

# Ecosystems and Succession

## (WJEC A2)



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### Teacher's Notes

This full day study will introduce students to the nature and study of ecosystems around the Eagles Nest field centre on Mont Lozere, how succession has caused those ecosystems to change since the last glacial advance, and more recently as a result of human activity. Because of its altitude, much of the Cevennes National Park and certainly that on Mont Lozere, has the same climatic climax vegetation as much of the British Isles – *temperate deciduous woodland*. The plagioclimax vegetation on Mont Lozere is heather moorland, so students can easily investigate ecosystems typical of the British Isles in this location!

### Key Specification Areas

Unit BY5: Environment, Genetics and Evolution.

5.7 Energy and ecosystems:

(b) Principles of succession as illustrated by the change from bare rock to woodland. Use of the terms primary and secondary succession, pioneers, sere and climax community.

### Ecosystem Change: Introduction and background.

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 weathers into slowly into coarse, thin, nutrient poor (due to leaching) acidic soils, with many large boulders.

During the last glacial advance, Mont Lozere was a periglacial environment, with permanent ice and snow fields on the summit. Tors and V-shaped valleys support this interpretation. 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 permafrost melted. When the climate began to gradually warm as the glaciers retreated, the bare rocks of Mont Lozere were slowly colonised. This process of gradual change in the plant (and animal) community in an area through time is called **succession**. In this case, because the start point in the sequence has no soil present, this is **primary succession**. Secondary succession occurs when there is a basic soil present, but no vegetation (for example, after a forest fire, or on waste land or farm land which had been ploughed). When this primary succession is on bare rock, the whole sequence from bare rock/sand/water to climax community is called a **sere**. The sequence of colonisation from bare rock to climax vegetation (eg. woodland) is called a **lithosere**. On bare sand (ie. sand dunes) this is called a **psammosere**. On open water this is a **hydrosere**, and around the margins of estuaries the succession sequence is called a **halosere**.

The first colonists of this rocky landscape would have been **lichens**. Highly specialised mutualists, (a lichen is 10% algae and 90% fungi and some species also have associated nitrogen fixing bacteria), 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 millimetre in several years. When the centre of the lichen colony dies, the 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. With wind distributed seeds and shallow roots needing little soil, these species thrive in these conditions. Later, as the soil thickened, grasses are over shadowed, literally, and out-competed by taller plants – the **biennial**, **perennial** and **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.

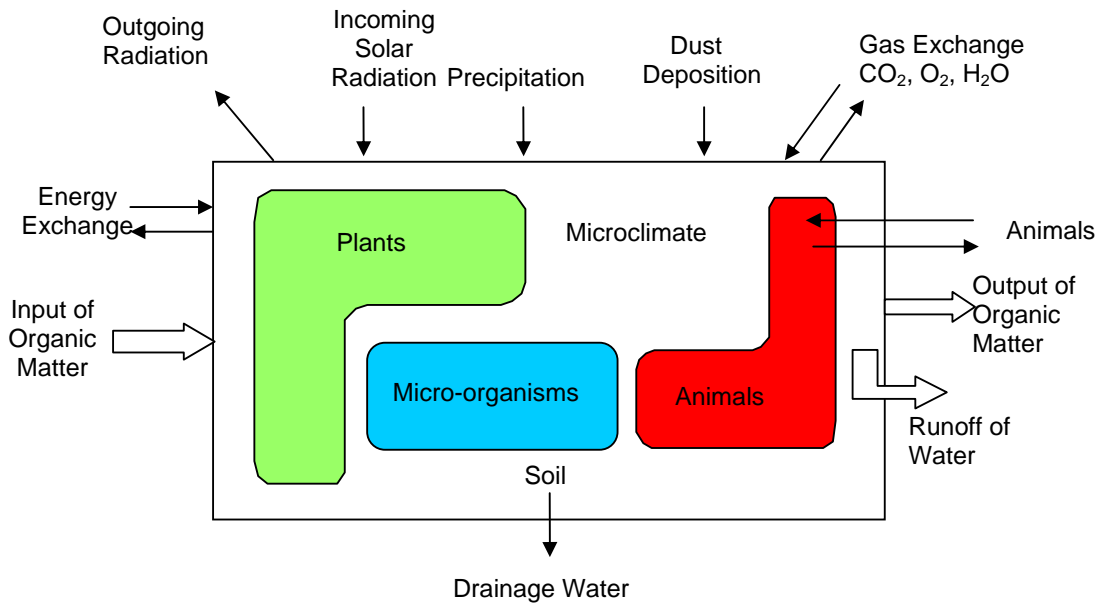
This temperate deciduous forest **biome** is typical of this latitude – it represents the **climatic climax community** – the dominant vegetation type which, without human interference, dominates in an area as a result of its climate. Other climactic climax vegetation types, or biomes, include tundra, coniferous forest (taiga), temperate grassland, desert, savannah and tropical rain forest.

Human activity can have huge impacts on climatic climax communities through burning, grazing of livestock, trampling and agriculture. Mont Lozere was heavily grazed by sheep brought to the upland pastures by transhumant farmers from the coastal plains every summer, for a period of several hundred years. Approximately 300,000 sheep were said to have been grazed on the massif every summer! This heavy grazing pressure has resulted in the development of a **plagioclimax** vegetation. The climatic climax vegetation was removed by forest clearance to open up areas of the mountain for grazing, and the never ending nibbling of millions of sheep teeth prevented the trees from re-growing. The dominant vegetation on Mont Lozere is now heather moorland. However, a lower level of grazing pressure since WW2 has meant Mont Lozere is now being re-colonised by trees, and scots pine, birch and beech trees are growing again on the summit plateau.

You will be taken to visit a beech woodland, which is typical of the **climatic climax vegetation** on Mont Lozere, around the Eagles Nest. Temperate deciduous woodland trees need plenty of sunlight, Warmth and moisture than many smaller plants. They need a long growing season for the growth and ripening of new shoots. Annual rainfall must be at least 350mm, and low temperatures prevent roots taking up soil moisture, resulting in physiological drought – so deciduous trees loose their leaves in winter to reduce evapotranspirative water loss when ground water is frozen. This sets the upper limit of altitude for deciduous trees which is visible on Mont Lozere above about 1300m. Above this altitude, deciduous trees are replaced by conifers, which are better adapted to lower temperatures in winter and a shorter growing season. Beech trees are better able to grow in the drier conditions experienced in the Cevennes during our relatively short but hot Mediterranean summer. However, other species of deciduous trees such as oak and ash are found at lower altitudes. This is complicated by the local geology, which on Mont Lozere is granite. Beech prefer the acidic, coarse soils produced by the weathering of granite rocks.

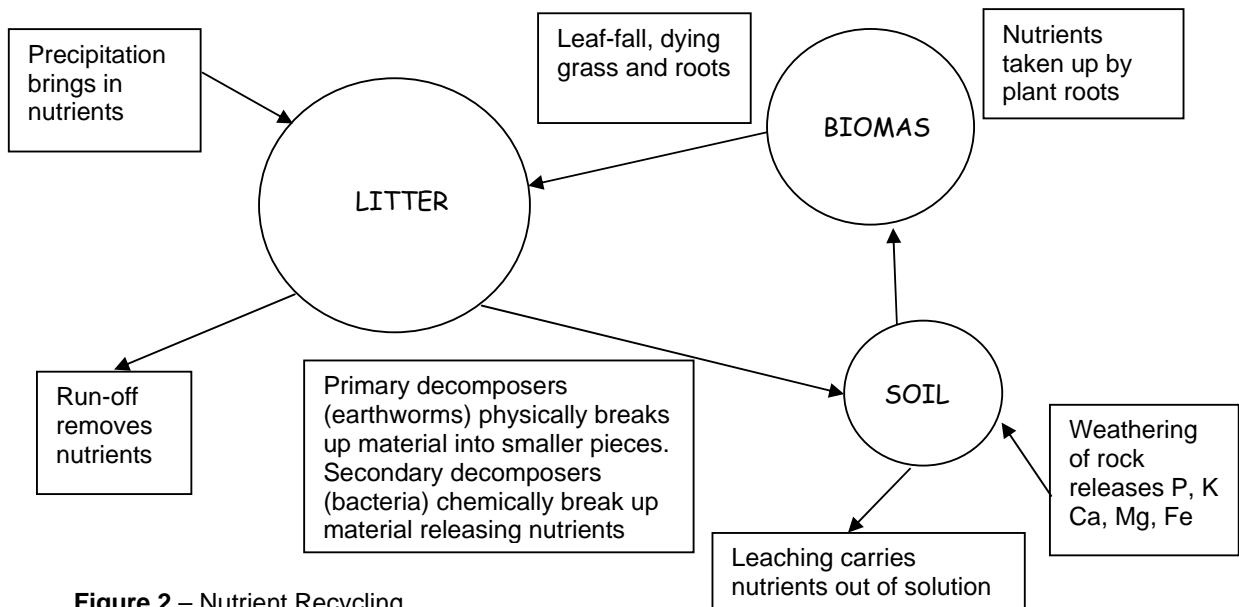
Beech has a very dense canopy, which enables it to out compete other species for light. It also produces a very thick layer of leaf litter every autumn, which decomposes very slowly. Much of the organic content in the

soil of a beech forest is therefore locked up in this leaf litter, again making it difficult for other species to compete with beech for soil nutrients. For these reasons, beech woodland is characteristically species-poor in terms of other ground flora. Low soil temperatures in the winter slows decomposition, and trees take up fewer soil nutrients through their roots as the ground water freezes.



**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 (figure 2):-



**Figure 2 – Nutrient Recycling**

→ = Nutrient Flow  
 ○ = Nutrient Pool

## Aims

- To investigate the principals of succession as illustrated by the change from bare rock to woodland.
- To introduce the terms primary and secondary succession, pioneers, sere and climax community.

## Equipment

Map and compass

Clinometer

2 ranging poles

Soil pH test kit and trowel

Infiltration can, mallet and water

Soil thermometer

Soil skewer

Soil auger and spade

Soil texture chart

Tape measure

50cm x 50cm gridded frame quadrat

Meter ruler

Plant identification charts

Random numbers table

Alcohol air thermometer

Whirling hygrometer and conversion chart

Hand-held anemometer

Light meter (environmental comparitor)

Recording sheets

Lux meters

Digital camera

## Sites:

1) **Temperate deciduous woodland** KEY SPECIES – beech, rowan, silver birch.

These are beech woods with very ground layer due to the dense leaf canopy characteristic of the species. Most beech woods in the area were planted and have been managed in the past for fuel wood. The trees were often coppiced for firewood and the mature trees used for furniture. The woods also provide 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. The site is quite a large wood on a steep, boulder-strewn slope. Many of the trees appear to be of a similar age, implying planting at some point – however, there are many mature specimens in the wood. Cattle still roam freely in the wood at certain times of year. The bedrock is granite.

2) **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 he occasionally grazes cattle on the field throughout the summer. The species diversity in this meadow is extremely high and again gives the opportunity to discuss plagioclimax ecosystems. The site is

also excellent in a consideration of low intensity (extensive) organic farming practises, conservation and the role of land management in maintaining high biodiversity on sites such as these.

### 3) Broom scrub KEY SPECIES – Mediterranean and purging broom, grasses.

Virtually any area of broom near to the centre can be studied to show this important intermediate community in the local succession sequence, and to contrast between other neighbouring ecosystems. Broom is a tough, shrubby plant that grows up to 2m in height. It has little nutritive value and cattle find it very difficult to eat and digest. The local cattle – Aubrac – are less selective grazers than modern varieties of cattle seen in the valley such as Charolais, and are more likely to be seen grazing the rough broom scrub on the higher fields. The broom scrub is burnt at approximately ten- year intervals, to remove the dense broom ‘canopy’ and allow smaller herbaceous plants and grasses to flourish for a short period. This practise called ‘ecobuage’ turns practically useless rough grazing into more productive grazing for while, and farmers move their livestock around the valley accordingly.

### 4) Scree KEY SPECIES – Mosses, lichens.

The scree slopes behind the Eagles Nest are ideal for studying the initial stages of succession, as would have appeared on Mont Lozere at the end of the last glacial advance. Please be very careful working on the rocky slopes.

## *Method and organisation of study:*

### (1) ABIOTIC FACTORS AFFECTING THE ECOSYSTEM:

#### ***Microclimate investigation:***

The vegetation in an ecosystem will modify and be modified by microclimate. Standardisation between groups is essential as data will be shared. At each site, set up the microclimate equipment as follows:

- ✓ Drive a ranging pole into the ground and attach an alcohol air thermometer using an elastic band, at 1.50m above the ground. Turn the thermometer out of direct sunlight;
- ✓ Put a soil thermometer in the ground to a depth of 5cm.

After five minutes equilibration time, at 15 minute intervals, record the microclimate at the station. Groups should take these readings at the same time. Read the air and soil temperatures. Measure light using the light environmental comparitor – held facing and at the same level as the air thermometer. Measure wind speed (m/s), air temperature (°C) and wind chill (°C) using the wind watch, held facing into the wind. Measure air humidity using a whirling hygrometer. Record all these factors clearly on recording sheet 1.

#### ***Gradient / relief investigation:***

Place students 10m apart and use ranging poles (or students of the same height) to line up clinometer. Take reading (sample every 10 m if desired and take average). The angle of slope affects drainage and soil depth. Steeper slopes increase the rate of through flow and surface runoff leading to an increased likelihood of mass movement and soil erosion. Soils on steep ground tend to be thin and relatively dry. Record the gradient of the site on recording sheet 1.

#### ***Aspect and altitude investigation:***

Using a compass or a map, each group of students should establish the aspect of the site. South-facing slopes tend to be comparatively more productive than north facing slopes due to higher temperature and more direct incident radiation. Establish the altitude by finding the nearest spot height or contour marker on the map to the study site. Record the aspect and altitude of the site on recording sheet 1.

### **Soil investigation:**

Using an auger, each group should extract a soil sample from the A-horizon at a representative site in the ecosystem, and establish soil pH and soil texture. They should measure the thickness of the organic horizon and the total soil depth. Infiltration rate can be used as an indirect measure of soil moisture. Hammer an infiltration can into the soil to a depth of 5cm. Fill the can to the top with water and record how far the water level drops every minute for a five-minute period. Record all these factors on recording sheet 1.

## (2) STUDYING THE PLANT COMMUNITY

### **(USEFUL NOTES ON VEGETATION SAMPLING FOR FIELDWORK INVESTIGATIONS!)**

#### **Qualitative techniques:**

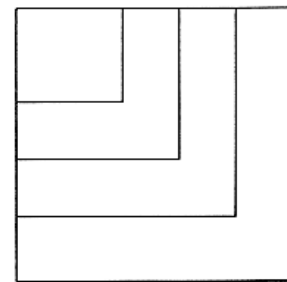
The simplest method of vegetation sampling involves recording presence or absence of a species at the site (usually done by a 'walk about' for a set time limit, e.g. 5 minutes). This technique is used by English Nature when assessing sites, and is called a 'Phase One' survey. This main disadvantage of 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 appropriate open frame 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. Using two metre rulers, make a right angle 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 2m x 2m and count the number of species in each. Plot the results – quadrat size on the x axis and species number on the y-axis.



Nested Quadrats

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

#### Systematic sampling:

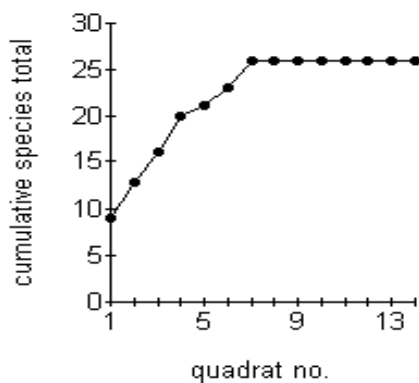
If the ecosystems are adjacent to one another, and students are investigating an environmental transition (in this case in soil factors including moisture and acidity) such as between the peat bog and heather moorland, it is best to use a systematic sampling technique. When examining environmental transitions, 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. Recording sheet 4.

#### Random sampling:

If the ecosystems are discrete sites, students should use a random technique. Quadrats are placed in a 10m x 10m grid according to 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. They will be able to collect a representative sample of the site:

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



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

Carry on 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. Recording sheet 3a, b or c.

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

Students need to consider the advantages and disadvantages of objective or subjective sampling techniques. If data is to be shared, it is normally better 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.



Scrub plants (woody)										
Trees and saplings										

**Follow Up Work and Discussion Points**

Students should make notes under the following headings, contrasting the communities at the initial stages and final stages of succession. This completed version is for your guidance:

<b>Abiotic and biotic factors:</b>	<b>Characteristics of the pioneer community:</b>	<b>Characteristics of the climax community:</b>
Abiotic environment: <i>Soils</i>	Nutrient poor, thin soils with extreme pH; dry with low organic content.	Nutrient rich, thick soils; high organic content with good water-retaining characteristics.
Abiotic environment: <i>Microclimate</i>	Extreme and often harsh microclimate with extremes of temperature, wind exposure.	More equitable microclimate without extremes of temperature between winter and summer.
Species diversity	Low	High
Growth rate of individual organisms	Fast	Slow
Population growth rate	Fast (J-shaped growth curve)	Slow (S-shaped growth curve)
Life-cycles of organisms in these stages	Organisms generally short-lived. May pass through metamorphic stages with short adult stage.	Organisms generally longer-lived. High degree of parental investment in the young. Adults longer lived
Size of organisms	Generally small organisms	Range of sizes to occupy range of niches available
Adaptation of organism	Generalist	Specialist
Niche specialisation	Low level of specialisation	High level of specialisation
Gross productivity of ecosystem	Low	High
Stability of ecosystem	Unstable, susceptible to change	Stable, more resistant to change
Competition between organisms	More inter-specific	More intra-specific
Complexity of food chains	Chains short and simple	Food webs complex and extensive

## DISCUSSION POINTS:

### *Primary Succession on Scree:*

- Calculate the **means** for the microclimate variables. Calculate a **Mann-Whitney U-Test** with this data to ensure that there is a significant difference between the sites for all of the microclimate factors. *How does the microclimate change as the lithosere advances towards its climactic climax community?*
- Calculate means for the soil depth and soil moisture measurements. *How does the soil change as the lithosere advances towards its climactic climax community? Do your results fit your hypotheses?*
- Calculate the **modal values** for the different DAFOR Scores, at each seral stage. *Which vegetation community dominated at each seral stage?*
- Calculate the **mean** plant height at each seral stage. *How does this change – does this fit the hypothesis?*
- *How does **species richness** change through the seral stages? Is the change linear? If not, can you think why this may be?*
- Now form the links between the abiotic environment, the soil factors and the biotic communities present at each seral stage. *How is species richness affected by a gradual change in the microclimate and the soil structure. At which point do biotic factors such as competition for resources (e.g. Light) outweigh the importance of the abiotic environment and soil factors in defining the nature of the biotic community?*
- *Were there any species that were only found within a particular seral stage? Were there any species that were found at all four sites? Is it a better strategy to be a generalist or a specialist? As successional sequences progress, would you find more specialists or generalists?*