Habitats and Biodiversity on Mont Lozere.

(OCR AS)

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This unit introduces students to a range of concepts and sampling techniques essential to the understanding of biodiversity and how it is measured.

KEY SYLLABUS AREAS:

2.3.1 Biodiversity. Biodiversity is an important indicator in the study of habitats:

(a) Define the terms: species, habitat and biodiversity;

(b) Explain how biodiversity may be considered at different levels; habitat, species and genetic;

(c) Explain the importance of sampling in measuring the biodiversity of a habitat;

(d) Describe how random samples can be taken when measuring biodiversity;

(e) Describe how to measure species richness and species evenness in a habitat;

(f) Use the Simpson's index of diversity (D) to calculate the biodiversity of a habitat, using the formula D=1-(Σ(n/N)2)

(g) Outline the significance of both a high and low value of Simpson's index of biodiversity (D);

(h) Discuss current estimates of global biodiversity.

2.3.4 Maintaining Biodiversity. Maintaining biodiversity is important for many reasons. Actions to maintain biodiversity must be taken at local, national and global levels.

(a) Outline the reasons for the conservation of animal and plant species, with reference to economic, ethical and aesthetic reasons;

(b) Discuss the consequences of global climate change on the biodiversity of plants and animals;

(g) Discuss the significance of environmental impact assessments (including biodiversity estimates) for local authority planning decisions.

Practical skills (HSW5) development:

Collection of quantitative data:

Measure the species richness and species evenness in a habitat;

Calculate Simpsons index of Diversity for a habitat

Investigate the limitations of data collection based on random sampling;

Investigate the problems involved in collecting data in the field.

Introduction

Biodiversity, or biological diversity, is all life on earth; the number, variety and variability of all living organisms (Groombridge, 1992). Biodiversity can be considered at different levels. The diversity of species (animals which reproduce and produce fertile offspring), and the variety of genes within a breeding population (the genetic biodiversity, which may be high or low) are key to considering biodiversity. Biodiversity may also be considered at the habitat level, with different habitats containing typical organisms, and some habitats being more biodiverse than others. Tropical rainforests are typically described as having a high biodiversity when compared with tundra, BUT the species which are represented in these habitats are exclusive to those habitats and so neither habitat can be considered of greater importance to biodiversity! (Unless we are obsessed with only numbers of species). Approximately 1.6 million species have been identified globally:

- 287,655 plants including:
  - 15,000 mosses
  - 13,025 ferns
  - 980 gymnosperms
  - 199,350 dicotyledons
  - 59,300 monocotyledons
- 74,000-120,000 fungi
- 10,000 lichens
- 1,250,000 animals including:
  - 1,190,200 invertebrates
    - 950,000 insects
    - 70,000 molluscs
    - 40,000 crustaceans
    - 130,200 others;
  - 58,808 vertebrates
    - 29,300 fish
    - 5,743 amphibians
    - 8,240 reptiles
    - 10,234 birds

- 5,416 mammals

One early estimate by Terry Erwin (an entomologist with the Smithsonian Institute) put global species richness at 30 million, following extrapolations from the numbers of beetles found in a species of tropical tree. In one species of tree, Erwin identified 1200 species of beetle, of which he estimated 163 were found only in that tree. Based on the 50,000 species of tropical tree, this would suggest that there are almost 10 million species of beetle alone, just in the tropics!

The Cevennes National Park was established in 1970, partly in recognition of it's high level of biodiversity. It now welcomes over 800,000 visitors each year. The Park boundaries are outlined below – in France, National Parks are sub-divided into core and perifora lzone, facilitating the prioritisation of different management approaches in the zones. For example, conservation and protection of rare species and habitats is prioritised in the core zone, and sustainable development for tourism in the periforal zone. Since 1984, the whole of the Park has also been designated a UNESCO Man and the Biosphere reserve. The total area of the Park is 3,210 km^2. The core zone area 91,279 Ha. The core zone contains land owned by the PNC (3%), sectionnaux (7%), domaniaux (30%) and privately (60%).

The altitude of the Park ranges from 378m (Sainte-Croix-Vallee-Francaise) to 1,699m (Mont Lozere). This altitudinal range influences the climate – we have areas experiencing oceanic, Mediterranean and continental climate conditions. On Mont Lozere, winters are cold, bright and dry (100+ days of frost/year), whilst summers are hot and dry. The main rainfall comes in the spring and autumn, which can also be very windy, influenced by the proximity of the mistral winds in the Rhone valley.

The PNC has five different geological areas which contributes to the Parks' high biodiversity:

1) The Causses, a limestone plateau to the south east of Mont Lozere, divided by large river gorges, making up the Causse Mejan, Causse Sauveterre, Causse Noir and Causse Larzac – the average altitude of this area is 1000m. It is primarily used to raise the local sheep, the Raiole, for meat and milk;

2) Mont Lozere, a granite massif rising to 1,699m. Used to raise the local beef cattle, the Aubrac, and as a major transhumance destination for sheep from the southern plains;

3) Montagne du Bouges, a granite and schist massif to the south of Mont Lozere, rising to 1,421m. Used to raise sheep and cattle, and for timber production;

4) Vallees du Gardons, a series of valleys cut into schist to the south of Mont Lozere. Used to raise Caprin goats, and sheep and for the production of chestnuts and honey;

5) Mont Aigoul and Lingas, a granite and schist massif in the far south of the PNC, rising to 1,565m. Used for timber (pine, spruce, beech, fir) and some transhumance in the past.

The PNC is home to 89 mammal species, 208 bird species, 17 reptile species, 18 amphibian species and 24 species of fish. The PNC has reintroduced roe and red deer, mouflon, beaver, black and griffon vultures and capercaille. Many species have returned to their original habitats since the formation of the PNC, including black woodpeckers, Tengmalm's Owl, otters and herons. The PNC is notable for its insect biodiversity – over 2000 species. This is due to traditional farming methods;

Because of the range of rock types and altitudes found in the PNC, the vegetation is very varied. In the sub-alpine conditions on the top of Mont Lozere are found a range of rare alpine species and broom. In the Mediterranean conditions found in some of the southern valleys grow fig and holme oak. The Causses support a huge diversity of alkalis-loving plants and the peat bogs support carnivorous plants including sundew. Of the 400 species of plant protected under French law, 35 can be found in the PNC, which has over 2,250 species in total. 48 species found in the Park are endemic, found nowhere else in the world.

Mont Lozere is an extreme habitat! The climate swings dramatically between an alpine in the winter and a Mediterranean 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 to the slow rate of weathering.

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 it's 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:

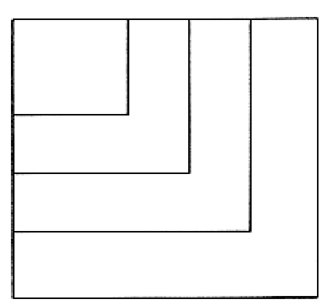
The simplest method of vegetation sampling involves recording presence or absence of a species at the site, done by a 'walk about' for a set time limit, e.g. 5 minutes. This technique is used when assessing sites quickly. This main disadvantage of this technique is that it gives no idea of the abundance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



Nestd Quadrats

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.

(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.

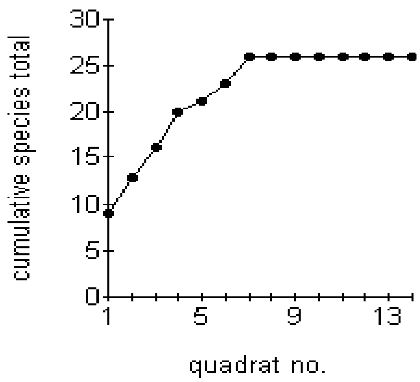


Figure 2
Graph indicating the running mean of the number of species in each successive quadrat

(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.

Vegetation sampling summary:

(1) Decide quadrat size – carry out the nesting quadrat exercise;
(2) Choose sampling method – random or systematic;
(3) Decide how you will record vegetation cover: objective or subjective? % cover or % frequency? Choose your equipment accordingly – point frame, gridded or open quadrats;

The Eagles Nest. Recording Sheet 1.

RANDOM QUADRATS - % cover (subjective) or frequency (objective)

Site ……………………………………………………………………

Species	% cover or frequency of each species in quadrat										Mean
	1	2	3	4	5	6	7	8	9	10	% cover

The Eagles Nest. Recording Sheet 2 .

RANDOM QUADRATS – Objective counts

Site ……………………………………………………………………

Species	Number of individuals of each species in quadrat										Mean number of species
	1	2	3	4	5	6	7	8	9	10	

The Eagles Nest: Recording Sheet 3.

Habitat Investigation.

Site…………………………………..

Abiotic factors		
Microclimate		**Soil**
Air temperature (oC)		
Soil temperature (oC)		O { } L Depth = } F Depth = } H Depth =
Air Humidity (%)		A {
Wind speed (m/s)		B {
Wind chill (oC)		C {
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 and Discussion Points

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) Calculate the Simpsons index of Diversity for each habitat studied:

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

What is the significance of your answer? Remember that a higher value for Simpsons indicates a high level of biodiversity. Remember that the Simpsons index of Diversity also gives you an indication of evenness of species representation in a community. A higher value also indicates relative equality of numbers of all representatives;

3) Discuss the limitations of data collection based on random sampling;

4) Discuss the problems involved in collecting data in the field.

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).

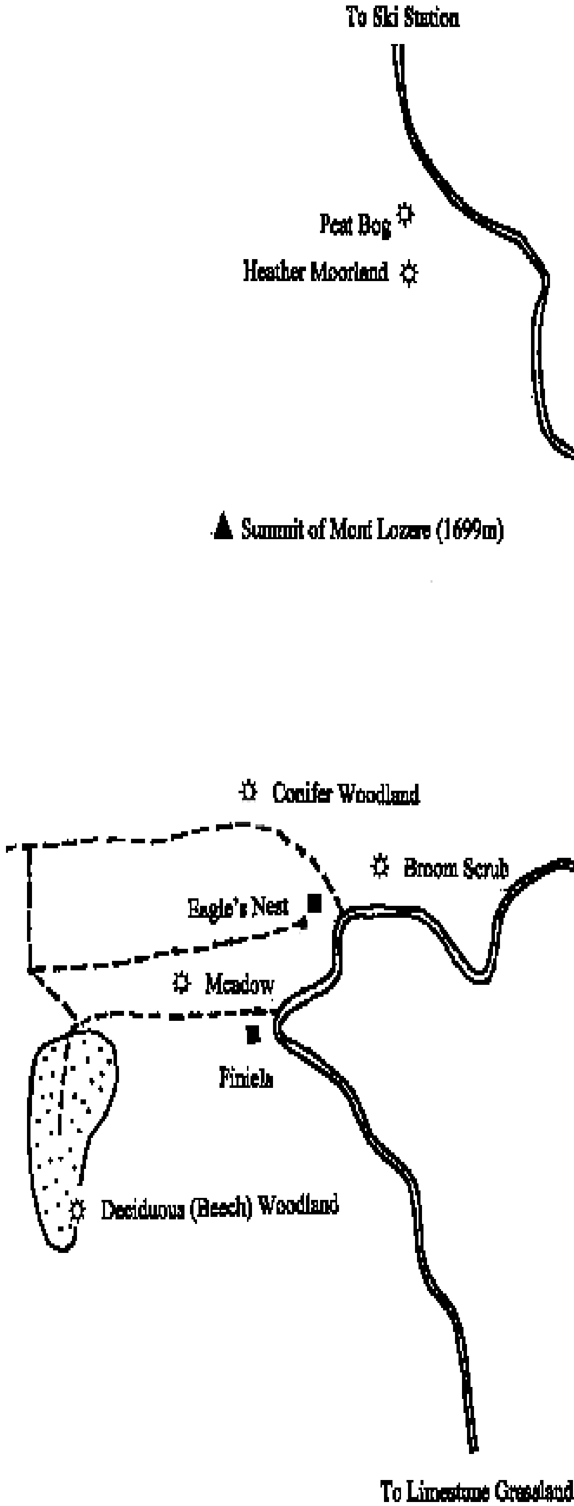
Biological species concept:

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.