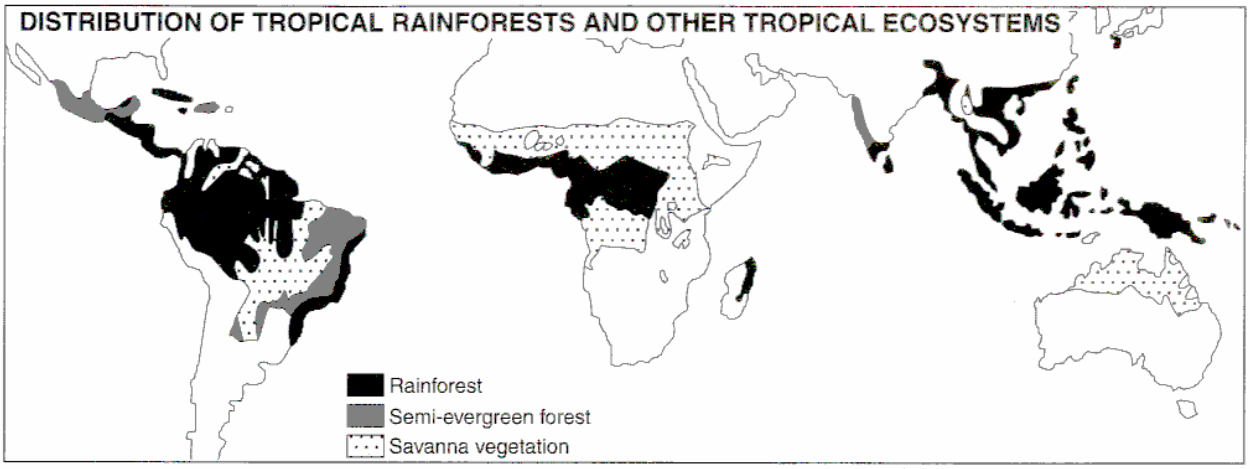
A2 Geography 4.3 Ecosystems Student Notes

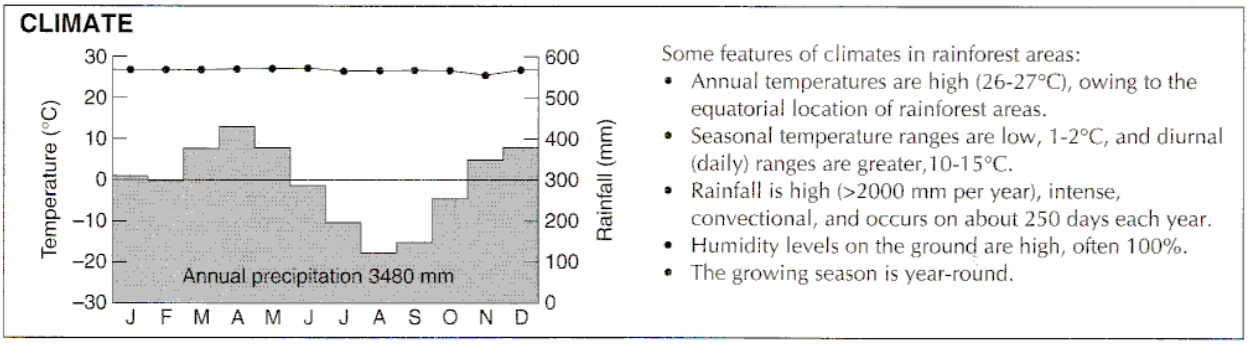
An The management opportunities and challenges associated with Tropical Rain Forest Ecosystems.

Where are the rain Forests?

The locations of the main tropical rain forests are in three large areas: the equatorial regions of **Central and South America**, including the Amazon; **equatorial West Africa** and the equatorial islands and the **Southeast Asian** peninsulas from Malaysia to Northern Australia, including most of Indonesia. Other pockets are found in India, Sri Lanka, Madagascar, and the Caribbean Islands.

Tropical rainforests





The Climate of Tropical Rain Forest

Pressure and wind – Close to the inter-tropical convergence zone (ITCZ) air is warmed and rises. Pressure is low leading to unstable air. Wind speeds, especially within the forests are generally low.
Temperature – Contrary to popular opinion, rainforests are not the hottest places on earth. Temperatures average 25 to 29ºC with little annual variation (usually less than 2ºC) but a higher diurnal variation with a range of 10-15ºC. There may be a degree of seasonality at higher altitudes and latitudes.

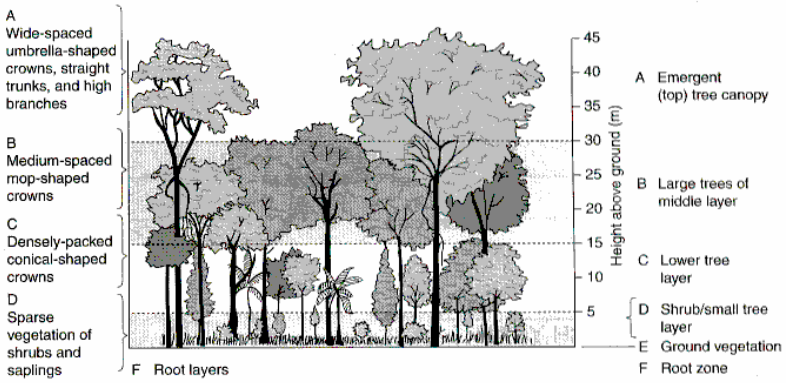
Rainfall – Total rainfall usually exceeds 2000mm. Most rainforests experience either one or two rainfall maxima. These depend on proximity to the equator with equatorial regions experiencing two rainfall maxima**.** There may be one or two short dry seasons, but the wet season(s) will last for at least 10 months of the year.

Humidity – Humidity is usually high (80-95% RH) but the forests are not always dripping wet. Evapotranspiration rates are high and the forests are often well drained. Some forests may flood during the rainy season.

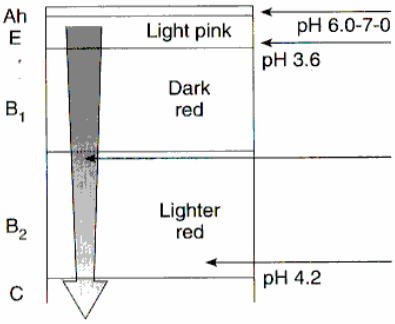
Microclimate – There are considerable micro-climatic variation, for example between canopy and the forest floor.
Light Penetration – The thick canopy means that some parts of the forest floor are well shaded, however this is not universal. Ther3 are many lighter clearings, particularly where trees have fallen and along riverbanks.

VEGETATION

- The vegetation is evergreen, enabling photosynthesis to take place year-round.
- It is layered, and the shape of the crowns vary with the layer, in order to receive light.
- Rainforests are a very productive ecosystem: NPP is about 2200 g/m²/yr, and there is a large amount of stored energy (biomass 45 kg/m).
- The ecosystem is diverse - there can be as many as 200 species of tree per hectare (an area the size of a rugby pitch), including figs, teak, mahogany, and yellow-woods.



SOILS: TROPICAL LATOSOLS



Thin layer of humus. Continuous supply of leaves: rate of humus turnover 1%/day. Very active soil fauna.

Accumulation of iron and aluminium gives the soil a red colour. Concentration of aluminium may form bauxite nodules.

Hot, wet conditions cause rapid removal of fine clay and silicate particles.

Loss of N, Ca, Mg, and K from the soil by leaching.

Bedrock intensely weathered - due to hot, wet conditions, and lack of disturbance in glacial times.

Forest Structure

Upper Tree Layer (emergent and canopy): Euphotic Layer – The most productive layer with the most biomass and biodiversity. Plants include numerous tree species over 25m tall (no single species dominates), epiphytes (e.g. orchids, lichens and bromeliads). Numerous insects, birds, bats and climbing mammals. This layer uses 25-30% of the available solar radiation.

Middle Tree Layer: Oligotrophic Layer – Woody climbers and large trees (10-25m). Animals include cats, squirrels, rats and mice.

Lower Tree Layer – Small trees and saplings.

Shrub layer – Tree seedlings, shrubs and pigmy trees. Grazing animals include antelope, deer, pigs porcupines and squirrels.

Herb layer – Small tree seedlings, forbs, graminoid plants (grasses) ferns and bryophytes.

Upper root layer – Compact root masses on surface soil for 5cm

Middle root layer – Fewer roots in sub-soil 5-50cm

Lower root layer – scattered tree roots below 50cm

Biodiversity

About half of the world's gene pool is thought to exist in tropical rain forests.

This can be explained by:

1. The greater **rate of mutation and evolution** of new species. One theory is that the greater amount of UV-B radiation at the equator can change DNA, leading to more frequent mutations and more rapid evolution.

2. The greater opportunities for **co-existence** within tropical rain forests Energy and food sources are plentiful.

3. Many rain forest areas are surrounded by **few physical barriers** allowing immigration of species from neighbouring regions.

4. Unlike other biomes, the rainforests have existed continuously in equatorial locations for **over 65 million years** (throughout the Tertiary and Quaternary). This has allowed uninterrupted evolution and has reduces the risk of extinction.

Many species have become specialists and live in narrow **ecological niches**. To co-exist with others many have adaptations that improve their chances of survival including **dispersal mechanisms** (plants), **symbiosis** (inter-dependence), **mutual association** (e.g. ants that guard tree species for their own exclusive food supply) and **allelopathy** (the production of toxic substances).

Nutrient Cycling

Nutrients such as nitrogen, phosphates, potassium, calcium and magnesium are vital for plant and animal growth and are recycle between the biomass, the litter and the soil. About 10% of leaf matter is decomposed above the forest floor and is used by **epiphytes** such as orchids. **Tropical latosols** lack nutrients but this is compensated for by the very rapid recycling of leaf litter.

Leaf litter in rain forests **decomposes** quickly (3-4 months) because the warm moist conditions favour the **decomposer organisms** such as **fungi**, **bacteria**, microscopic **arthropods** (there may be 38,000 per square metre) and **termites** with microscopic **protozoa** in their guts, which help them digest cellulose.

Plant up-take of nutrient is also rapid because the warm, humid conditions favour plant growth, leading to large nutrient store in the biomass. The shedding, excretion or death of parts of the biomass to form "**litter**" completes the cycle. Nutrients lost in runoff and in leaching are replaced by new nutrients that are supplied by rapid weathering rates from the parent rock. Chemical weathering in particular is rapid in the warm, humid conditions. Additional inputs of nutrients are supplied dissolved in rainwater.

For the synoptic link, you need to be aware of the variables influencing the ability of people to overcome the challenges of tropical rainforests in order to exploit opportunities. These variables include capital, technology and knowledge.

You need to be aware of the issues of environmental concern and the sustainable management possibilities.

There are clear links in this section with your studies of agriculture and development processes.

Management Issues in Tropical Rain Forests

Forests ecosystems are altered by people for a range of reasons:

1. On a small scale, traditional slash and burn **shifting agriculture** leads to small forest clearings. In isolation, this has little impact, but when population densities are high, the cumulative impact can increase, such as in resettled areas in Rondonia in Brazil.

2. Commercial **cattle ranching** in Central and South America (from Mexico to Panama to Brazil), leads to significant modification of the ecosystem when trees are replaced with grass.

3. Monoculture **plantations** of cash crop such as teak, rubber or bananas may replace the diverse forests. Similar plantations of fast growing trees may be grown for **wood pulp** for paper mills.
4. **Mineral extraction** of iron ore, copper ore, bauxite or oil can lead to deforestation for opencast extraction, communication links and compounds.

5. **Hydroelectric power** schemes in Brazil and Malaysia have drowned areas of rain forest.

6. One of the most destructive and widespread issues is the extraction of tropical **hardwood timber**, such as teak and mahogany. In 1993, 80% of timber came from Asian and Pacific countries and was sold to MEDC's such as Japan, Europe and the USA.

What is the link between forest clearance, GNP and international debts?

Top ten countries with the largest area of tropical forest being destroyed, 1989–90

Country	Area of forest lost each year (km^2)	Percentage of total forest area	GNP per person (US$)	Debt per person (US$)
Brazil	34 500	0.7	2 680	772
Indonesia	12 000	1.0	560	355
Bolivia	10 000	2.1	620	586
Mexico	9 000	1.9	2 490	1 096
Venezuela	8 500	1.5	2 560	1 722
Zaire	7 000	0.6	230	256
Peru	5 500	0.9	1 160	912
Myanmar (Burma)	5 000	1.6	No data	112
Sudan	4 500	1.0	No data	515
Malaysia	3 500	2.0	2 340	1 089

GNP per person for the UK in 1990 was US $ 16 070.

Environmental Impacts of Large-Scale Deforestation

Diversity of plant and animal species are reduced. Some species with narrow ecological niches may be threatened with **extinction**.

Exposed soils reach temperatures of 35°C to 40°C leading to damage or death of crops or remaining natural plants and animals.

The topsoil is no longer protected, leading to **soil erosion** and high levels of **leaching**. Aluminium and iron oxides accumulate to toxic levels in the soil. They may also create a soil crust. Streams silt up, reducing water quality leading to a **decline in aquatic ecosystems**.

At a local level, interception and transpiration are reduced leading to increased surface runoff. Combined with silting streams, this can increase the **risk of flood downstream**

Burning of trees increases the CO_2 levels adding to **global warming** and reducing the earth's biosphere's ability to remove CO_2 from the atmosphere.

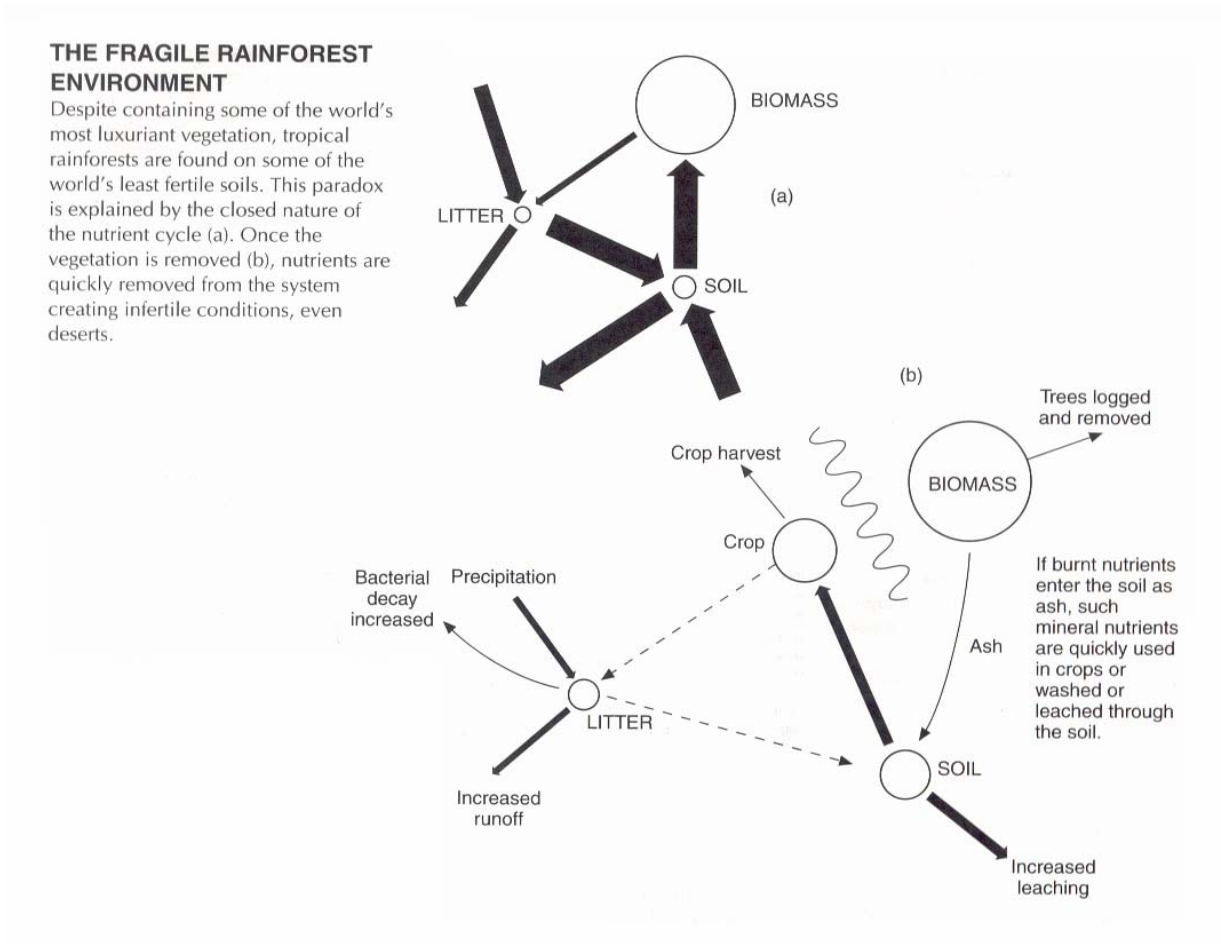
At a regional scale the **reduction in transpiration** reduces humidity, cloud development and precipitation leading to more lengthy dry seasons and drought. This can increase the **risk of forest fires** in remaining forests.

Some Key Terms in Forest Management

Sustainable management - This occurs when the level of exploitation of resources from an ecosystem is no greater than the ability of the ecosystem to replace itself.

Conservation - This is the protection of an environment that people believe to be of value. This may be a single species or an entire ecosystem. Conservation requires the modification of inputs to achieve the required outputs.

Preservation - A “hard-line” conservation approach, which means keeping something as it is and not changing the inputs. People are kept away.



Managing Rain Forests in Sierra Leone

Primary forest remains untouched by human activity.

Secondary forest has been cleared for but has been allowed to regenerate. Secondary forest often superficially resembles primary forest but it may have lower species diversity.

Background to the Gola Forest in Sierra Leone

The climate of Sierra Leone could support rain forest over about 50% of its area but by 1976, there was an estimated 5% was covered with closed canopy forest with a further 3.5% covered with secondary forest. A further 55% was covered by bush fallow. These areas are burnt, cleared and cultivated in the dry season for 1-2 years and then left fallow for 8-10 years. Further reduction has taken place since the 1976 survey.

The **Gola Forest Reserves** (East, West and North) were established in the 1920’s and 1930’s to supply commercial timber. Then they were administered by the British MAFF (Ministry of Agriculture, Fisheries and Food).

Management Issues in the Gola Forests

Agriculture – Areas of forest have been cleared for rice, mixed crops (yam, cassava and other root crops) or cash crops. The process involves clearing areas of 10's of hectares by slash and burn methods during the dry season. Land is farmed for 1-2 years and left fallow for 8-10 years, by which time only a low secondary forest has grown. A major concern of local people is crop failure and loss of soil through erosion.

Logging – This is often wasteful and causes variable amounts of damage to the forest. Only about 10% of the trees are removed for timber but in the process, up to 50% of the tree crowns can be destroyed. Soil can be compacted by machinery, reducing the potential for re-germination of seeds. Logging also opens up the forest to hunters, miners and shifting cultivation. Some local people regard loss of forest as advantageous as it relieves them from some of the hazards of wild animals, although they are concerned about loss of medicinal plants.

Hunting – Hunters from other regions collect "bush meat" for regional markets and for export. Hunting is not controlled and populations of many species have been reduced including elephant. Chimpanzees are captured for use in medical science in MEDCs.

Mining – Miners enter the Gola forests in search of diamonds. This causes damage to forests and leads to changes in the stream flow and sedimentation.

Forest Management Plans in the Gola Forests

Conservation research – Additional research is needed to understand the ecology of forested areas. Existing research suggest that the core **Strict Forest Reserves** in primary forests are essential for the survival of important species.

Management of Logging – Forest Reserves are managed for timber, water management and habitat protection. Local people have access rights to collect non-commercial forest products. Hunting, fishing and, trapping and firewood collection are prohibited. By 1993, the only completed management plan was for the Gola Forest.

The Role of NGO's – The RSPB and Birdlife International have been involved in the management. They recommend that:

> **Research** must be carried out into the **carrying capacity** of timber extraction that produces sustainable yields but minimises the impact on wildlife.
>
> **Large fruiting trees** should not be felled to maintain food supplies for wildlife such as hornbills.
>
> **Riverside forests** should be protected to preserve habitats for water dependent species and to act as a wildlife corridor. Water quality could also be maintained.
>
> Areas containing **endangered species** such as white-necked rockbirds should be left unlogged.
>
> A **Buffer zone** should be maintained between logged areas and primary forests. No logging should take place in these areas. The most important wildlife areas should be left as **Strict Wildlife Reserves**.

Measures to develop sustainable extraction of forest products needs to be encouraged including community forests for medical plants, rattan and timber; forestry plantations for cash crops; fish farming to increase yields from bush fallow and agro-forestry for timber, food and cash crops. This mimics the natural forest structure.

Conservation Education

Local people need to be involved in conservation at all levels. Education is a two-way process. The "outsiders", who want to conserve the forests, need to educate themselves and others about the values and needs of the Mende people. These people regard the regeneration of the bush fallow after

cultivation as a sign, blessed by their ancestors, showing that they have not angered them by felling trees.

The bush fallow system may be the key to conservation since this is the source of most of the needs on the Mende. The Mende do not see themselves as guardians of the forests, instead they believe that the forests protect and provide for them.

The conservation of the Gola forests therefore requires managers to understand and to take into account the different cultural views.

Other Sustainable Management Techniques

Debt for Nature – MEDC's have been willing to reduce the debts of LEDC's by swapping the debt for conservation projects. NGO's have bee involved and have managed to buy areas of rainforest at discounted prices, while international debts have been written off. Such projects have been successful in Madagascar involving the National Westminster bank and the WWF.

Sustainable Forestry – Western consumers are now being encouraged to buy timber products, such as furniture from woodlands that are managed in a sustainable way. However, so far the success of such schemes has been limited to less than 1% of tropical timber. There is also confusion between **sustainable yields** and **sustainable forest management.** The disturbance to the forest must be minimised

Other Sustainable Forest Products – A range of other products can be collected for commercial gain from tropical forests without causing significant damage. These include Brazil nuts, rubber from wild trees, craft items made from sustainable materials (such as rattan), bees wax and honey, farmed butterflies (e.g. WWF community butterfly farm in Papua New Guinea) and medical plants.

Ecotourism

Ecotourism may be a way of managing fragile ecosystems in a sustainable way by marketing their appeal while providing income for local communities. However, there are concerns that groups of tourists, however small and well intentioned, may still have a negative effect on environments and indigenous people.

In the Cuyabeno Nature Reserve in Ecuador, tour companies have built jungle lodges in relatively remote locations. Local materials were used to build island and floating hotels on the Rio Aguarico. Although staff come from outside the area, local Indian tribes provide basic services. Trained guides take small groups of tourists on foot or canoes to explore the rainforests to search for the abundant wildlife and to take part in scientific research. Visitors learn about the indigenous people and environmental issues (including those resulting from oil exploration in the Ecuadorian forests).

The money raised supports local people and local products, and is used to help finance the management of the Cuyabeno Nature Reserve.

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