Discussion

Abiotic parameters and how they may affect vegetation

SLOPE ANGLE: The slope angle of both slopes should be approximately equal.
LIGHT INTENSITY: Overall, this is higher on the SFS as it directly faces the sun, whereas the NFS will be in shade for a large part of the time. These results are not found on a cloudy or overcast day or in summer when the sun is higher.
AIR AND SOIL TEMPERATURE: Overall these are higher on the SFS as it directly faces sun and receives directly from the sun's incident rays. These results may not be found on a cloudy or overcast day.
SOIL pH: Soil pH is affected by differences in the vegetation, slope aspect and soil depth.
SOIL DEPTH: This is affected by differences in vegetation, slope aspect, soil temperature, erosion and other factors.

In summary the differences are as follows:-

	NFS	**SFS**
Slope angle	equal	equal
Light intensity	lower	higher
Air temperature	lower	higher
Soil temperature	lower	higher
Soil pH	lower	higher
Soil depth	greater	shallower

Aspect will also affect the biological and physical characteristics of the vegetation community:-

	NFS	**SFS**
Vegetation height	taller	shorter
% vegetation cover	higher	lower
Species diversity	lower	higher
Species abundance	variable depending on species	variable depending on species

How the physical factors affect the biological and physical characteristics of the vegetation

Light
Plants can be divided into two categories according to how they are adapted or tolerate light intensity. Plants can be *light* demanding such as dandelion, mouse-eared hawkweed or daisy and as such are more usually found on the SFS. Plants may also be

Shade tolerant such as violet, celandine and wood sorrel and thus are more commonly found on the NFS.

Plants are adapted to different light intensities in various ways:-

1. They may be adapted to the habitat in which they grow. Shade tolerant herbaceous in woodlands or hedgerows may leaf out early in the season before the trees. They may also have larger, thinner leaves with the chloroplasts spread between the palisade and spongy mesophyll layers to capture the most light. Light demanding plants may require short grassland or open waste ground which receive a lot of light (parsley piert). Their chloroplasts will be concentrated in the palisade layer of the leaves, and this layer will be thicker.

2. A plant's growth form may be adapted, eg. a basal rosette form is saucer shaped to intercept light (daisy). This adaption allows the plant to compete with other plants for both light and also space. By covering a relatively large area of ground more nutrients are available and because the ground is covered at ground level water loss is reduced.

Temperature

Diurnal and annual temperature fluctuations are greater on the SFS than on the NFS. Diurnally, it has been found (Anderson and Shimwell) that air temperature can vary from 0°C at 5am to 40°C at 12am on the SFS compared to O°C at 5am to 28°C at 2pm on the NFS. Soil temperatures at a depth of 2cm ranged from 12° to 33°C on the SFS compared to 8° to 18°C on the NFS. This effect is exaggerated in winter especially if snow is lying. Snow has insulating properties. Snow takes longer to melt on the shaded NFS and so the vegetation is buffered from higher midday temperatures and lower night-time temperatures. In contrast, snow on the SFS melts faster in the direct sun which allows the plants to experience much higher midday temperatures and extremely low night-time temperatures.

Temperature affects the chemical processes within a plant ('degree days : A higher cumulative temperature increases the physiological and metabolic processes in a plant). ie. a higher temperature increases growth. A soil temperature of greater than 5°C is required for plant growth ie. a 'growing day'. The growing session in a limestone dale varies between 220 and 247 days per year, depending on attitude, although aspect may also have an effect as temperatures on the NFS may not reach 5°C as often as on the SFS.

However, germination is the part of the plant's life cycle which is most dependent on temperature. A period of chilling is necessary for germination to occur in many plants. Chilling reduces the abscisic acid content of the seed coat and enables the embryo to make gibberellic acid which makes food reserves available to the embryo. The optimum germination temperature varies from plant to plant and many limestone plants avoid the extreme physical conditions found on limestone slopes in summer by having a relatively low optimum germination temperature, thus germinating early in the season and completing their life cycle in spring.

Therefore, fluctuations in temperature may provide the optimum germination conditions for many plants. The plants generally most dependent on temperature fluctuations for germination and thus for their survival are annuals and biennials. Winter and summer annuals and biennials are often pioneer or weed species invading bare ground. These plants are, therefore, ideally adapted for the conditions found (bare ground and fluctuating temperatures) on whitlow grass, rue-leaved saxifrage, purging flax, hairy bittercress and parsley piert.

The climate of Britain is considered to be a maritime climate (mild and wet). However, local conditions produce areas with significantly different microclimates which affects the local distribution of plants. The Peak District limestone dales are one such place. The habitat of the SFS of a limestone dale can be compared to that in a mediterranean climate. Physically, the SFS is hot and dry with sunny conditions and shallow soil – conditions very similar to the Mediterranean. The plants found in such conditions are similar in the type of plant and the xerophytic adaptions developed, eg. wild thyme is found in the med and the SFS. The soil of a SFS in winter may be cold but it also tends to be dry. Plants can tolerate cold but not damp, again conditions similar to the Mediterranean. Many culinary herbs grown in Britain are of Mediterranean origin and need to be grown in 'mediterranean' conditions ie. conditions similar to those of a SFS limestone dale.

Soil pH

Soil pH is affected by

(i) Parent rock
(ii) Translocation (leaching and eluviation) rate
(iii) Amount of humus

Minerals from the parent rock contribute to soil formation thus affecting the pH. A parent rock high in calcium such as limestone will increase soil alkalinity.

Translocation is the removal of minerals and nutrients from the surface horizons of the soil by the action of water moving down through the soil profile. Soil materials are either removed in solution (*leaching*) or in suspension (*eluviation*). One of the minerals which is most easily removed from the top soil layers is calcium, the removal of which makes the upper layers of the soil more acidic. Translocation, therefore, acidifies the soil; the rate of acidification is affected by rainfall and evaporation (the movement of water up to the soil surface through capillary action). A higher rainfall will result in a higher translocation rate and therefore increased soil acidity. A higher evaporation rate (caused by higher temperatures) will result in the faster deposition of calcium salts, normally dissolved in soil water, near the surface of the soil. The reversal of the translation process means that calcium ion concentration in the upper soil layers is higher and thus soil alkalinity is increased ie. soil acidity is reduced.

Translocation is more severe at the top of a slope than at the bottom. The bottom of the slope receives ions leached from above. Translocation is also more severe on a wetter versus a drier slope.

Humus or humic acid is a layer of decaying vegetation at the top of the soil, the depth of which depends on the decomposition rate. Decomposition is the process whereby organic, woody material is changed into inorganic chemicals such as nitrates, sulphates, phosphates and other plant nutrients. The rate of decomposition is reduced at lower temperatures and at a low pH as bacterial activity is inhibited.

Soil pH differs between the north and south-facing slopes of the limestone dale because:-

1. Parent rock is the same on both slopes and has little affect, although it may increase the alkalinity of the shallower soil of the SFS.

2. Effective translocation rates are different on the two slopes. Although rainfall is the same on both slopes, evaporation is higher on the SFS due to

higher temperatures. Therefore, soil on the SFS is less acidic. This effect is exaggerated by the shallower soil of the SFS.

3. Humus development is higher on the NFS because there is a greater volume of vegetation available for decay (higher plant cover and taller vegetation). There is also more humus because the rate of vegetation decay is slower due to lower temperatures and lower pH.

Soil pH affects the plants found. Plants can be divided according to their ability to tolerate different pH levels:-

1. **Calcicoles** tolerate lime and are adapted to a high pH.
2. **Calcifuges** can not tolerate lime and are adapted to a low pH (ie. take re**fuge** from a high pH).

Most plants tolerate a wide range of pH's but others are very specific in their adaptations and are calcicoles or calcifuges. The reason for this is that in acidic soils metal ions are much more mobile and freely available for uptake by plants than in alkaline soils. Calcicoles, in more alkaline soils, have developed an efficient system for the uptake of essential plant salts and minerals including iron and magnesium. Some calcicoles eg. have developed secretory glands for eliminating excess calcium. These usually appear as white dots on the leaf margin.

Calcicoles are not found in acidic soil because they cannot tolerate some of the metal ions which are more mobile and freely available there. The Al, Zn and cadmium which would be absorbed by calcicoles would poison theseplants. Calcifuges are not poisoned by these toxic heavy metals because they have evolved screening mechanisms which ensure the heavy metals don't interfere with normal enzyme activity.

Calcifuges would not survive in more alkaline soils because insufficient essentialsalts and minerals, including iron and manganese, are available and calcifuges have not evolved efficient mechanisms for mineral uptake.

Calcifuges	**Calcicoles**
Bilberry	Thyme
	Bird's Foot Trefoil
	Limestome bedstraw
	Purging flax

There could be a difference in soil pH from top-to-bottom of the slope especially on the NFS. As translation occurs and minerals are washed up from the top of the slope to the bottom, so pH will become relatively more acidic at the top of the slope.

Soil depth

Soil depth is, on average. greater on the NFS than on the SFS. This is an indirect result of the deeper humus layer on the NFS (see above) and also because there is less soil erosion on the NFS than on the SFS. Soil erosion is less on the NFS because there is less droughting due to lower temperatures and there is less bare ground on which wind and rain can act. A greater vegetation cover on the NFS also means the soil is bound more tightly by roots.

The deeper soil also takes longer to heat up and cool down thus buffering the vegetation further from extreme temperature changes.

There is also a top-to-bottom difference in the soil depth on the two slopes. Soil may be deeper at the bottom of the slope than at the top, as soil washed down from the top of the slope will come to rest at the bottom.

Soil depth will have an indirect effect on nutrient on water availability – often more nutrients and water are available where soil depth is greater.

Differences in the biological characteristics of the plant community due to aspect

Vegetation Height

The vegetation growth tends to be better on the NFS for two main reasons:-

1. The different species found on the two slopes have different growth forms adapted to the conditions in which they live.
2. Physical conditions are more suited to growth on the ~~SFS~~ NFS as conditions are less extreme.

Plants are able to grow taller on the NFS due to the damper conditions, less temperature extremes and the greater soil depth. These conditions are suited to tall growing plants such as grasses.

In contrast, plants growing in the harsh physical conditions of the SFS must be suitably adapted. This means plants on the SFS tend to be slow growing, creeping, xerophytic and adapted to high light availability. Such plants often display a basal rosette growth form which is a very low or flat growth form.

One factor not considered is that the vegetation may be shorter on the SFS due to a higher grazing pressure. Sheep may prefer the vegetation and the climate of the SFS and therefore, spend more time there.

Vegetation cover

This is lower on the SFS for two main reasons:-

1. The more severe growing conditions of the SFS reduce the growth of the vigorous and competitive species such as grass leaving space and light for many other species. Such plants, though tolerant of the heat and water loss, are not so vigorous and do not spread as effectively as grasses (which use seed and rhizomes).
2. Many of the plants found on the SFS are annual (germinating in winter or spring) which complete their life cycle by June thus avoiding the most extreme of the summer conditions. This very rapid life cycle creates bare patches of ground from June onwards.

Species diversity

Species diversity tends to be higher on the SFS where there is less competition from the grasses. The shade cast by the taller grasses on the NFS can out compete and eliminate many species. The greater area of bare ground and smaller plants of the SFS allow more species to invade and germinate.

Abundance

Species abundance differs between the slopes due to the effect aspect has on the physical (light, temperature and soil) conditions and how each species is adapted to those conditions. Abundance is also affected by the competitive balance of the plant community.

Plants which are commonly more abundant on the:-

SFS	NFS	Competitive adaptation
	Mosses	Damp and cool and desiccation tolerant. Shade tolerant.
	Violet	Shade tolerant – often found in woods
	Bilberry	Calcifuge
Thyme		Calcicoles
Bird's Foot Trefoil		
Limestone Bedstraw		
Purging Flax		
Daisy		Light tolerant
Mouse-ear hawkweed		
Parsley piert		Annuals – avoid physical extremes
Rue-leaved saxifrage		
Whitlow grass		
		Many plants on the SFS also have xerophytic adaptions such as waxy or hairy leaves, sunken stomata or small leaf surface area.

Species' abundance also differs within the slopes due to the top-to- bottom slope physical variations.

Possible sources of experimental error

If the gathered results differ from the 'textbook' results this may be due to:-

- Species diversity: This appears to vary greatly throughout the year on the SFS and may appear similar to that of the NFS at certain times, especially from June onwards, as many plants have completed their life cycle and thus 'disappeared'. Regular surveys are needed throughout the year to account for this.
- Mis-identification. The smallness of plants, lack of flowers, lack of identifier's experience and other factors make positive identification difficult.
- Sample size may be too small, for both vegetation and physical factors (eg. soil pH).
- Lack of repetitive sampling. Ideally permanent quadrats in place for several years are needed.

- Vegetation height – the level of grazing intensity was not measured. It could be higher on the SFS than on the NFS.
- Light intensity and air and soil temperature are greatly affected by cloud cover. Hourly monitoring throughout the year is needed so that averages can be interpreted.

Extension work to the study

- More repetitive sampling.
- Bigger sample sizes.
- Monitoring the effect and levels of grazing with aspect.
- Monitoring light and temperature throughout the year at, for instance, hourly intervals.
- Comparing the results with those found on the NFS and SFS of another rock type.