentrating the salts and increasing the salinity. Organisms adapt to changes in salinity in two ways. They retain sea-water inside their shell (mussels), or quickly adjust their internal salt balance (tide pool fishes).

To measure salinity: Salinity can be measured using a conductivity probe and meter. Alternatively, since the density of water is related to the amount of salt dissolved in it, the salinity of the water can be determined from the density and water temperature. A hydrometer can be used to measure density. Using density and water temperature values the salinity can be read from a salinity table.

Degree of exposure

(a) Air

When the tide is out, intertidal organisms are exposed to the air. They must not dry out, and they must withstand air temperatures, which vary from hot in summer to bitter cold in winter.

The intertidal area can be divided into zones, based on the length of time of exposure to air. Zones often are identified by the plants and animals that live within them.

The splash zone is exposed to ocean spray, but is covered completely only during the highest of high tides. The plants and animals e.g. lichens, snails, sand hoppers that live here cannot live submerged in sea water but may benefit from salt water spray.

The upper shore is out of the water most of the time; it is completely covered only during high tides. Plants and animals e.g. barnacles, snails, spiral wrack and channel wrack that can withstand much exposure to air live here.

The mid shore is exposed to the air twice a day and it supports a great variety of plants and animals e.g. bladder wrack, knotted wrack, sea anemones, limpets.

The lower shore is exposed to air only during the lowest tides. The plant and animal life e.g. sea urchins, starfish, and serrated wrack found here is abundant and varied.

Some organisms have adapted to prevent drying out in the following ways:

- They have protective body structures. Molluscs have shells; kelps have strong, smooth blades (fronds); chitons have flat bodies.
- Snails withdraw into their shells; some snails then secrete a mucus seal.
- Anemones gather in large masses to reduce the body surface area exposed to the air.
- Limpets fit themselves into small depressions that they make in rocks.
- Seaweeds are protected by their vast numbers. The upper layers of seaweed shelter the lower layers so that only a few plants are sacrificed to protect the entire colony.
- Mussels close their shells tightly to retain water.

When considering wind speed and direction, it is important to remember that for most ecological studies, degree of exposure is more important than wind speed at any one time. Degree of exposure is a function of wind frequency, speed and direction.

(b) Waves

Whether on rocky shores or sandy beaches, intertidal plants and animals must survive the action of the waves. Intertidal organisms protect themselves from being smashed against rocks or cast up and stranded on beaches in the following ways:

- They fasten themselves securely to rocks. Limpets have strong, muscular feet; kelps have strong holdfasts.

- Some animals hide from the waves by crawling under or between rocks or plants. Crabs crawl into crevices in rocks, and small animals hide in the holdfasts of kelp. Encrusting algae grow under rock ledges.
- Some burrow into the sand e.g. lugworm.

Slope

Slope usually influences run-off, nutrient accumulation, soil and organic matter accumulation.
Slopes are important when considering the temperature of the soil surface.
South-facing slopes receive more sunlight, and are therefore warmer than north facing slopes (in the northern hemisphere). In Ireland, the south-western slopes face the rain bearing winds.
Slopes with a steep gradient are generally drier than those with a shallower gradient as water drains more readily from a steep slope. As a result they are more nutrient poor, have shallower soil and are more subject to erosion and higher winds. Less steep slopes can accumulate soil, nutrients etc. and may be subject to less erosion.
If a slope is convex, erosion, winds and run-off are enhanced. If a slope is concave, accumulation of water and nutrients may occur.

Advance preparation

- Refer to Fieldwork Checklist – Appendix 1

Helpful hints

- Datalogging equipment may be used to measure pH, temperature, dissolved oxygen, light intensity, and salinity.
- Students could look at the distribution of an organism and relate it to a changing abiotic factor in the ecosystem.