Geo Factsheet

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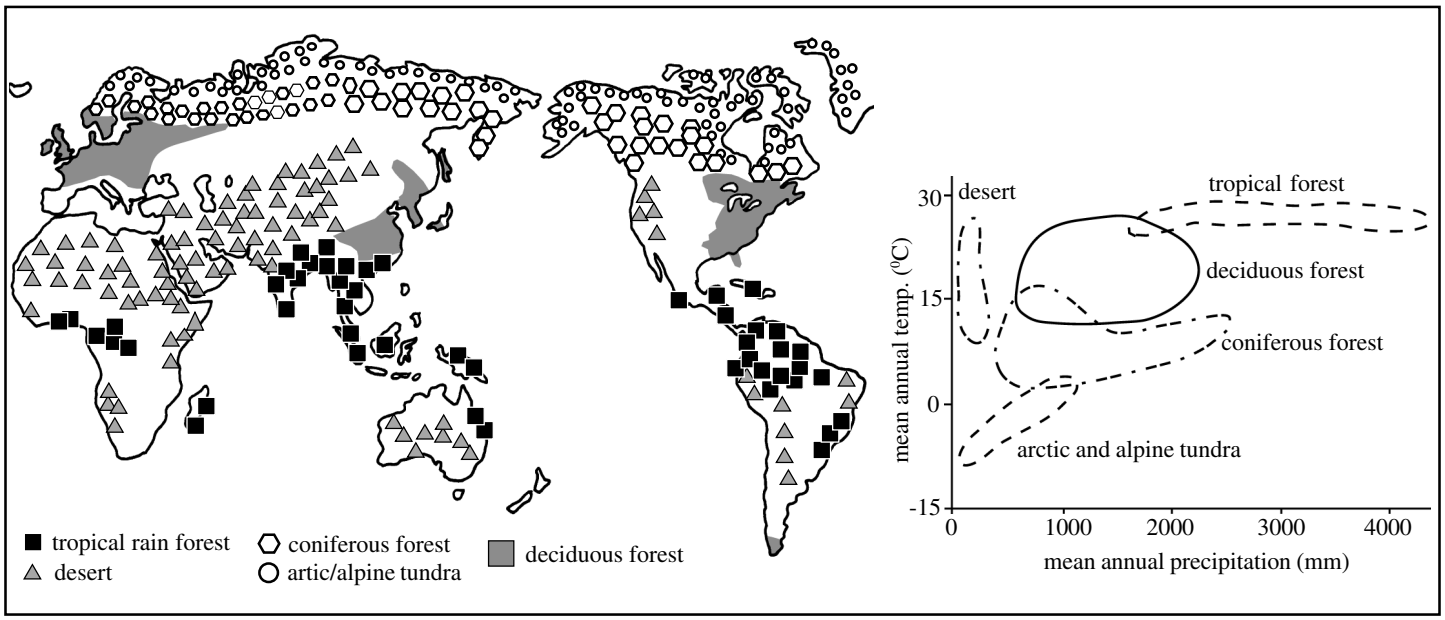
Temperate Deciduous Forest Biomes

The basic facts

Woodlands are long established, complex ecosystems dominated by trees. Temperate deciduous forests are found mainly in north-west, central and eastern Europe, eastern North America and east Asia (e.g. northern China, Korea, Japan).

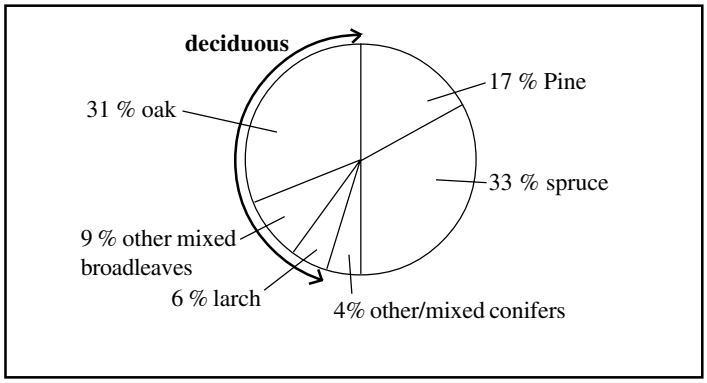
Fig 1 Biomes of the world



These forests require a climate which has a growth period of 4-6 months, and a cool but mild winter period of 3-4 months, when their leaves are shed. Fig 1 shows the distribution of the major terrestrial biomes with respect to mean annual temperature and precipitation; the deciduous forest biome is also well supplied with rainfall, which is well distributed throughout the year.

Deciduous woodlands are multi-layered (stratified), usually with distinctive shrub, field and moss layers and often with a lower tree layer as well. Broadleaf trees of oak, ash, elm, beech and maple are dominant within the biome and the number of different tree species per hectare varies between 5-20, depending on local environmental conditions. Such tree species may grow up to 50m tall; deciduous trees react to lower winter temperatures by losing their leaves to conserve moisture. Fig 2 shows the area of woodland in Great Britain by main tree species.

Fig 2. Main tree species in Great Britain



Woodland is relevant today not only for its monetary value (the worth of timber and associated timber products), but also for less tangible reasons such as conservation, scientific, cultural and material grounds (services):

- Woodland areas often include areas which are unmanaged – this gives rise to variety and structure within the woodland which is important for the purposes of **conservation**.
- The **ecology** of woodlands is an important branch of biology. Not only in terms of species and populations, but natural woodland can act as a reference point, or control, for measuring human impacts on the environment. Woodlands, for example, can hold clues as to longer term changes in the earth's natural environment, especially pollution and climatic change. On a global scale, woods and forests act to help stabilise climates through their role in the carbon cycle
- Natural woodland is a major element of wilderness and amenity and therefore has **cultural** significance. The tragedy, is that so little primary deciduous forest remains.

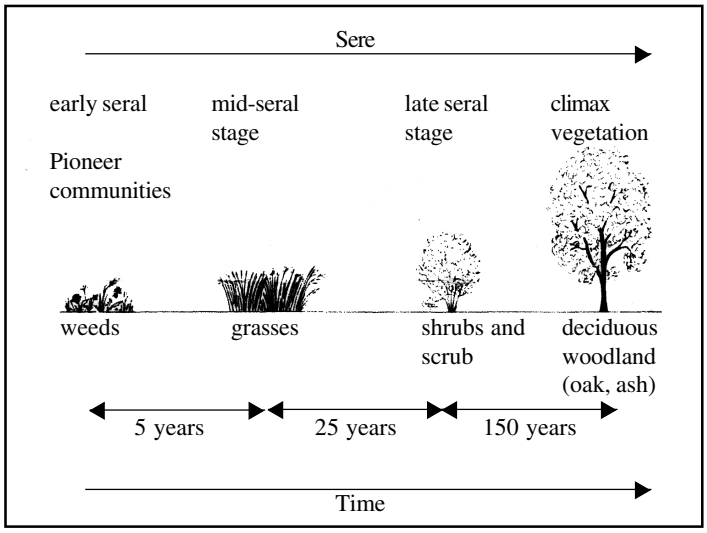
Role of Succession

Natural woodland is a product of **succession** – that is a gradual and predictable change in plant and animal species over time. Following a clearance of the ground (this can be natural such as an ice age or fire, or human-centered, e.g. the abandonment of an arable field), pioneer 'weed' communities will invade and then be replaced by grassland. If left un-grazed and managed for a few years, bushes will invade and the land will convert into scrub. Eventually tree species will be able to colonise and so the area is changed into a woodland.

Fig 3 shows a diagrammatic profile of plant succession within an abandoned field. As succession occurs (e.g. from weeds to woodland) there is usually an increase in:

- (i) the stratification (structural complexity) and biomass mass of living plants);
- (ii) the numbers of species occupying the site;
- (iii) the growth rate or productivity of the vegetation.

Fig 3. Plant succession



Succession is able to occur because species modify the site making it more suitable for the next colonisers, i.e. pioneer communities are able to bind the soil with their roots thus stabilising the environment; vegetation also alters the properties of the soil by adding organic matter through its decomposition.

This means that the 'natural vegetation' of much of SE Britain (its 'climatic climax') is deciduous woodland, dominated by oak, ash and beech. Parts of Scotland and in NW Britain this pattern of tree is replaced by more hardy coniferous species, e.g. pines and deciduous birch or by smaller shrubby plants which are better adapted to withstanding the climatic extremes of cold.

The woodland ecosystem, productivity and nutrient cycles

The term 'ecosystem' describes the structure, organisation and interrelationships between a community of plants, animals and microbes together with the processes of energy flow and nutrient cycling. Feeding relationships or food webs are often used to demonstrate woodland complexity,

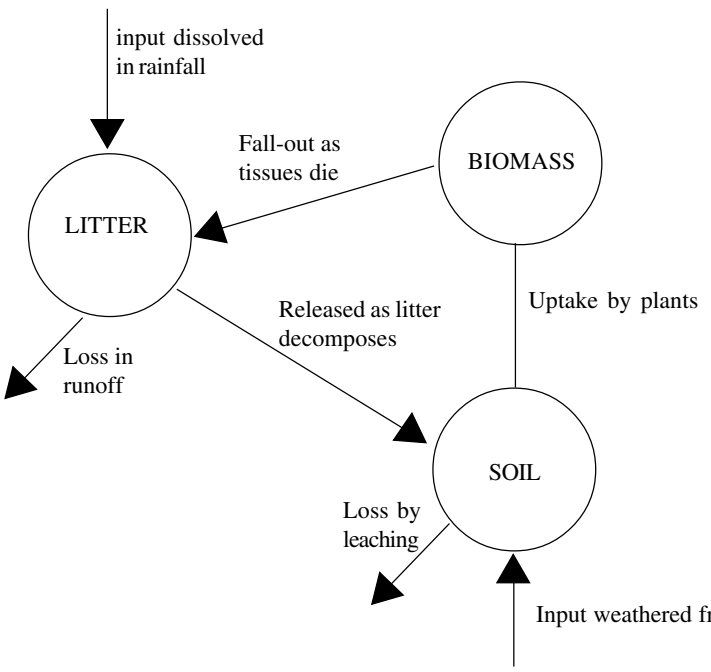
Compared to some lower-latitude ecosystems and biomes, temperate deciduous forest has low productivity – Fig 4).

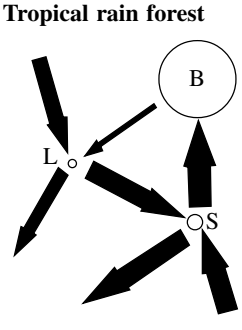
Fig 4. Comparison of ecosystem productivity

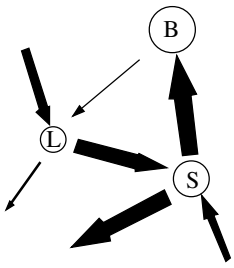
Ecosystem	Productivity kg/m²/Yr)	Mean biomass (kg/m²)
Tropical rain forest	2.2	45
Tropical deciduous forest	1.6	35
Tropical scrub	0.37	3
Savanna	0.9	4
Mediterranean sclerophyll	0.5	6
Desert	0.003	0.002
Temperate grassland	0.6	1.6
Temperate deciduous forest	**1.2**	**32.5**
Boreal forest	0.8	20
Tundra and mountain	0.14	0.6
Open ocean	0.12	0.003
Continental shelf	0.36	0.001
Estuaries	1	1

'Productivity' refers to the rate of energy captured and 'biomass' the weight of living material within the system (Fig 5).

Fig 5. Diagrammatic comparison of nutrient cycles for a tropical rain forest and temperate deciduous system.







S Soil
B Biomass
L Litter

This is a common exam question

Note the relative sizes of the stores B (biomass), S (soil) and L (litter), and the relative thickness of the interconnecting arrows which represent transfers of nutrients.

Soils of temperate deciduous woodland

The characteristic soils of the temperate deciduous forests are brown earths and similar 'brown' soils. There is a complex interrelationship between soil and vegetation, each factor having an influence on the other. Brown earths are generally well-drained, with a reddish-brown horizon which extends below about 30cm in depth.

The soils occur mainly below altitudes of 300m and so dominate the warmer lowlands of Britain (covering about 50% of the land surface in England and Wales). Typically, they have a pH of around 5.5-6.5

Brown earths are traditionally associated with broadleaf, deciduous forest and many now lie below fertile improved grasslands since the removal of the original woodland cover. The upper layers of the soil are biologically active – this is denoted by a rich mixture of humus and mineral matter. The lower 'B' horizon is seldom separated from the upper 'A' horizon because of soil mixing by earthworms.

In areas where soils are freely draining, the profile may become increasingly leached, with the loss of macro-nutrients such as iron and aluminium ions into the lower horizons of the soil. (For details on profiles see GeoFactsheet 131 on Soils in Britain)

Historical Change

Human activity in the last 3,000 years has cleared many areas of their natural tree vegetation. Now in many places, just the remnants or relic fragments of previously extensive forests remain. Yet throughout history, trees have been part of our cultural landscape and have been managed and used. From the Bronze age onwards land was cleared for agriculture, both pastoral and arable; burning was the main method of clearance. One example of an area extensively cleared in this way is Malham in North Yorkshire where there is evidence of Iron Age field systems and boundaries. Agriculture in that area today is dominated by sheep farming on rough grassland. The 'natural' vegetation in this area is deciduous woodland, but grazing prevents regeneration of saplings. Where the natural process of succession has been arrested in this way, we are left with a '**plagio-climax**'.

Natural fires may also have been responsible for a significant amount of woodland clearance. Lightning, quite capable of starting a fire, caused significant areas to be cleared. Early settlers would have taken advantage of the cleared ground and used it for grazing animals. Similarly many areas within the temperate grasslands of the prairies could support deciduous woodland.

Woodland facts and figures

Today in the UK about 12% of the land area is wooded (this includes both coniferous and deciduous species). This figure compares favourably to a century ago when only 4% of the UK was afforested yet the figure is significantly lower than EU average of around 45% (but remember that there are considerable differences in population densities between member states).

Fig 6 Areas of woodland in thousands of hectares (2003) – source National Statistics

	Conifers (non-deciduous)	Broadleaves (deciduous)	Total woodland area
England	372	739	1,111
Wales	163	123	286
Scotland	1052	275	1327
Great Britain	**1,587**	**1,137**	**2,724**

Until the 1980's the area under broadleaf (deciduous) woodland continued to fall and losses of ancient semi-natural woodland (woodland dating back to before 1600) were particularly severe. At this time nature conservation policies became more widespread in both public and private woodlands. Since this time the Forestry Commission has been working with landowners and conservation groups to improve not only the area under woodland cover, but also the quality of the resource (both commercially and aesthetically) with an emphasis on planting deciduous woodlands of the new forests of Mercia.

Multi-Purpose Systems

Woodland management is often complex, not least because of the range of demands (or services) that a single area of woodland may be expected to provide, both locally and globally. Hence the idea of managing a 'multi-purpose' system. Woodlands represent resources of great versatility – offering an enormous variety of 'products', i.e.

- Commercial timber and fuelwood
- Recreational space for leisure activities
- Habitats for flowers, birds and insects
- Shelter for stock, e.g. deer
- Hydrological significance, e.g. interception

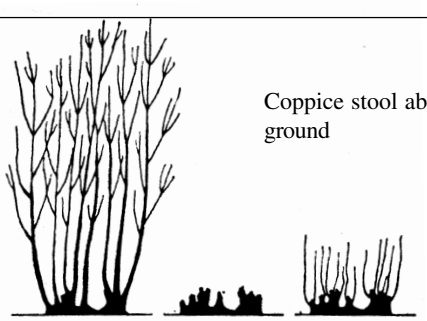
In addition to the above, the woodland resource may also have to provide land for commoners, transport routes (major roads and pipelines) and facilities for education and interpretation.

Inevitably there are conflicts of interest between different uses and user groups. In particular there are often differing opinions regarding access for recreation, conservation and commercial timber production. Even within particular user groups there may be disagreement, e.g. shooting and paintball; off-road vehicles and orienteering. The recreation activity causing most concern in a number of larger woodland systems, like the New Forest, is riding in groups. Shod horses damage vegetation by widening paths under damp conditions.

Case Study 1 – Hayley Wood, Cambridgeshire

For many centuries Hayley wood had been utilised by people and its history has been recorded for the last 700 years. The wood, now owned by Cambridgeshire Wildlife Trust, has been the subject of much research. Occupying a 150 ha site, the area is dominated by species of oak, ash, elm, maple and willow. Hayley Wood's significance in historical times was as a source of timber for construction, and the smaller 'underwood' used for firewood and other purposes. Much of the hazel and willow was coppiced on 10-15 year cycles within selected areas or 'coupes' harvested at intervals of approximately seven years to provide timber for the manufacture of wooden sticks for fences etc.

Fig 7

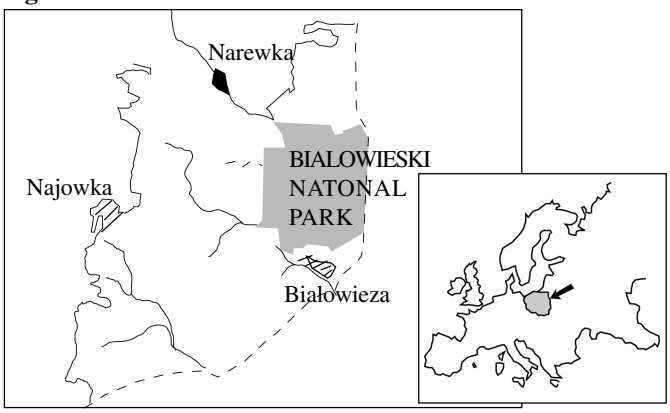


Underwood trees such as beech and hazel are cut near to ground level and them regrow from the remaining stump or 'stool'. This is a sutainable method of generating timber.

Other trees such as oaks were allowed to reach maturity before harvest; these 'standards' were felled and used in construction of buildings etc. During the 19 century the importance of Hayley Wood as a supplier of timber products decreased. Coal became increasingly important and metal substitutes became available as alternatives to timber products. The wood then became valued as a cover for game, fox hunting and shooting. The wood is now managed for both people and wildlife.

Case Study 2 Bialowieza Forest, Poland

Fig 8. Bialowieza Forest



This vast area of forest - 57,000 ha (1,250 sq. km), is located in North east-central Poland on the border with Belarus. Situated on the hydrological divide between the Baltic and Black Seas, it lies in the drainage basin of the River Narewka, a tributary of the Narew. The region experiences a temperate continental cool climate, where mean annual precipitation is 650 mm and mean annual temperature is 6.8° C.

Part of the area was designated a UNESCO Biosphere reserve in 1993 because of its ecological diversity and cultural significance - a total of 184 burial sites from the 11th and 12th centuries have been found in the region. Within the preservation area of the forest there are 632 species of plants, constituting about 29% of the flora of Poland.

254 lichen species, 80 liverworts and more than 3,000 fungi have been recorded in addition to the 10 or so dominant species of trees.

There are 54 species of mammal including European bison, grey wolf, lynx, otter and beaver. An estimated 230 species of birds are found within the reserve including capercaillie, black stork, crane, and a large number of raptors such as spotted eagle and booted eagle. Approximately 8,500 species of insects have been recorded.

There are about 95,000 visitors annually, 30% of which visit the strict preservation area where access is limited to guided groups. Trained guides are provided by the tourist offices and are assigned to individual tourist groups and youth excursions, in accordance with park management. Guided trips use traditional horse drawn vehicles to get round the park.

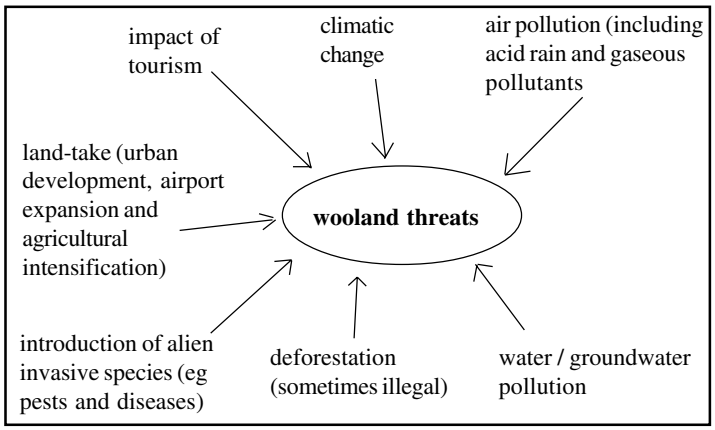
The park area consists of a strict core zone (4,747ha) and a protective zone (276ha) around the village. Here activities such as clear felling, hunting and the use of insecticides are banned. Access is limited to research and guided visitors, all motor vehicles are banned. The 'Hwozna' Protective District covers an area of 5,155ha. It comprises of a mosaic of old growth forest stands, including species that are not represented in other areas of the park. This is surrounded by a 1km wide forest buffer zone to the north-west and south.

Contemporary Problems and The future of Deciduous woodlands

After reaching a low point early in the 20th century, the area of woodlands and forests in Britain has risen steadily since. Trees and woodlands also have a higher political currency than they once did. This is due in part to climate change and Local Agenda 21 whereby woodlands are recognised as important pollution 'sinks'. Visits to forests (both deciduous and coniferous) are also more commonplace than 20 years ago with an increased range of recreation facilities and activities being provided by organisations such as the National Trust, Woodland Trust, Royal Forestry Society and the Forestry Commission. There have also been notable successes in terms of urban forests, the National Forest and Millennium Forest initiatives.

However there are always pressures and issues within areas where there is a rich mosaic of land-uses. The box below some of the threats to woodlands which can operate at a range of scales.

Fig 9. Woodland threats



One woodland threat which is of particular concern is the projected expansion and development of airports. Fig 10 shows areas of woodlands under threat from airport expansion in the Midlands. There are number of direct and indirect impacts.

Fig 10. Woodland under threat from airports

airport	area under threat: ha (acres)	area subject to wider threat: ha (acres)	Total: ha (acres)
Birmingham	22.4 (55.33)	0	
East Midlands	4.05 (10)	0	
New Rugby/Coventry	34.12 (84.28)	>400 (988)	
Coventry	9.55 (23.59)	0	
Total	**70.12 (173.2)**	**>400(988)**	**470.12 (1161.2)**

Direct Impacts

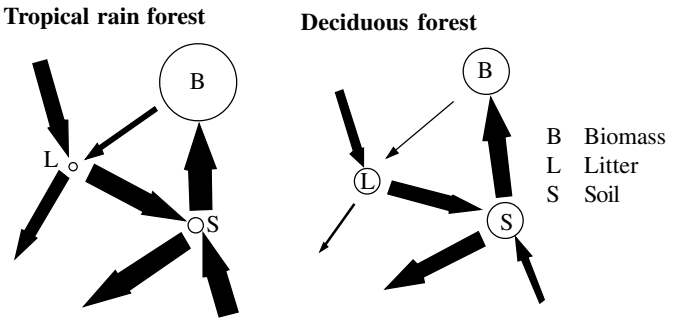
- Loss of good quality habitats (not only woodlands but associated hedgerows etc)
- Noise – disturbance of wildlife, particularly nesting birds
- Smell and visual intrusion of airports has a negative impact on forest amenity value
- Pollution from aircraft, in particular oxides of nitrogen. This has impacts at a range of scales
- Development of improved infrastructure and terminal buildings will result in land-take and increased loss of forest.

Indirect Impacts

- More people would be attracted to living close to the airport. This puts pressure on the woodland resources within the catchment of any new proposal / expansion as there will be a need for new housing
- There will likely be a substantial increase in visitors to local woodland amenities; sensitive areas of ancient forest can be damaged (in particular litter, loose dogs, stealing dead-wood, setting fire to hollow trees etc)

Review Questions

1. Compare the nutrient cycle of a tropical rain forest to that of a deciduous forest. Explain why there are such differences.



2. Describe and explain the key features of soils associated with temperate deciduous forests.

3. Outline a fieldwork programme you could undertake in order to examine the productivity of two different deciduous woodlands.

Guidelines for answers

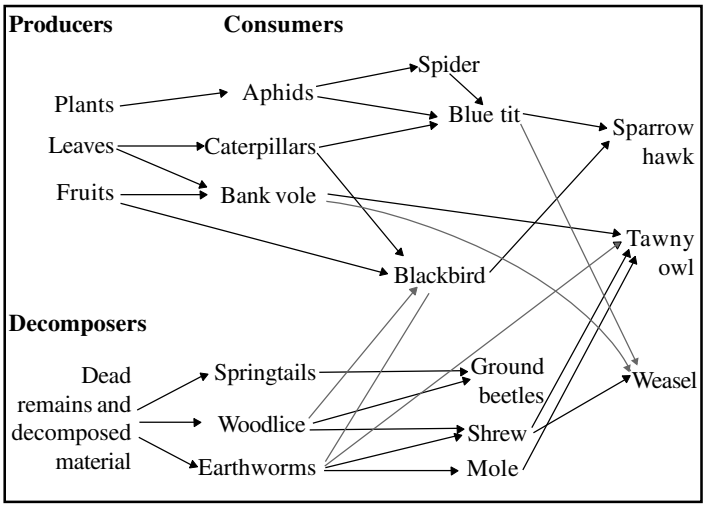
1. Tropical Rain forest – biomass store much larger compared to litter and soil, whereas in the deciduous forest the stores tend to be much more evenly balanced. This means in the tropical forest much of the nutrient store is locked up in tree biomass – this is why deforestation has such a serious impact on the forest productivity. In both systems there are similar transfers in terms of decomposition and loss by leaching. However some inputs and outputs are significantly different, e.g. nutrient dissolved in rainfall, and input from weathered rock. This can be explained through a discussion of climatic differences, and how this in turn impacts on rates of weathering for example.

2. Just as in the text you should perhaps consider the distribution of soils and link soil type to process. The development of particular horizons within the soil is as a result of particular processes which occur within certain layers of the soil. The soil colour is also partly a function of these processes as well as the impact of geology and vegetation.
   Note – Factsheet 131 provides a more detailed account of brown earth development

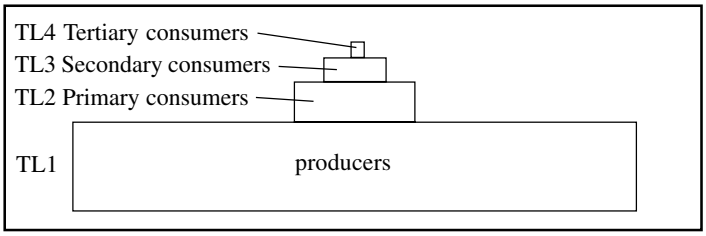
3. Productivity can be approximated by estimating tree volume and relating this figure to tree age. Start by selecting two appropriate woodlands where the ages of trees can be deduced. Decide on a suitable sampling strategy or frame, i.e. stratified, systematic or random. Collect data on tree height by using a clinometer and then trigonometry to estimate in metres. Then measure the girth of the tree and convert this circumference figure into a cross-sectional area. Repeat the measurement for 20 or so trees in each woodland. Use the cross-sectional area value and height to estimate the volume of a cylinder. Compare the results for both woodlands. For further fieldwork projects see "Fieldwork Investigations for Geography"

Data Response Questions

The diagram below shows a food web in a temperate deciduous forest.



The diagram below shows a trophic level diagram



(a) (i) Define a **food web** [1]

(ii) Explain what is meant by a **trophic level** [2]

(iii) For each of the four trophic levels shown above name **one** example shown on the food web [4]

(iv) Explain the function of **decomposers** [2]

(v) Suggest why less energy is available at each successive trophic level [2]

(vi) Outline the impact on the woodland ecosystem of a very harsh Spring which decimated blue tit numbers [4]

Further Reading

O'Hare, G (1989) Soils, Vegetation and Ecosystems (Oliver and Boyd). Now out-of-print, but you can probably find a copy in a cupboard at school/college!

Rackham, O (2001) Trees and Woodland within the British Landscape (Weidenfeld & Nicholson history)

www.magic.gov.uk MAGIC - Multi-Agency Geographic Information for the Countryside. A one-stop shop for rural and countryside information. Here you can get information on woodland cover and grant schemes, which can then be viewed as a scalable map.

Acknowledgements; *This Factsheet was researched and written by David Holmes who lectures at King Edward VI College Stourbridge.* ***Curriculum Press, Bank House, 105 King Street, Wellington, Shropshire, TF1 1NU****. Geopress Factsheets may be copied free of charge by teaching staff or students, provided that their school is a registered subscriber.*