

Studying Ecology and Ecosystems. (Edexcel A2)



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Studying Ecology and Ecosystems.

This unit introduces students to a range of concepts and sampling techniques essential to the understanding of populations and ecosystems and how they are measured.

KEY SYLLABUS AREAS:

Unit 4 The natural Environment and Species Survival

Topic 5: On the wild side.

9) Discuss how understanding the carbon cycle can lead to methods to reduce atmospheric carbon dioxide (including the use of bio-fuels and reforestation).

10) Explain that the numbers and distribution of organisms in a habitat are controlled by biotic and abiotic factors.

11) Describe how to carry out a study on the ecology of a habitat to produce valid and reliable data (including the use of quadrats and transects to assess abundance and distribution of organisms and the measurement of abiotic factors, eg. Solar energy input, climate, topography, oxygen availability and edaphic factors).

12) Explain how the concept of niche accounts for the distribution and abundance of organisms in a habitat.

13) Describe the concept of succession to a climax community.

15) Describe the effects of global warming on plants and animals.

18) Analyse and interpret different types of evidence for global warming and its causes (pollen records in peat bogs, dendrochronology), recognizing correlations and causal relationships.

Introduction

An ecosystem is the result of an infinitely complex series of interactions between the abiotic environment and the biotic community. The abiotic environment includes the microclimate, relief, aspect and geology of an area. The biotic community encompasses the range of organisms living in a given area and all their interactions with other organisms – be that inter- or intra-specific competition – and their environment. This unit focuses on three major areas:

- What abiotic factors affect an ecosystem and how are they measured?
- What organisms are present in an ecosystem and how are they sampled?
- How are components of an ecosystem interrelated?

We have made suggestions for the influencing factors that can be studied at the different ecosystems, various vegetation surveying techniques and pointers for looking at Man's influence. There are also suggested methods of following up the day's fieldwork. Recording sheets are included. There is information on fieldwork sites, including background information and key species. Colour plant identification sheets are available at the Eagle's Nest for each ecosystem to help identification, and there is an extensive collection of identification books at the Centre.

Background to vegetation change on Mont Lozere.

Mont Lozere was periglacial during the last ice age, with permanent ice and snow fields on the summit; the presence of tors and V-shaped valleys support this idea. 10 000 years ago, the landscape would have been rough and rocky, with virtually no soil – washed away as the water locked up in the perma-frost melted.

The first colonists of this rocky landscape would have been lichens. Highly specialised symbiotic organisms (10% algae and 90% fungi – some have nitrogen fixing bacteria in the colony) they are carried in fragments or as spores by the wind from lower-lying areas. They were able to colonise bare rock, and gradually broke down its surface using organic acids to acquire minerals. Lichen growth is very slow – a millimeter in several years. When the centre of the lichen colony dies, this simple organic material and minerals provided all that was needed for the next community of colonists, the mosses.

Mosses cannot colonise bare rock, but thrived on the material left by the dead lichens. Grass seeds which fell in amongst the mosses grew, adding their own organic matter the surface of the rock – slowly a poor, thin soil began to form. These early colonisers are collectively known as pioneer species. Wind distributed seeds, shallow roots needing little soil, they thrive in these conditions.

Later, as the soil thickens, grasses are over shadowed literally, and out-competed by taller plants – the shrub community. Eventually, trees are able to colonise. Their larger seeds mean that travel from the seed reservoirs on low lying ground is slow, taking thousands of years. After perhaps four thousand years, the succession sequence was complete – Mont Lozere would have been covered with thick forests of beech, birch and pine. There would have been few trees on the exposed summits, where harsh winter weather prevented even the conifers from surviving.

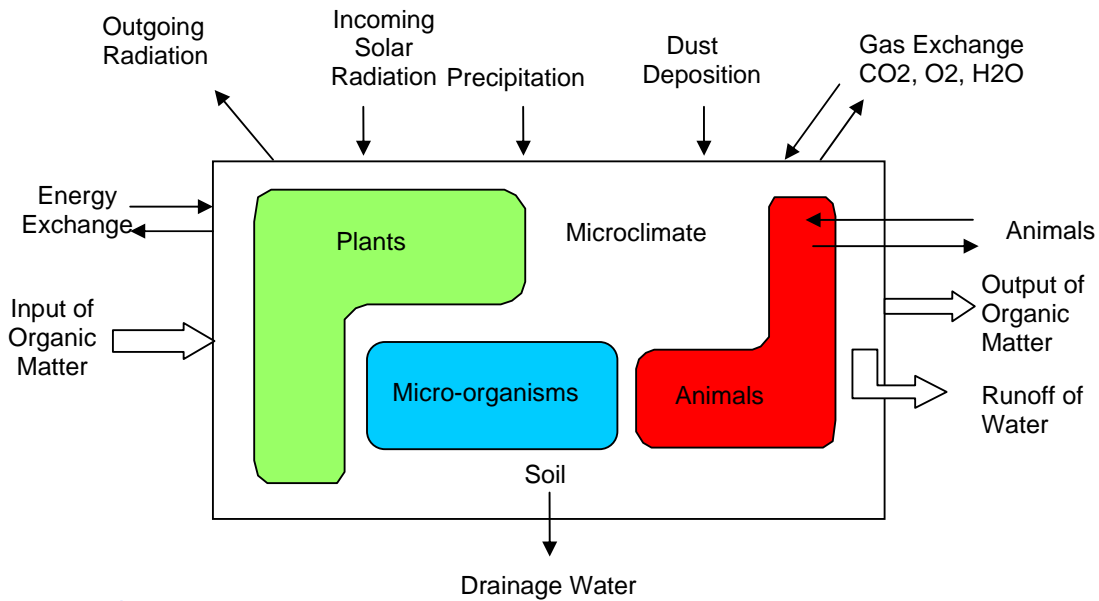
This deciduous forest ecosystem is typical of this latitude – it represents the climactic climax community – the dominant vegetation type which, without human interference, dominates in an area as a result of its climate. Other climactic climax vegetation types, or biomes, include tundra, coniferous forest (taiga), temperate grassland, evergreen hardwood (Mediterranean scrub), desert, savannah and tropical rain forest. So why, when you look out of the window of the classroom don't you see thick deciduous forest?

- Local geology affecting: drainage, soil moisture, soil pH, soil texture, soil depth;
- Relief, aspect; altitude;
- Local microclimate – light levels, air temperature, soil temperature, humidity, wind exposure;
- Management – Human interaction with the environment – burning, grazing, trampling;
- Inter (between members of different species) - and intra (between members of the same species) - specific competition between organisms living there.

Within each vegetation biome are a number of ecosystems, each affected by abiotic and biotic factors at a local level. Studying ecosystems enables one to understand how and why certain ecosystems are where they are, and how are affected by human activity. The techniques of studying the environment are relevant

to many professions in the UK. All major developments must have an Environmental Impact Assessment (EIA) before they can go ahead.

Figure 1 - Diagrammatic representation of an ecosystem exchanging energy and compounds with its environment:



Nutrient Cycling

The term 'nutrient cycling' refers to the circulation of minerals around an ecosystem. Nutrients are taken up by the root system of plants; these are then used and released as the plants shed organic matter such as leaves or when the plant dies. The litter which accumulates on the surface is broken down by micro-organisms and fungi, which return nutrients to the soil store to be used in the cycle again. There are three main storage areas to the cycle: - litter, soil and biomass. The relative importance and hence size of these stores and transfers depends upon the nature of the biome:-

main storage areas to the cycle: - litter, soil and biomass. The relative importance and hence size of these stores and transfers depends upon the nature of the biome (figure 2):-

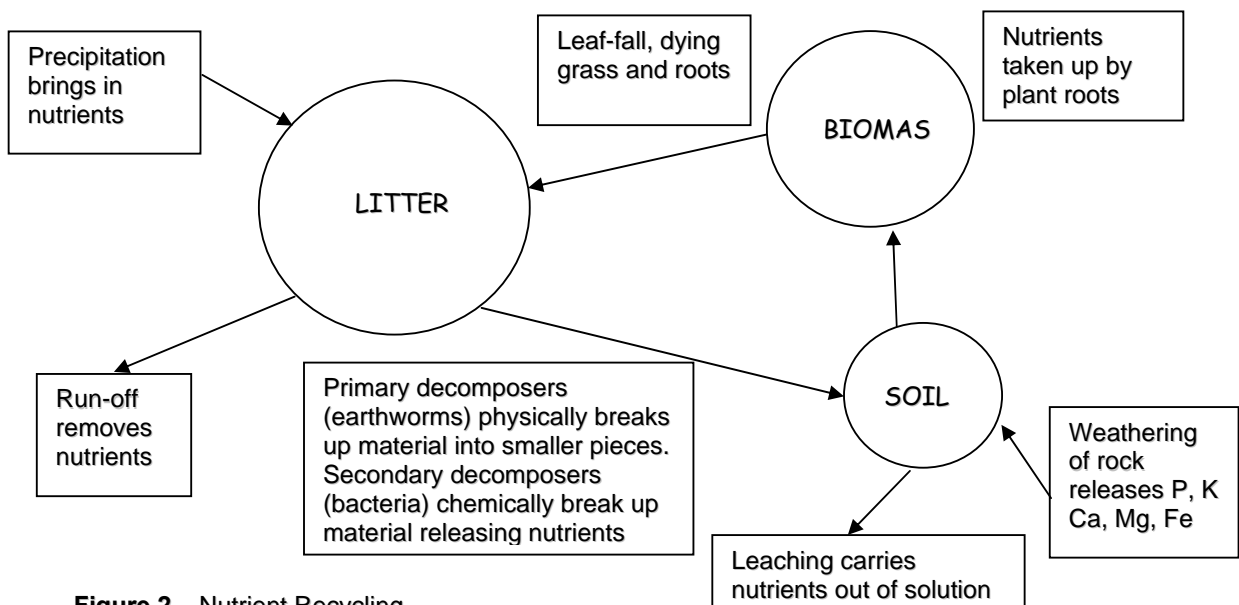
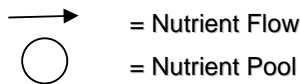


Figure 2 – Nutrient Recycling



Specific Information

Mont Lozere has a microclimate that swings dramatically between an alpine climate in the winter and a Mediterranean climate in the summer. Winters are typically very cold with moderate snowfall – there is a small ski-resort on the summit. Summers are hot and drought conditions are frequent. Spring and autumn are typically short seasons, with significant rainfall and often high winds. The bedrock of the area is granite, and so non-porous and impermeable. There are many peat bogs on the summit as a result of this, and many surface drainage features. Granite produces nutrient poor, thin, acidic soils, with many large boulders, due in part to the slow rate of weathering. All of the study sites are in either the core or peripheral zone of the Cevennes National Park (PNC). There are only five main land National Parks in France, and the PNC is the only one with a permanent resident population. This makes the area extremely special, and at the Eagle's Nest we demand the greatest respect from students for the natural environment in which they work.

Aims

- To determine which abiotic factors are instrumental in bringing about certain ecosystems;
- To quantify the plant community in several contrasting ecosystems and understand what factors in the abiotic environment lead to their presence;
- To identify any land management practises which may have resulted in particular ecosystems.

Objectives

- To assess the microclimate in several contrasting ecosystems and determine whether the light levels, air temperature, humidity, or wind exposure is important in producing a particular ecosystem;
- To examine the soils in several contrasting ecosystems and determine whether the soil depth, moisture, pH, texture, nutrient content or temperature is important in producing a particular ecosystem;
- To compare the altitude, aspect and relief of several ecosystems and determine whether they influence that ecosystem;
- To use and rationalise a range of vegetation sampling procedures to quantify the vegetation community in a range of contrasting ecosystems, to determine the effects of microclimate and soil type in producing a particular vegetation community at a site;
- To carry out a land management survey to determine human influence in contrasting ecosystems.

Hypotheses

The species composition, diversity and distribution of plants in a given ecosystem will be affected by:

- Microclimate – particularly wind exposure, and light levels, which will directly influence air temperature and therefore humidity;
- Soil – particularly soil moisture and nutrient levels;
- Altitude, aspect and relief.
- Land management practises will have a strong influence on what ecosystem occurs at a given site.

AIMS:

- To understand the terminology used in the study of biodiversity and habitats;
- To use a range of techniques available to ecologists to quantify the biodiversity of a habitat, including Simpson's index of Diversity, species richness and species evenness.

HYPOTHESIS:

- The biodiversity of habitats on Mont Lozere is high, and the range of species encountered justifies its status as a National Park and Natura 2000 site.

DATA COLLECTION SITES:

We have a range of study sites in which we can study habitats and biodiversity, in both the core and peripheral zone of the Cevennes National Park (PNC). This makes the area extremely special, and at the Eagle's Nest we are lucky to have good access to a range of habitats to investigate biodiversity.

(1) PEAT BOG

KEY SPECIES – *sphagnum and star mosses, purple moor grass, sedges, heath spotted orchid, marsh marigold, marsh violet, starry saxifrage, sundew.*

Peat bogs are formed in hollows in the impermeable granite on Mont Lozere. The ground is permanently waterlogged, which halts the decomposition of plants in the bog, the rate of organic accumulation exceeding the rate of decomposition. Partial decomposition releases organic acids into the surrounding bog and sphagnum moss actively produces H⁺. When granite bedrock becomes weathered, it produces acidic soil under normal conditions - so any weathered material washed into the bog from up slope will contribute to the acidic nature of the site, exacerbated by humic acid and organic acids produced by the heather, washed in from the surrounding moorland. Peat bog soils are therefore wet, acidic and as a consequence, low in nutrients, although rainwater will wash in soil and nutrients. Many bog plants are highly adapted. *Sphagnum* species have cell walls that actively pump out hydrogen and heavy metals ions, which accumulate. The sundew is insectivorous – bog soils are so nutrient poor that sundew acquires essential nutrients from insects. The peat bog is subject to occasional grazing. Peat bogs are vital to the hydrology of the area since they act as water stores for the dry summers when they keep the streams fed. The bog is a fragile habitat where several protected plants are found, so students must work with care and consideration.

(2) CONIFER FOREST

KEY SPECIES - *Norway spruce, Sitka spruce, European larch, Douglas fir, Scots pine.*

Mont Lozere was originally covered with native mixed deciduous (beech at upper elevations, oak and ash in the sheltered valleys) and scots pine. Deforestation was well advanced by Roman times, but depopulation in 500 AD led to an increase in natural woodland. Population and sheep number increase in the fifteenth century resulted in deforestation and severe soil erosion, being at its worst towards the end of the nineteenth century. Afforestation began with the help of compulsory land purchase. About two-thirds of the core area of the Parc National des Cevennes (PNC) is owned by the Office National De Fôret (OFN). The main species planted are a variety of conifer species, planted in mixed age stands to reduce fire and disease risk. The wood from the conifers is taken to saw mills to produce building material. Native stands of oak and beech are planted in places and are used for furniture- making. Fire is a problem in late summer, and there are

dams for use by fire-fighters and large fire-breaks. There is little ground cover in the coniferous forest, due to lack of sunlight reaching the forest floor and the deep acidic layer of slowly-decomposing needles. Many older trees are covered in lichens, which indicates high air quality.

(3) DECIDUOUS WOODLAND

KEY SPECIES – beech, mountain ash, silver birch.

Mont Lozere is dominated by beech woods with very little undergrowth due to the dense leaf canopy, characteristic of the species. Some beech woods in the area were planted and all have been managed in the past for fuel wood, often coppiced for firewood and the mature trees used for furniture. The woods also function as shelter for cattle during the harsher spring and autumn months. The beechnuts were of importance as part of the locals' staple diet (usually ground into flour) and to animals such as pigs, let loose into the woods to forage. Some beech woodland on Mont Lozere is secondary woodland, regenerated in sheltered hollows and valleys, away from grazing sheep and retaining a very natural appearance. Many of the trees show stunted growth, due to the thin soils and harsh winters on Mont Lozere.

(4) HEATHER MOORLAND

KEY SPECIES – common heather (ling), bilberry, cowberry, alpine ladies mantle, matt grass, red fescue grass, tormentille, heath bedstraw.

The heathland ecosystem is adjacent to the peat bog site, making a contrast between the two very convenient. On either side of the peat bog hollow, the ground is raised up and produces a well-drained heathland community. The site, which is at 1530m, is very exposed. Winters are extreme and the ground may be under snow for four months. Summers are hot and droughty. Low growing, shrubby species with xerophytic adaptations survive the harsh conditions at this site, and there is evidence of scrub encroachment by scots pine, due to the reduction in grazing by sheep since WWII. In previous years, there has been intense grazing pressure over the whole of the Mont Lozere massif. Transhumance practises saw peasant farmers from as far afield as Ales and Langogne bringing their sheep and cattle onto Mont Lozere to graze during the summer months, to escape the heat of the plains. The hills appeared white from a distance, not with snow but with sheep.

(5) MEADOW

KEY SPECIES - grasses, plantain, scabious, clover, yarrow, maiden pink, mountain pansy, ladies bedstraw, pheasant's eye narcissus, stitchwort, chickweed, yellow rattle.

This field lies within close walking distance of the centre. It is too steep for the farmer to take a cut of hay from, but cattle graze on the field throughout the summer. The biodiversity in this meadow is extremely high. The site is also excellent in a consideration of (extensive) organic farming practises, conservation and the role of land management in maintaining high biodiversity on sites such as these.

EQUIPMENT

- Map and compass
- Sweep net, sheet, pooter and collecting pots
- Spade and soil pH kit
- Tape measure
- 50cm x 50cm open frame quadrat
- 50cm x 50cm gridded frame quadrat
- 2m string (for nesting quadrat exercise) and soil skewer
- Point frame quadrat
- 2 meter rulers
- Plant identification charts
- Random numbers table
- Recording sheets

METHOD AND ORGANISATION OF STUDY

Select several sites for comparison. A good contrast can be seen between heather moorland and peat bog ecosystems; conifer forest and deciduous woodland; meadow and woodland – discuss this with your group leader. Either treat each habitat as a separate entity, or look at the transition between habitats, such as that seen between the peat bog and heather moorland, which are adjacent to one another. Students are best organised divided into groups of 3 or 4.

a) Studying the animal community

Many of the invertebrates in a woodland or forest ecosystem are found on tree leaves, and can be difficult to see. A simple way to sample them is to spread a white sheet under the tree and then to shake a branch over the sheet. A whole community of insects will fall onto the sheet. Quickly collect as many as possible using a pooter. Identify the invertebrates and record how many different species you find, and the numbers of each. This study can be done beneath different types of tree to compare what species they support.

To collect the invertebrates in meadow habitat, use a sweep net to brush through the undergrowth and collect organisms into pooters for identification. Again, identify the invertebrates and record how many different species you find, and the numbers of each.

The ground litter layer can also be sampled for invertebrates at each of the study areas. Using your hands or a trowel pick up a quantity of ground litter and scatter onto a white sheet or into a white tray. The different types of invertebrates are then identified where possible, their frequency counted and then replaced where you found them. Alternatively, bring samples back to the centre and rig up some simple tulgren funnels.

Calculate the Simpson's index of Diversity for each site using the following formula:

$$D=1-(\Sigma(n/N)^2)$$

B) Studying the plant community

Qualitative technique:

The simplest method of vegetation sampling involves recording presence or absence of a species at the site, done by a 'walk about' for a set time limit, e.g. 5 minutes. This technique is used when assessing sites quickly. This main disadvantage of this technique is that it gives no idea of the abundance of different species, only the species composition of a site.

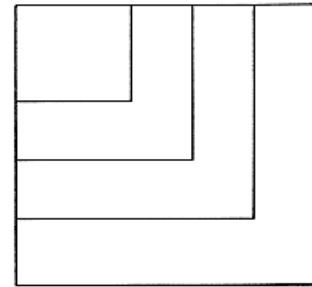
Quantitative techniques:

Quantitative sampling involves the use of quadrats – either open or gridded frame quadrats, or point frame quadrats, depending on whether the data collection technique is to be subjective or objective. Sampling a representative proportion of the site gives an indication of what is present across the whole site.

(i) **Selecting quadrat size using a nesting quadrat exercise.**

The choice of quadrat size is affected by the diversity of the ecosystem, and by the size of the organisms under investigation.

Place two meter ruler at right angles, somewhere representative in the study site. With the piece of string and soil skewer, make progressively bigger 'quadrats' eg. 10cm x 10cm, 20cm x 20cm, 30cm x 30cm to 1m x 1m and count the number of species in each. Plot the results – quadrat size on the x axis and species number on the y-axis.



Nestd Quadrats

(ii) **How quadrats should be placed in the study area(s).**

Systematic sampling:

If the ecosystems are adjacent to one another, and students are investigating an environmental transition such as between the peat bog and heather moorland, it is best to use a systematic sampling technique. When examining environmental transitions, use a transect. This may be a belt transect (using quadrats) or line transect (sampling at discrete points along a line), and may be continuous, or discontinuous - leaving a consistent gap between each sample point. If investigating vegetation along a transect, it is worthwhile investigating how the abiotic environment also changes along this transect, and influences or is influenced by the biotic community.

Random sampling:

If the ecosystems are discrete sites, students should use a random technique. Quadrats are placed in a 10m x 10m grid by using a random number table. This will avoid bias in the sampling that may otherwise see some areas being more heavily sampled than others. Students place quadrats at random and after assessing the vegetation cover, calculate a running mean for the number of species in each successive quadrat.

Quadrat number	Number of different species	Running mean (number of species / number of quadrats)
1	10	10
2	20	15

3	9	13
4	17	14
5	12	13.6
6	10	13
7	21	14.1
8	15	14.3
9	13	14.2
10	14	14.2

Continue doing quadrats until the running mean figure remains within 0.1 for three successive quadrats – this will ensure a data set which is representative of the area and in which all the plants are represented in the sample.

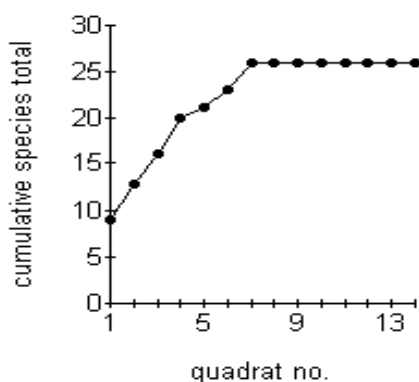


Figure 2
Graph indicating the running mean of the number of species in each successive quadrat

(iii) How to record vegetation cover in each quadrat:

Students should consider advantages and disadvantages of objective or subjective sampling techniques. If data is shared between groups it is essential to use an objective technique.

Objective sampling methods:

- Presence / absence – indicate with a tick or cross if a species is present in the quadrat;
- Counting;
- Biomass;
- % Frequency – Use a point frame quadrat or a gridded frame quadrat and record the number of 'hits' – use this to calculate the % frequency.

Subjective sampling methods:

- Percentage cover – estimate using open frame quadrats;
- Abundance scale, eg. DAFOR scale, where plants score D if dominant, A if abundant, F if frequent, O if occasional and R if rare.

Remember that whatever sampling technique is used, students must search their quadrats thoroughly. Species overlap one another and with percentage cover techniques, the cover will add up to more than 100% as species layer over the top and grow through one another. This is particularly relevant in sampling woodlands – remember the canopy cover.

RECORDING SHEET 4 – INTERRUPTED BELT TRANSECT (EG. MOORLAND TO PEAT BOG)

SITE.....

Species	% cover for each plant species – distance across transect (m)										
	0	2	4	6	8	10	12	14	16	18	20
Heather											
Cowberry											
Bilberry											
Heath bedstraw											
Fine leaved grass											
Sedge											
Sphagnum moss											
Sundew											
Tormentille											

Soil factors across transect:

Soil factor	Distance across transect (m)				
	0	5	10	15	20
Soil pH					
Soil texture					
Total soil depth (cm)					
Infiltration rate (cm/min)					

The Eagles Nest: Recording Sheet 3.

Habitat Investigation.

Site.....

Abiotic factors																			
Microclimate	Soil																		
Air temperature (oC)	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 15%; padding: 5px;">O {</td> <td style="width: 50%; border: 1px solid black; height: 20px;"></td> <td style="width: 35%; padding: 5px;">} L Depth =</td> </tr> <tr> <td></td> <td style="border: 1px solid black; height: 20px;"></td> <td style="padding: 5px;">} F Depth =</td> </tr> <tr> <td></td> <td style="border: 1px solid black; height: 20px;"></td> <td style="padding: 5px;">} H Depth =</td> </tr> <tr> <td style="padding: 5px;">A {</td> <td style="border: 1px solid black; height: 20px;"></td> <td></td> </tr> <tr> <td style="padding: 5px;">B {</td> <td style="border: 1px solid black; height: 20px;"></td> <td></td> </tr> <tr> <td style="padding: 5px;">C {</td> <td style="border: 1px solid black; height: 20px;"></td> <td></td> </tr> </table>	O {		} L Depth =			} F Depth =			} H Depth =	A {			B {			C {		
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Soil temperature (oC)																			
Air Humidity (%)																			
Wind speed (m/s)																			
Wind chill (oC)																			
Wind direction (NSEW)																			
Light (0 – 10)																			
Site factors:	Total soil depth =																		
Altitude	Soil texture in A horizon =																		
Relief (gradient)	Soil pH in A horizon =																		
Microrelief	Infiltration rate (cm / min.) =																		

Field Sketch

Biotic Factors		
Vegetation species present		Techniques used to measure vegetation species and abundance (equipment, how used, advantages & disadvantages):
Species	Abundance	
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
Past and present management		
Explanation (how does the biotic and abiotic environment interact?)		

Data Interpretation

Critical appraisal:

Data collection should be considered and evaluated in the light of the potential for:

- Human error;
- Equipment error;
- Problems inherent in the technique.

Follow up:

Species richness and species evenness are probably the most frequently used measures of the total biodiversity of a region. Species richness is the number of species present in the area surveyed. Species evenness is an indication of how evenly represented the species in a community are numerically.

One could imagine a habitat which has the greatest diversity in terms of species richness. However, another habitat could be described as being *richer* insofar as most species present are more evenly represented by numbers of individuals; thus the species evenness (E) value is larger. A process is often seen in tropical ecosystems, where disturbance of the ecosystem causes uncommon species to become even less common, and common species to become even more common. There may even be an increase in the number of species in some disturbed ecosystems but this may occur with a concomitant reduction in the abundance of individuals or local extinction of the rarer species.

- 1) Calculate species richness (number of species/area surveyed);
- 2) Discuss the limitations of data collection based on random sampling;
- 3) Discuss the problems involved in collecting data in the field;
- 4) What is an ecological niche? Discuss how niche theory accounts for the distribution and abundance of five organisms you have studied today.
- 5) Make notes about some of the potential effects of global warming on some of the plants, animals and ecosystems you have studied and visited today;
- 6) What is likely to happen to the peat bog in the light of potential climate change – suggest a range of possible scenarios;
- 7) Make a diagram of the carbon cycle and its applications to the ecosystems you have studied today;

Discussion Points

- How are the numbers and distribution of key species you have studied today affected by abiotic and biotic variables? How does this relate to the concept of niche?
- Describe how vegetation on Mont Lozere has changed in the last 10,000; 300 and 50 years.
- How is global climate change likely to affect some of the key organism you have studied on Mont Lozere today?

- How can we use evidence from peat bogs (pollen and preserved timber) to inform us about past climate?

Glossary:

Habitat:

the characteristic physical locality in which specified organisms live. Habitats have a definite geographical locality and a definite boundary. Common examples include a pond, a woodland, a meadow and so on.

Species diversity:

the number of different species in a particular area (i.e., species richness) weighted by some measure of abundance such as number of individuals or biomass.

Species richness:

the number of different species in a particular area

Species evenness:

the relative abundance with which each species are represented in an area.

Phylogenetic diversity:

the evolutionary relatedness of the species present in an area.

Morphological species concept:

species are the smallest natural populations permanently separated from each other by a distinct discontinuity in the series of biotype (Du Rietz, 1930; Bisby and Coddington, 1995).

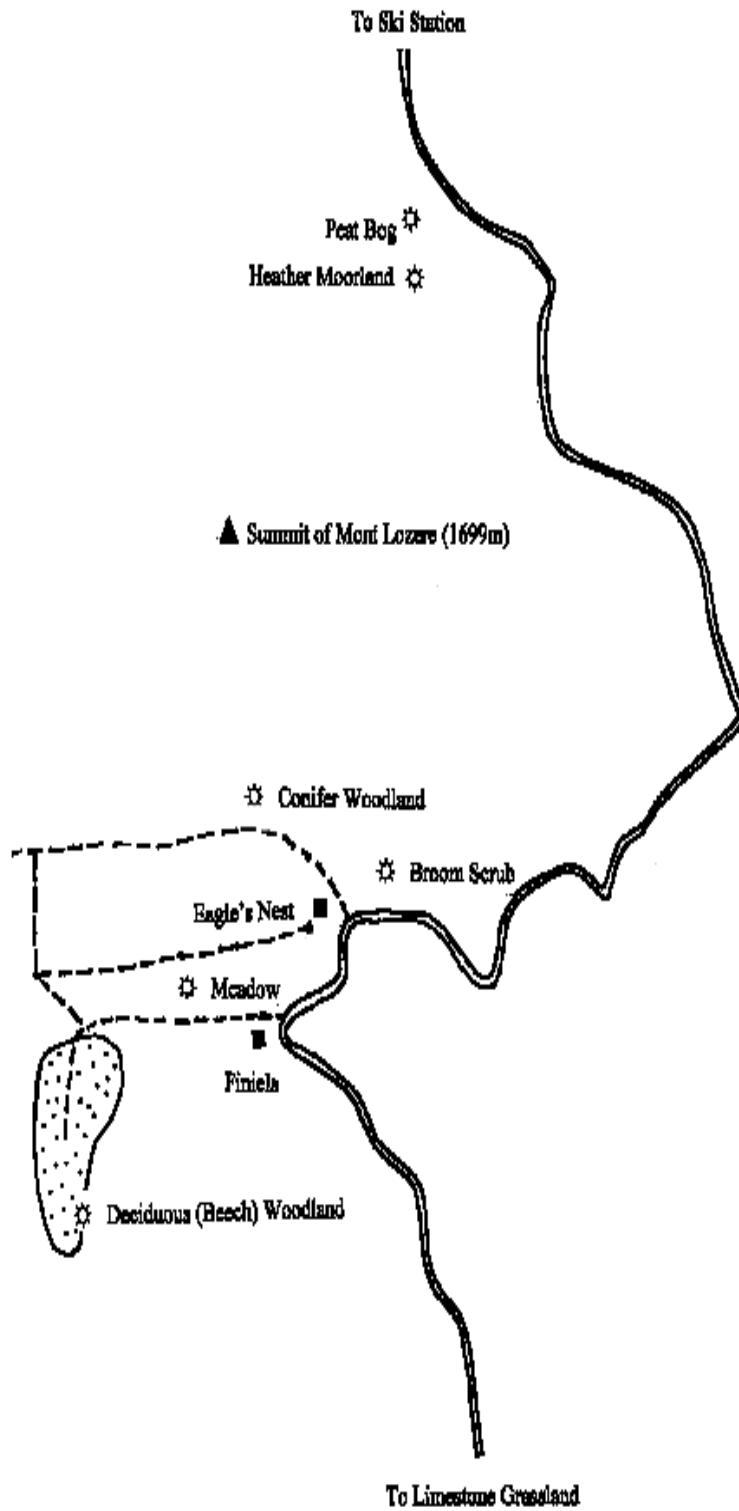
Biological species concept:

a species is a group of interbreeding natural populations unable to successfully mate or reproduce with other such groups, and which occupies a specific niche in nature (Mayr, 1982; Bisby and Coddington, 1995).

Ecosystem:

a community plus the physical environment that it occupies at a given time.

APPENDIX 1 Map of Field Investigation Sites.



APPENDIX 2. Adaptations of Selected Plant Species.

Moorland Plants:

Heather.

Cannot tolerate water logged soil – roots have higher than usual oxygen requirement for active transport of chelating agents (organic acids released from the roots). Therefore, needs a light, well aerated soil and will dominate on free draining mountain slopes. Tough, low-growing woody shrub – somewhat resistant to grazing and months of snow-cover.

Bilberry.

Deciduous shrub, but has green, photosynthetic stems so can continue to photosynthesise through winter.

Peat Bog Plants:

Sphagnum moss.

Huge water-holding cells in stems that help the plant survive should the bog dry during summer. Releases H⁺ that acidify surrounding soil and aid competition with other species.

Sundew.

Sticky tendrils on outside of leaves trap tiny insects that the plant is able to digest slowly – helps the plant survive in low-nutrient soil.

Purple moor grass.

Forms huge root mat – living part of grass ball is therefore above the water table, giving access to oxygen needed for active transport in the roots.

Woodland Plants:

Wood sorrel.

Produces 'shade' and 'light' leaves (larger surface area and thinner, and smaller surface area and thicker respectively) depending on light levels in the forest.

Broom Scrub:

Broom.

Root ball able to survive low-intensity burning used by farmers to control it (pyrophytic adaptation). Plant re-grows from original root stock after as little as six months.