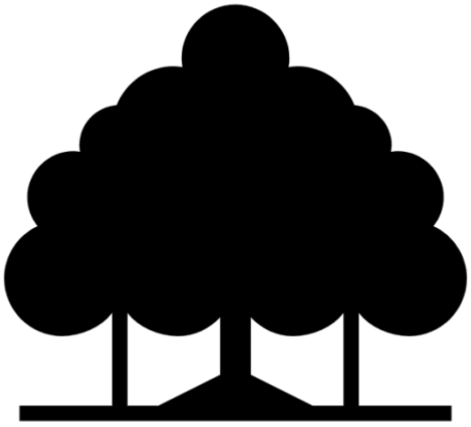
Department of
Education

GOVERNMENT OF
WESTERN AUSTRALIA

Year 11 General Geography

The study of tropical rainforests



Depth Study 1

GEGEO
Geography
General 11

Depth Study One
The study of tropical rainforests

The study of a biome: Tropical Rainforests

Instructions

- This work booklet should be completed over three (3) weeks.

Useful SCSA ATAR Geography documents
Year 11 Geography General Syllabus
https://senior-secondary.scsa.wa.edu.au/__data/assets/pdf_file/0008/10133/Geography-Y11-Syllabus-General-2016-GD_pdf.pdf

Syllabus points - Depth Study One
Students study an environment at risk. The context will be tropical rainforests, in order to investigate:

- biotic and abiotic elements of the selected environment, biome or ecosystem
- location and distribution of the environment, biome or ecosystem
- characteristics of the following elements of the environment, biome or ecosystem:
  - climate, including temperature and rainfall
  - soils and landforms, including soil structure and topography
  - flora and fauna, including dominant species and community structures
- the interactions between the flora and fauna of the environment, biome or ecosystem, including the following ecosystem concepts:
  - biodiversity
  - food chains and webs
  - biomass
  - trophic levels
  - pyramid of numbers
  - pyramid of energy
  - flows of matter and energy
- interrelationships between biotic elements and abiotic elements of the environment, biome or ecosystem, such as xerophytic adaptations of plants to drought conditions
- human activity and land use impacts upon patterns and processes within the environment, biome or ecosystem
- cultural landscapes associated with the environment, biome or ecosystem
- economic, political and social factors that impact upon decisions about sustainability of the environment, biome or ecosystem
- the different values and viewpoints (environmental, economic and social) that shape the human use of the environment, biome or ecosystem
- benefits of implementing sustainable practices within the environment, biome or ecosystem
- the extent to which current land use practices are sustainable within the environment, biome or ecosystem
- measures by which humans are caring for the environment, biome or ecosystem; and the extent to which these measures have been successful.

Depth Study One: Tropical Rainforests

WEEK ONE

Tropical Rainforests

The tropical rainforest biome has the most complex ecosystems in the world. Almost half of the world's total plant and animal species live in tropical rainforests. This is an amazing fact considering that tropical rainforests only cover 6% of the earth's land surface.

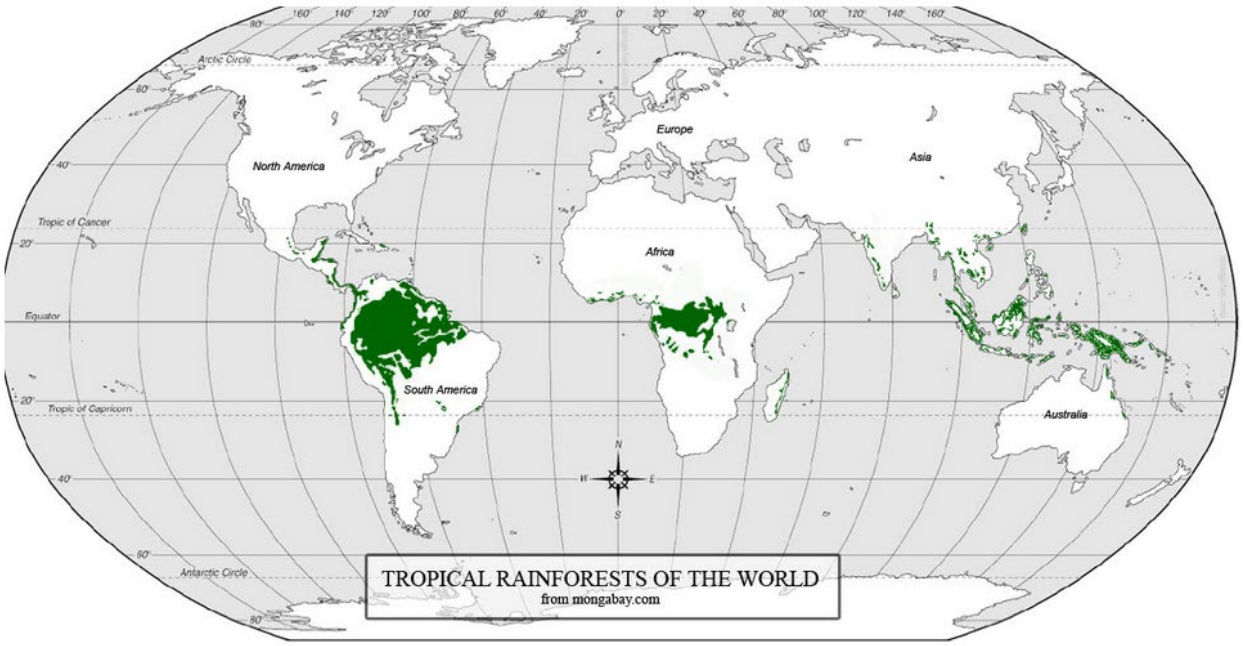
The best introduction to tropical rainforests comes from walking through them. All your senses are aroused for the forest teems with life. Dense plant growth surrounds you. Sunlight filters through the palms and creepers. Within this shadowy green world, animals are more likely to be heard than seen. Overhead monkeys crash through the branches and parrots screech. The constant buzz of cicadas almost deafens you. Underfoot rustling sounds reveal the movements of lizards and beetles amongst the leaf litter. Occasionally you catch a glimpse of an iridescent butterfly or the bright blooms of a flowering tree. Strange scents waft towards you. Sweet perfumes of blossom or ginger plants combine with the odour of decaying matter. It is a dark, clammy world. Far above the tree tops cumulus clouds build up daily.

Rolling thunderclaps announce the arrival of the afternoon downpour. Such is the setting of the tropical rainforest. Our studies in this lesson book will explore the characteristics and future prospects of tropical rainforests.

The tropical rainforest teems with life

Tropical rainforests - location

Tropical rainforests occur in a belt on both sides of the equator. You can see the major locations on this world map below.



Map showing world distribution of rainforests

Image by mongabay.com, https://rainforests.mongabay.com/ CC BY ND 4.0

Covering 6% of the earth's land surface, tropical rainforests occupy an area of 8·5 million square kilometres. Our map shows most of these forests lying between 15° north and 15° south of the equator. This is the humid tropical zone where rainfall annually exceeds 2000 millimetres. Temperatures are constantly above 20°C.

Now let's study our map more closely. Notice that the largest area of tropical rainforest occurs in Central and South America. This includes the lowland rainforest of the Amazon and Orinoco river basins. In Africa another major lowland rainforest occurs in the Zaire river basin. Tropical rainforests are also found on the island of Madagascar, in much of South-East Asia, in New Guinea and along the north-eastern coast of Australia.

(Note: More than half of the world's tropical rainforests are found in the countries of Brazil, Indonesia and Zaire. Locate these countries on an atlas map.)

Check your understanding

Take out your atlas and turn to a world map (or use google).

1. On the map below draw in lines to show the **tropics of Cancer and Capricorn**. Also label the **four continents** where tropical rainforests are found.

2. Locate **Central America** (the narrow neck of land which connects North and South America) on your atlas map. The eight Central American countries with a tropical rainforest biome are:
   M……, G……, E…… S……,
   B……, H……, N……,
   C……R……, and P……

3. The South American country which has the largest area of tropical rainforest is ……

4. In Africa four of the countries crossed by the equator have tropical rainforest. From west to east these countries are:
   G……, C……, Z…… and U……

5. The world's most northerly area of tropical rainforest is found in the Asian country of ……

6. Three countries along the tropic of Capricorn with tropical rainforest are
   B……, M…… and A……

Tropical rainforests - characteristics

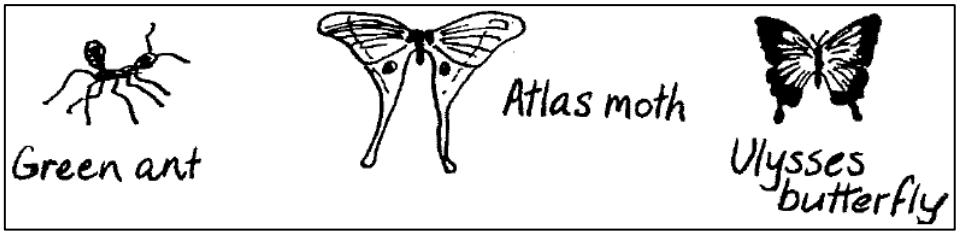
Despite their widely spread locations, tropical rainforests have many characteristics in common. Four of these major characteristics will be identified here.

Rainforest structure

All tropical rainforests are composed of evergreen trees. These trees grow close together with their crowns of foliage (canopies) almost interlocking. Trees of different heights form well-defined layers or storeys within this closed forest. A mesh of vines twines around the tree trunks. Many rainforest trees have large buttress roots at their bases.

Diversity of species

The tropical rainforest has the greatest number of plant and animal species of any world biome. The layered structure of the rainforest provides homes for a multitude of different creatures. Plants and insects abound. In one hectare of tropical rainforest there are likely to be more than 100 different species of trees. A one-hectare plot of rainforest in Peru yielded a record 300 species of trees! Just one tree within that plot was home to 43 different ant species. Such is the diversity of life in the tropical rainforest!



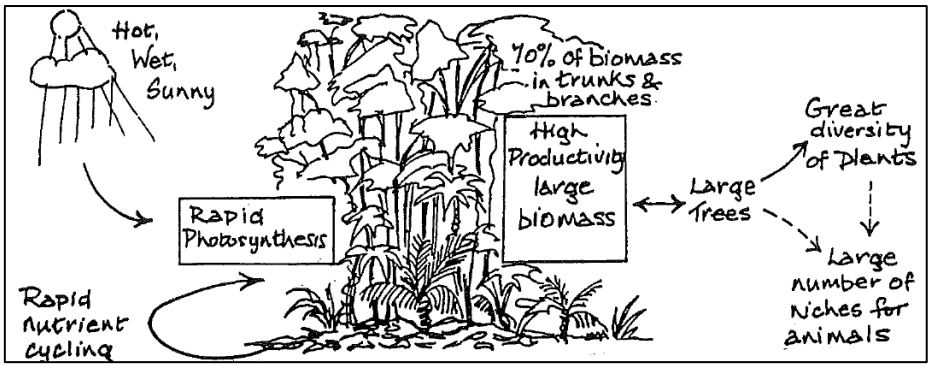
85% of all the world's insect species live in tropical rainforests.

Long evolution

The plants and animals of the tropical rainforest have evolved over a long period of time. During the last 200 million years, stable environmental conditions have existed in tropical rainforests. This explains the presence of ancient life forms in rainforests today. Such an important storehouse of genetic material needs to be protected for the future.

Productive environment

Luxuriant plant growth is the most obvious feature of the tropical rainforests. Optimum growing conditions exist in the humid tropics. Temperatures are uniformly warm, and nights are frost-free. Rainfall is abundant every month of the year. In the absence of a cold or dry season, plants grow continuously throughout the year. Tropical rainforest is one of the most productive biomes on earth.



Tropical rainforests are highly productive with a great diversity of plant and animal life.

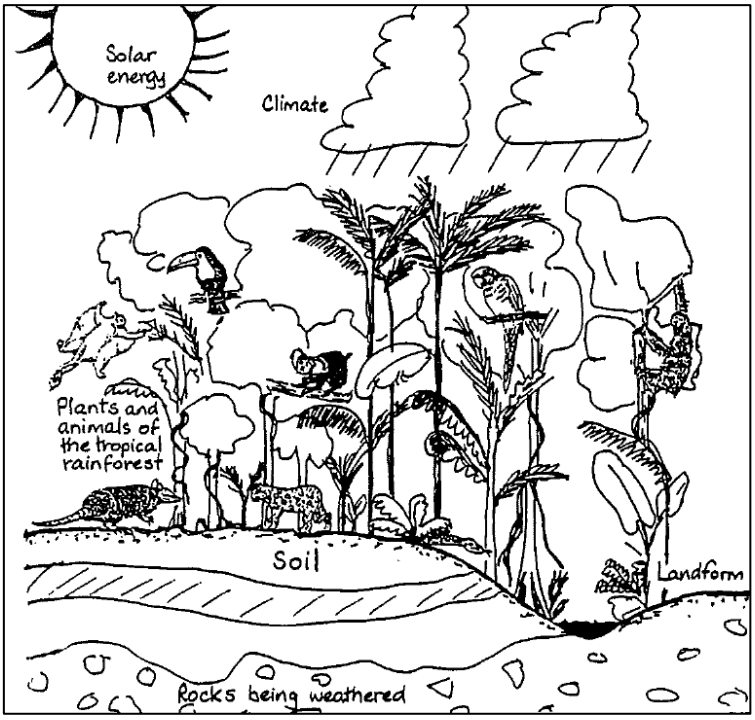
Check your understanding

1. Write a brief comment beside each of the **major characteristics** of tropical rainforests.

	Your comment
Rainforest structure	
Diversity of species	
Long evolution	
Productive environment	

Components of the tropical rainforest

Tropical rainforests have evolved into highly complex types of ecosystem. The living and non-living components of this ecosystem have been interacting for millions of years. The result is highly specialised plants and animals adapted to the tropical environment. Interactions between the living and non-living components of the tropical rainforest are the subject of this lesson. Study the diagram below to remind you of the principal components of an ecosystem.



Living and non-living components of the tropical rainforest ecosystem.

The non-living component

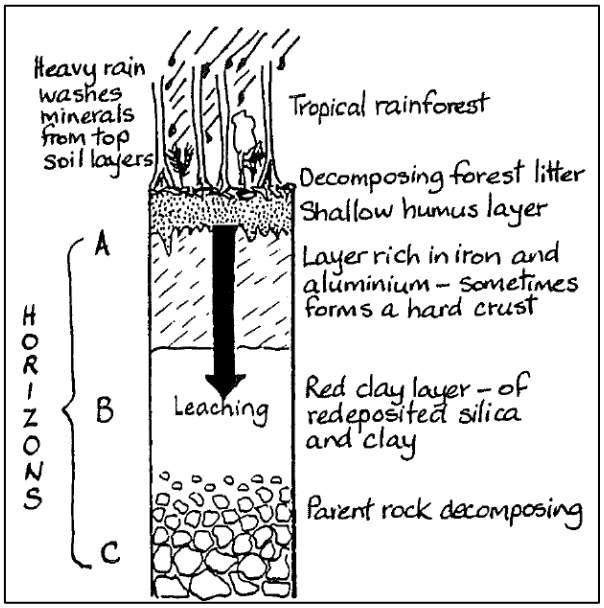
The non-living components of the ecosystem include climate, soil and landforms. Let's look at each of these non-living components of the tropical rainforest in more detail.

Climate

The tropical rainforest is a product of its **equatorial** climate. The heavy rainfall and high temperatures provide ideal conditions for plant growth. Most tropical rainforest areas have average monthly temperatures of 25°C to 28°C. The range of temperature between day and night is also low. Rain is abundant, falling in every month. Towering cumulonimbus clouds appear daily. The convectional downpours which follow bring 2 000 to 4 000 millimetres of rain annually to these areas (convectional rain is created by updraughts of warm moist air within large thunderclouds). Humidity is high in the tropical rainforest.

Soils

Soils of tropical rainforest areas are mainly classified as **latosols**. Like the rainforest, latosols are also a product of the equatorial climate. A careful study of the following diagram shows us the characteristics of this soil type.



Profile of a latosol - the main soil type of tropical rainforest areas.

Latosols are red-coloured soils which are rich in iron and aluminium oxides. These deeply weathered soils extend to 30 metres below the surface. Latosols have a shallow layer of humus (decaying organic matter) at the top of their profile. Decay occurs rapidly in the humid environment, so humus does not accumulate. Dead organic matter is soon broken down by the actions of soil bacteria and fungi. The released chemicals are then recycled as nutrients to feed new plant growth. Beneath the crumbly humus we find a red-coloured layer of iron and aluminium oxides. When wet, this layer becomes sticky and pliable. However, if allowed to dry out this layer sets hard like a brick. This hard crust formation is called laterite. Heavy rainfall has washed all the fine particles from this **A horizon**. The particles have been redeposited as a clay layer in the **B horizon**. This downward movement of particles dissolved in water is known as leaching. As **leaching** rapidly washes plant nutrients out of reach most latosols are infertile soils. Finally, in the **C horizon** the parent rock is being broken down by chemical weathering.

Did you know that it takes only six weeks for bacteria and fungi to decompose fallen leaves, fruit and animal remains? Even the largest trees are completely broken down within one or two years!

Landforms

Tropical rainforests occur on fold mountains, weathered plateaux and coastal plains. The most extensive rainforest areas have developed on **weathered plateaux**. These areas have been tectonically stable for many millions of years. The ancient granite rocks have been deeply weathered so they now form a gently sloping landscape. Vast river systems with gentle gradients flow across these low-lying areas. Examples include rainforests in the Amazon-Orinoco basin in South America, Zaire basin in Africa and parts of southern India.

Rugged landforms are typical of those tropical rainforests growing near the boundaries of tectonic plates. Active volcanoes are located within these fold mountain chains. The landforms consist of steep slopes, sharp ridges and deep 'V'-shaped valleys. Basalt lava is weathered by carbonic and humic acids to form steep spires. Such landscapes are common throughout central America, the Andes 'Mountains and the Indonesian archipelago.

Coastal plains and river deltas are the third landform type associated with tropical rainforests. Rivers continually deposit sediment in these low-lying areas. Swamps are common here. Examples of lowland rainforest occur in New Guinea as well as the deltas of the Amazon and Zaire rivers.

Check your understanding

1. Most tropical rainforests have an e…… climate. Average monthly temperatures are consistently between ……°C and ……°C. Rainfall comes from c…… downpours which usually bring …… millimetres of rain annually.

2. The red-coloured soil of tropical rainforests is known as a ……. The red colouring comes from …… and …… oxides which form a concentrated layer. The process of …… washes silica and clay particles into the B horizon of this soil profile. Plant nutrients are also leached away causing this soil type to be i……

3. Give **locations** of tropical rainforests growing on the following landform types:

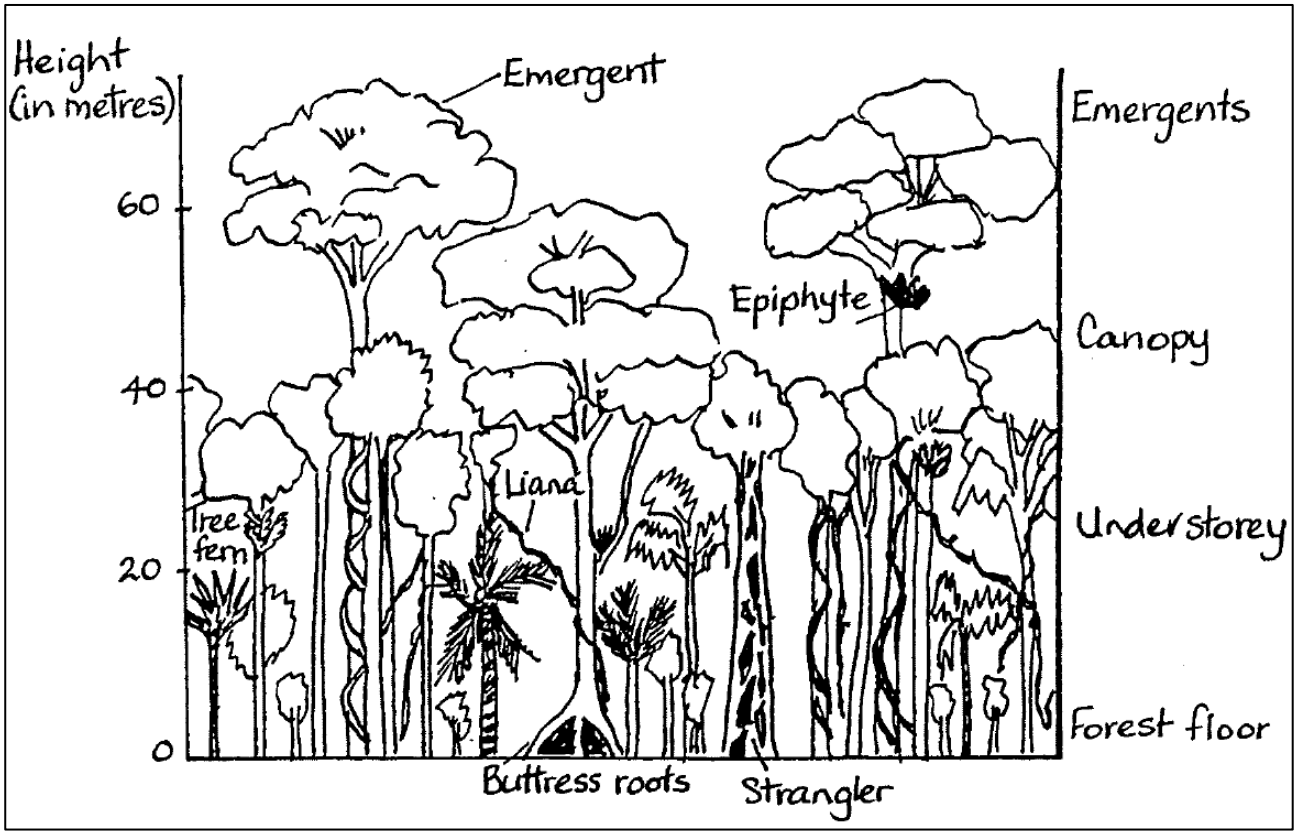
Weathered plateaux	
Fold mountains	
Coastal plains	

The living component

Plants (vegetation) and animals (fauna) make up the living component of the tropical rainforest.

Vegetation

Tropical rainforests are composed of a great diversity of evergreen plants. These plants grow in well-defined layers or storeys. The following diagram highlights these two features of vegetation in the tropical rainforest.



Profile of vegetation in a tropical rainforest

Let's begin from the top of the rainforest profile and examine each storey in turn. The top storey is composed of **emergent** trees which rise above 40 metres in height. Notice that these tall, straight-trunked trees are scattered throughout the forest. Despite their great height, these trees only have a shallow rooting system. That is why emergents are often supported by plank-like extensions (**buttress roots**) at the bases of their trunks. An emergent grows tall and straight in its quest for sunlight energy. Its dense crown of leathery leaves is high above the rainforest where sunlight is in abundance. Branching occurs only near the top of the tree.

The next storey at about 35 metres in height is the **canopy**. Within the canopy the crowns of adjoining trees almost interlock. 70-80% of sunlight striking this dense canopy of leaves is trapped. Sunlight provides the energy for photosynthesis and plant growth to take place. When a tree dies leaving a hole in the canopy this is quickly filled by a sapling.

Apart from trees, there are many other light-seeking plants in the canopy. The tree branches are cloaked in green moss and algae. **Liana creepers** grow from the forest floor twining around tree trunks for support. These rope-like vines attach themselves to tree trunks by hooked tendrils or barbs. Lianas grow their leaves at the top of the vine where more sunlight is available. **Stranglers** also need the support of another tree. For example, strangler figs germinate high up on a tree branch. From there, the strangler grows aerial roots which eventually reach the forest floor. When the roots penetrate the soil, the strangler has a spurt of growth. Soon the strangler encases its support tree in a wooden lattice of aerial roots.

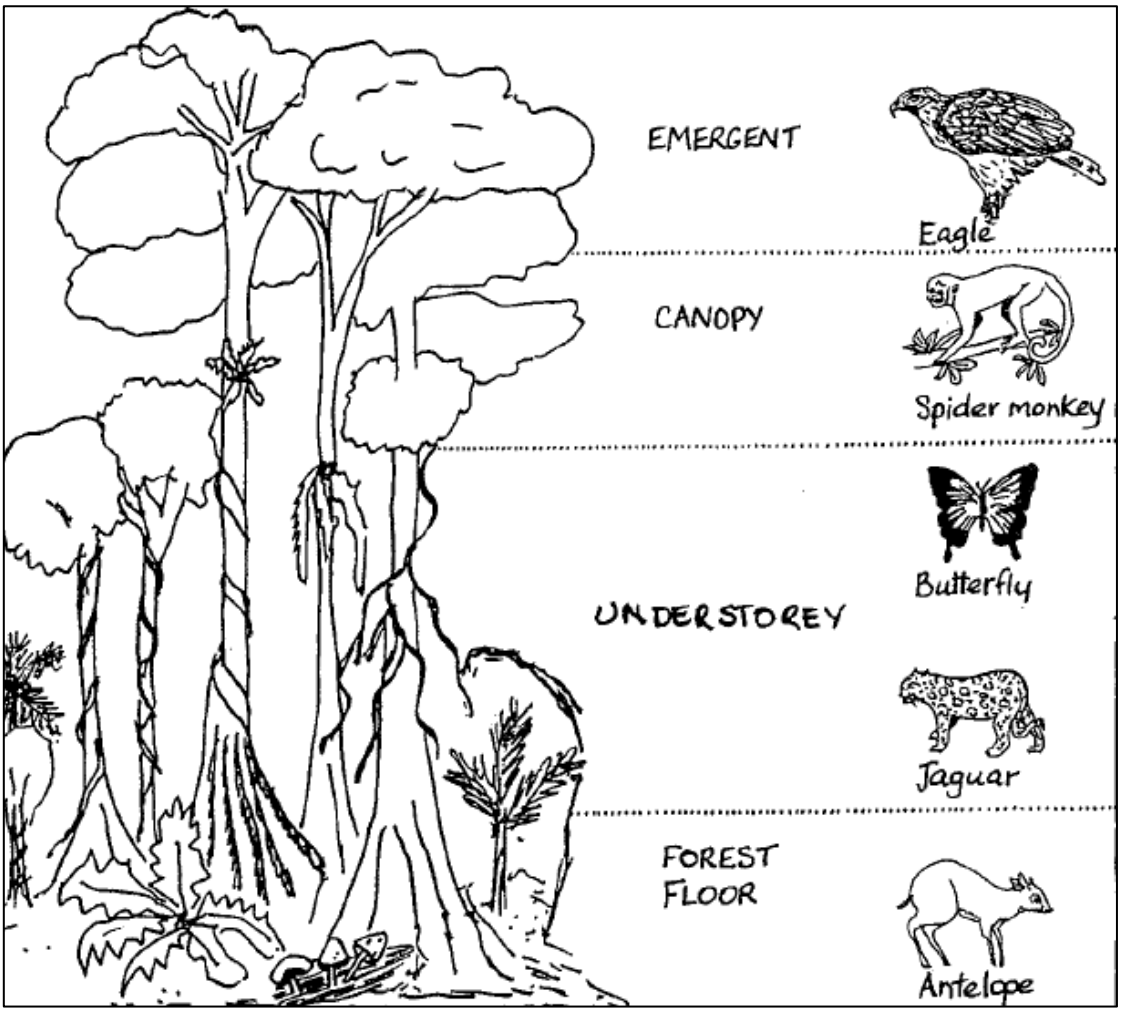
Some plants, called **epiphytes**, grow high up on the tree trunks and in forked branches. Examples include orchids, tree ferns and funnel-shaped bromeliads which grow in pockets of rotting organic matter. These plants obtain moisture by dangling their roots in the humid air.

The **understorey** is the dark zone beneath the canopy. As little as 1% of the sunlight may filter through to this storey. The saplings growing here have slender trunks and narrow crowns. In order to trap the little sunlight that is available, plants have evolved large leaves. These leaves also have a drip tip which sheds water quickly. Palms, saplings and ferns are the main plants of the understorey.

Finally, we reach the **forest floor**. The lack of sunlight here results in sparse vegetation. However, bacteria, moulds and fungi are abundant in the leaf litter. Fine white threads of fungi form a web over the forest floor. The fungi's colourful umbrella- shaped fruits grow on rotting logs. Ferns and mosses also grow on the forest floor.

Fauna

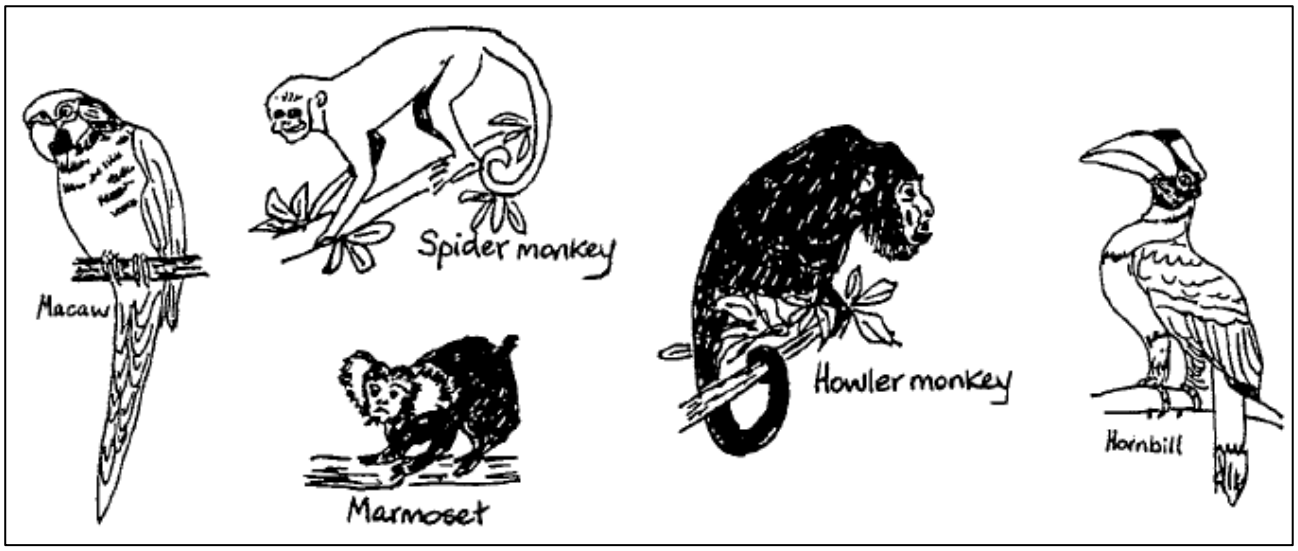
The tropical rainforest with its abundant food supply is home to a great diversity of animals. Each storey of the rainforest is occupied by different animals. The close relationship between vegetation and fauna is illustrated in the diagram on the next page.



Different animal communities inhabit each storey of the tropical rainforest

Animal life is most abundant in the upper storeys of the rainforest, for this is where the greatest concentration of leaves, fruit, seeds and nectar is to be found. In the emergent trees you are most likely to see eagles, bats and insects. Brightly coloured birds such as hornbills, macaws and pigeons feed upon the fruits. Hummingbirds and sunbirds feed on the nectar from flowers.

The greatest variety of animal life is found in the busy canopy below. Here you'll see animals specially adapted to a life in the trees. Spider monkeys and howler monkeys have long limbs which allow them to swing from branch to branch. Other animals are adapted to gliding such as the flying frogs and flying squirrels. Tree sloths have long claws which enable them to grip onto branches. Some of these animals rarely descend to ground level. In the canopy you'll also find butterflies and insects.



Animals of the emergent storey and canopy

In the lowest part of the canopy and the understorey, the bare trunks and vines are inhabited by snakes and lizards and tree dwelling cats (jaguars, leopards). Less food is available so there are fewer animals living here. Animals tend to forage between the understorey and the forest floor. Anteaters are an example. On the forest floor, you'll see small deer, pheasants and rodents grazing on roots, leaves and fallen fruit. Peccaries and wild pigs scavenge the carcasses of apes and monkeys. Elephant shrews prey upon the bounteous supply of worms, beetles and lizards in the leaf litter. Insects such as leafcutter ants and termites dominate the forest floor.

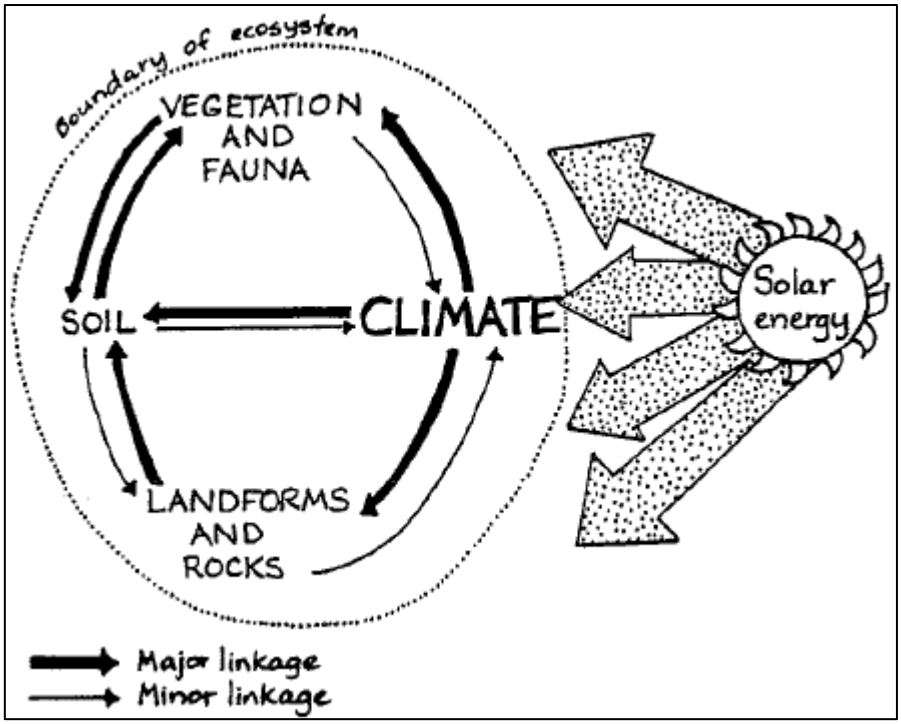
Check your understanding

1. Make a summary of the vegetation patterns in a tropical rainforest by **naming the four storeys** and **listing the main features** of **plants** found at each level.

2. Give examples of **animals** you are likely to see in the **four storeys** of the tropical rainforest.

Interactions within the tropical rainforest ecosystem

Living and non-living elements of the tropical rainforest interact with each other. This familiar diagram should help us to summarise interactions within the tropical rainforest ecosystem.



Environmental linkages within an ecosystem are two-way

Climate - Vegetation

The equatorial climate accounts for dense rainforest vegetation. High insolation and abundant rainfall provide ideal conditions for plant growth. Production of organic material occurs at the average rate of 2200 grams per metre² annually. This represents one of the most productive biomes on earth.

The tropical rainforest influences climate. Tropical rainforest plants pump enormous quantities of water vapour into the atmosphere through evapotranspiration. You should remember that evapotranspiration is a cooling process. Rainclouds develop in the humid air above the forest. These rainclouds reflect sunlight away from the earth and cause temperatures to be cooler. Some of the heat energy trapped in the clouds is transferred by winds to cooler latitudes.

Fifty percent of rain falling in the Amazon rainforest is generated from evapotranspiration. If the trees are felled rainfall would be greatly reduced!

The structure of the tropical rainforest creates its own microclimate. Only the emergent trees are subject to daily variations in wind, temperature and humidity. Plants below the dense canopy are shielded from weather changes. Still, humid conditions prevail with low levels of evaporation. Seasons do not exist here so plants flower at any time of the year. The dense canopy also blocks sunlight from reaching the forest floor. The limited sunlight is captured by plants which have broad leaf surfaces or numerous leaflets as in ferns. Another special adaptation to this wet environment is the drip tip on many leaves. The drip tip enables water to be shed quickly. This keeps the leaf free from fungal disease and leaf rot. A coating of fungus on the leaf would prevent photosynthesis from occurring.

Climate - Soil

The equatorial climate plays an important role in the formation of latosols. High temperatures and moist conditions cause organic matter to decay rapidly. The result is a shallow humus layer. High rainfall causes leaching which leads to concentrations of iron and aluminium oxides. Leaching also impoverishes the soil of plant nutrients. Latosols have deep soil profiles. Humid conditions promote chemical weathering of the bedrock.

No significant linkage exists between soils and climate.

Climate - Landforms

Climate affects the gradational processes acting upon landforms. In regions of equatorial climate chemical weathering is the dominant gradational process. Weathering is so intensive that sediment carried by streams is very fine. Without the tools of abrasion tropical streams are unable to erode deep channels. Mass movement in the form of landslides is most likely to occur on waterlogged, steep slopes.

The influence of landforms on climate is particularly noticeable in mountainous rainforest areas. When moist air is forced to rise above these mountain barriers orographic rainfall results (orographic rainfall occurs when a moist air mass rises to cross a mountain barrier). Combined with convection currents this means exceptionally high rainfall is recorded. Central America, the foothills of the Andes Mountains and parts of South-East Asia illustrate this effect. The higher altitudes of mountainous rainforest also experience slightly cooler temperatures.

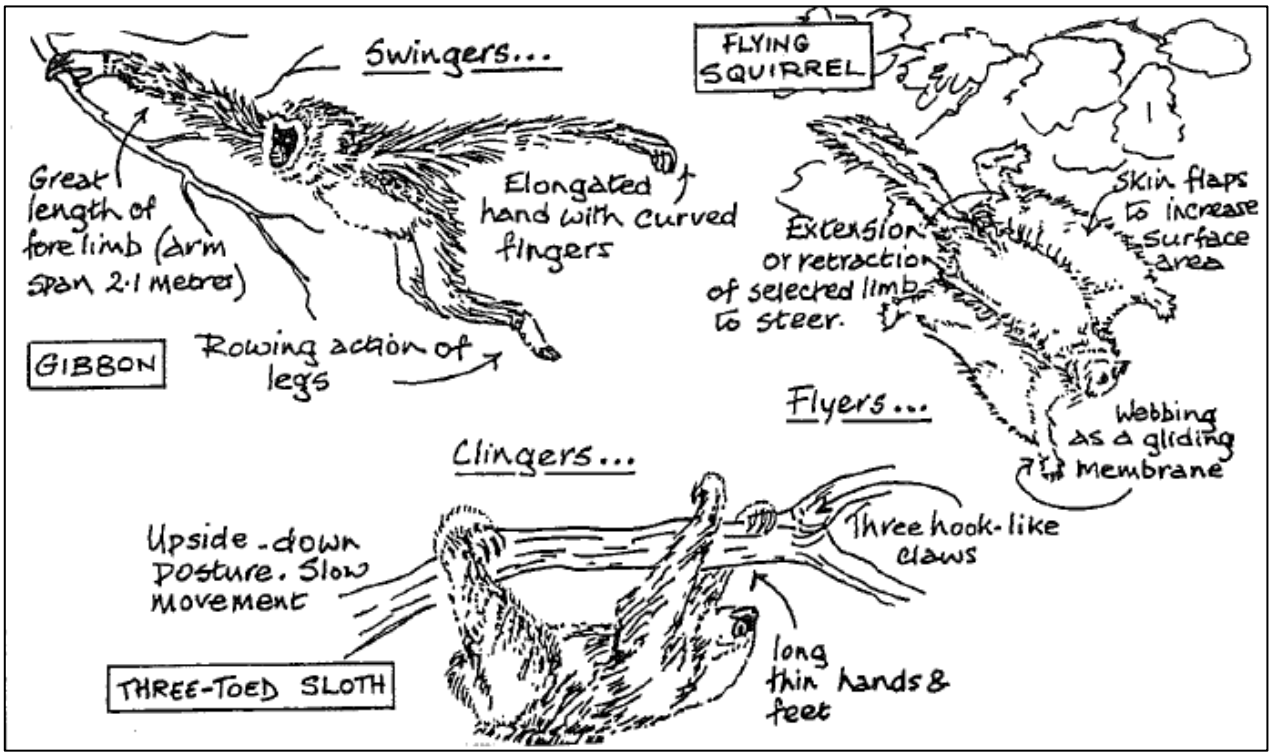
Soil - Vegetation

We have already learnt that latosols are infertile and lack nutrients essential for plant growth. Latosols are generally deficient in nitrogen, phosphorus, potassium, calcium and magnesium. Fortunately, these minerals are present in the fallen leaves and organic matter lying on the forest floor. Special adaptations enable plants to trap these nutrients before they are leached away. Shallow spreading root systems and roots covered in fungi quickly channel nutrients back to the plants.

Rainforest vegetation also influences the soil. Evergreen plants drop their leaves continuously showering a steady supply of organic matter onto the forest floor. Annually 11 tonnes of organic matter fall per hectare on the Amazon rainforest! It is this energy-rich litter that supplies the nutrients for further plant growth. Bacteria and algae living in the litter trap nitrogen. In this way nitrogen is made available to the plants. There is a very fine balance of nutrients being cycled between the living rainforest and the latosol. Where rainforest vegetation is cleared the litter-layer is lost. This means the main source of plant nutrients is also lost. Plants are then unable to grow.

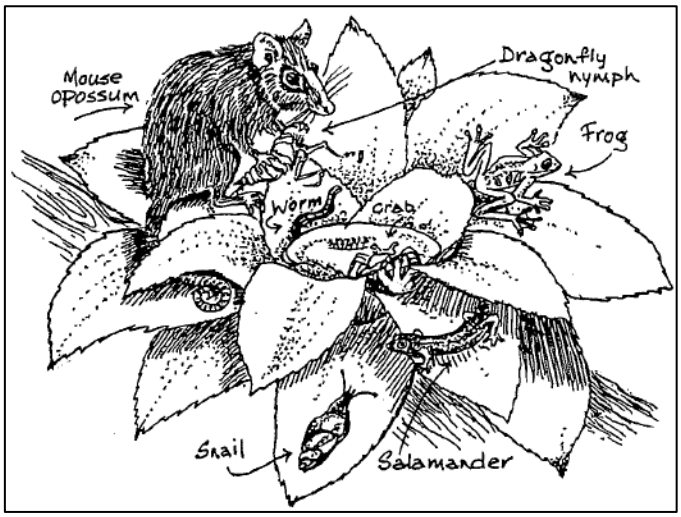
Vegetation - Fauna

Special relationships exist between rainforest vegetation and fauna. Only a few examples will be described here. Rainforest vegetation is dominated by evergreen trees. These trees do not have a single flowering season, so fruit and nectar is available continuously. This is the reason for the great variety and abundance of animals in the rainforest. A high percentage of rainforest animals are **arboreal**. This means the animals are adapted to a life in the trees. Birds, bats and insects are particularly abundant in the rainforest. Other animals have adapted to life in the trees by developing the ability to swing, cling or fly. The diagram on the next page illustrates how sloths, gibbons and flying squirrels have adapted to their arboreal life.



Adaptations for an arboreal life

Some rainforest plants are ecosystems on a miniature scale. Consider, for example, the bromeliad plant which is an epiphyte. The bromeliad has a funnel-shaped rosette of leaves in which water collects. This tiny pool of water provides homes for many different creatures. In return the animals provide organic wastes so necessary for the bromeliad's continued growth high up in the trees.



The bromeliad is an epiphyte growing on tree trunks. The pool of water which collects in the funnel-shaped rosette of leaves provides homes for many creatures

Another epiphytic plant has a special relationship with ants. The plant supplies nectar and a tuber-like chamber in which the ants live. In return the ants store organic matter within the plant providing food both for themselves and the epiphyte. The ants also disperse the plant's seeds and protect it from insect attack. These two examples illustrate that relationships between plants and animals are usually of mutual benefit.

Animals also influence rainforest vegetation. Insects are the most abundant consumers of rainforest vegetation. The huge number of insects could rapidly deplete the rainforest of its vegetation. Weevils and floor-dwelling animals also seek out the seeds which lie on the forest floor. To ensure their survival many rainforest plants produce chemicals which are toxic to insects and larger animals. Other plants have spines or thorns which help to repel predatory insects. Some plants, like the epiphyte described earlier, house colonies of ants to act as their guard against insects. Adjoining trees in the rainforest canopy have crowns of foliage which don't quite touch. This prevents the spread of caterpillars from one tree to another. Animals sometimes provide nutrients for the plants in which they live. The South American sloth is an example. The sloth is a slow-moving animal which feeds and lives in one tree. The sloth only descends to the ground to pass waste. In this way the nutrients are rapidly returned to the tree that fed the sloth!

Check your understanding

1. Compile your own notes on the interactions between elements of the tropical rainforest ecosystem.

Your notes should:

- have a clear title
- use subheadings to indicate separate sections
- highlight and define key terms
- list main points of information
- include diagrams where useful
- cover 1-1½ A4 pages.

WEEK TWO

Energy flows within the tropical rainforest

Tropical rainforest is the most productive of the world's major biomes. Its year-round growing season produces large quantities of plant matter. Study this table for a quick comparison of productivity in the world's major biomes.

Table 1. The annual production of plant matter (in grams/metre 2) for the world's major biomes.

Biome	Net production of plant matter (grams/metre^2/year)
Tropical rainforest	2200
Tropical deciduous forest	1600
Temperate deciduous forest	1200
Tropical savanna grassland	900
Coniferous forest	800
Mediterranean woodland	700
Temperate grassland	600
Tundra and mountain	140
Desert scrub	90
Extreme desert (rock, sand, ice)	3

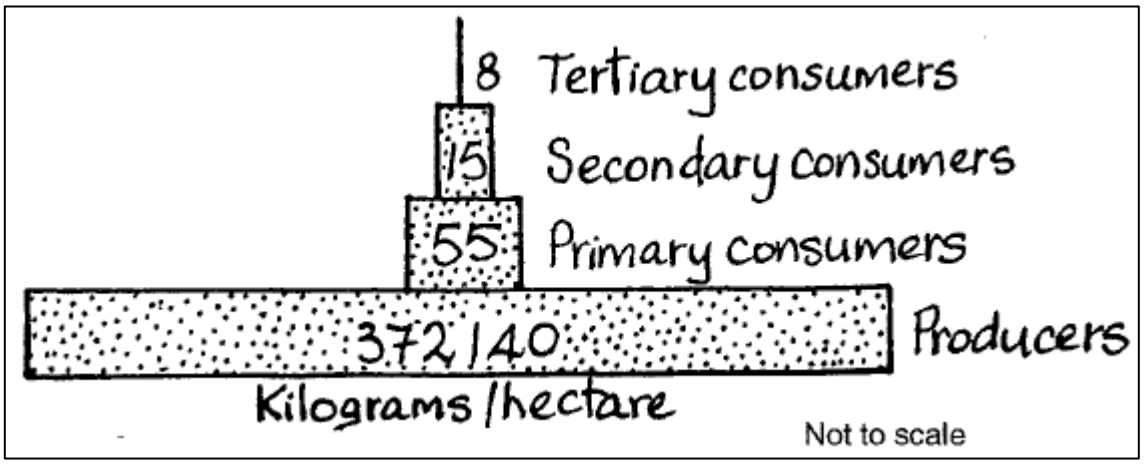
Total production calculated by multiplying the area of a biome (in km^2) by its net production of plant matter.

The only ecosystems which exceed tropical rainforests in productivity are tropical swamps, marshes and reefs. However, these ecosystems cover a much smaller area of the earth than tropical rainforests. Total production is therefore much higher for the tropical rainforest.

Energy in the tropical rainforest ecosystem

It is the high inputs of solar energy which make tropical rainforests so productive. Most sunlight energy is trapped by leaves in the canopy of the rainforest. Here the conditions for photosynthesis are ideal. The canopy is exposed to full sunlight, high temperatures and high humidity. Photosynthesis proceeds at a rapid rate. For every hectare of rainforest, 25-30 tonnes of new growth is produced annually! No wonder the canopy has such a thick growth of trees, epiphytes and liana creepers. This dense vegetation represents a storehouse of energy available for other creatures to consume. Just one rainforest tree produces more than 1·5 kilograms of pure glucose daily! Half of this glucose is converted into plant tissue which can then be consumed by animals. The rainforest canopy with its concentration of leaves, flowers and fruits has the largest populations of different animal species.

An ecological pyramid of biomass demonstrates the energy distribution in the tropical rainforest.

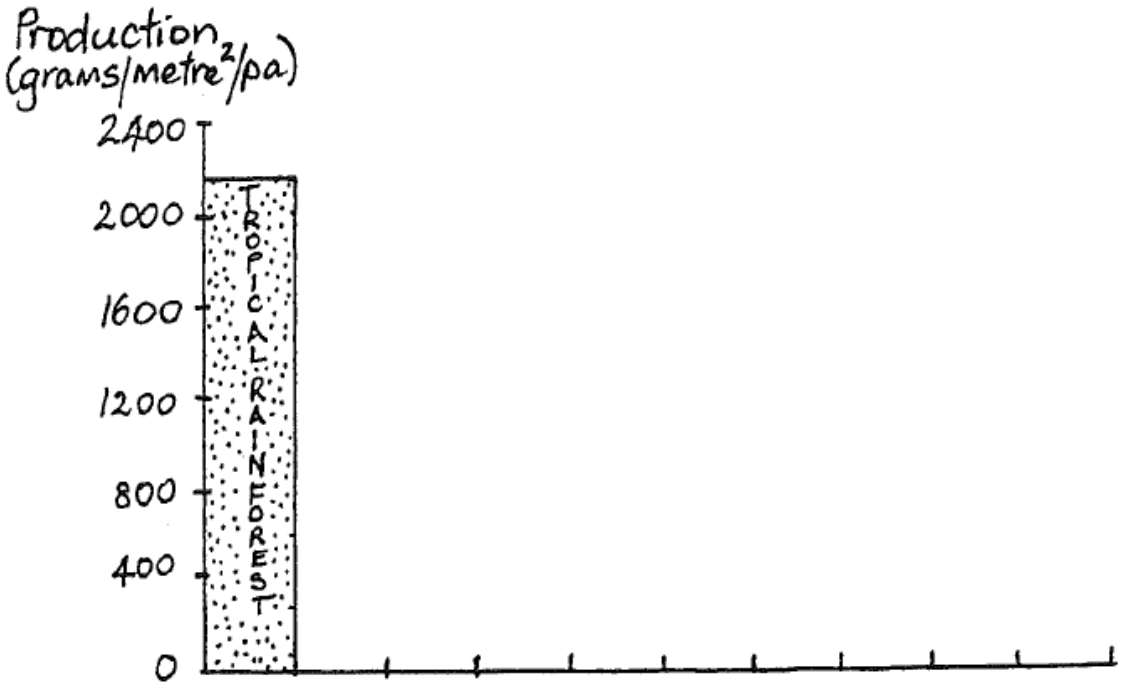


Pyramid of biomass for the tropical rainforest

Notice that the pyramid is heavily weighted at the base. Producers (plants) make up the bulk of the living material in the tropical rainforest. Animals (consumers) make up less than 1% of the total weight of living matter. Clearly the greatest amount of energy is available at the producer level of the food chain.

Check your understanding

1. Use the statistics from **Table 1. The annual production of plant matter (in grams/metre 2) for the world's major biomes** to complete this column graph.



The annual production of plant matter (in grams/metre^2) for the world's major biomes

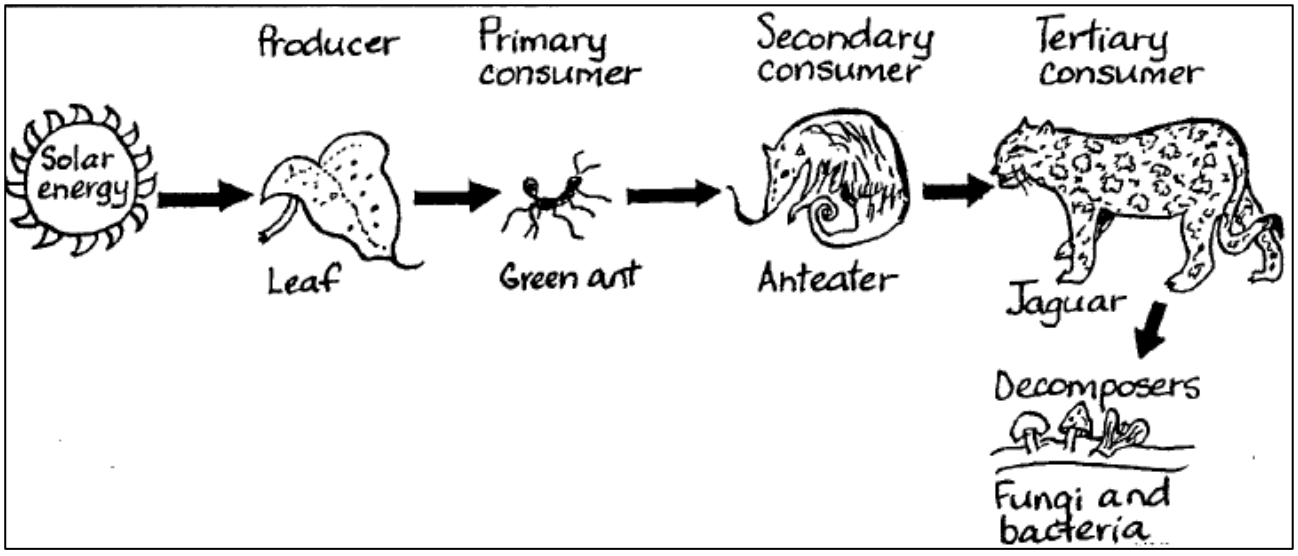
2. Productivity is high in the tropical rainforest because of its

3. Most photosynthesis takes place in the …… of the tropical rainforest.

4. In the tropical rainforest the greatest amount of energy is available in the …… level of the food chain

Food chains in the tropical rainforest ecosystem

Food chains demonstrate energy flows from **producers** through to **consumers** and **decomposers**. Entire food chains can be identified within each storey of the tropical rainforest. For each storey has a unique collection of plants and animals linked together in feeding relationships. We will study a food chain typical of the understorey in this lesson. However, food chains of the canopy and forest floor will also be considered briefly in the assessment activities. So, you will have to research these yourself.



A food chain in the understorey of the tropical rainforest. This is an example from South America

Food chains begin with solar energy. Varying amounts of sunlight energy reach each storey of the tropical rainforest. The understorey, in our example, receives only a small amount of sunlight. Most of the energy has been trapped by the dense foliage of the canopy above. Plants (**producers**) in the understorey have evolved large leaves to collect the limited sunlight. Flowers and fruit are uncommon in this shaded part of the forest. Leaves then are the main source of food available to the consumers in the understorey.

A **primary consumer** typically found in the understorey is the ant. Huge numbers of ants feed on the energy-rich leaves. Long processions of ants are a familiar sight in tropical rainforests.
Often the ants carry cut pieces of harvested leaves back to their nests. These cut leaves grow fungi which is fed to young ants in the nursery.

The **secondary consumer** which feeds almost solely on ants is called an anteater. This animal has a long sticky tongue which, when thrust out, captures many ants at once. Anteaters of various types are found in most rainforests around the world. The South American anteater is also known as a tamandua. The tamandua has strong gripping claws enabling it to climb trees in its search for ants.

The **tertiary consumer** shown in our food chain is the jaguar. This large cat preys upon animals living between the forest floor and lower canopy. The anteater is just one of the many animals hunted by the jaguar. The number of jaguars in the tropical rainforest is low. These large animals occupy the top position in the food chain where less energy is available.

Finally, the plants and animals in our food chain die. This is when **decomposers,** such as fungi and bacteria, begin their work. Fallen leaves, branches and dead bodies are quickly broken down by the action of decomposers. Fungi and bacteria thrive in the hot wet conditions of the tropical rainforest. Carbon, nitrogen and phosphorus are among the elements released by the decay process. These elements are rapidly recycled by rainforest plants to ensure their continued growth. With the plants we go back to the beginning of the food chain. Life in the rainforest is an endless cycle.

Most animals are part of more than one food chain and eat more than one kind of food in order to meet their food and energy requirements. These interconnected food chains form a food web.

Check your understanding

1. Construct a forest floor and a canopy food chain. Fully label each food chain of the tropical rainforest. Remember to add arrows showing the flow of energy. Appropriate examples of producers and consumers may be obtained from this booklet.

   a. Forest floor

   b. Canopy

2. Construct a food web that may be found in a tropical forest. Appropriate examples of producers and consumers may be obtained from this booklet.

3. Why are decomposers important?

4. Provide two (2) examples of a decomposer.

Human impact on tropical rainforests

Tropical rainforests have faced increasing exploitation in recent decades. Mechanisation has made this possible. In the past, the impenetrable world of the rainforest was generally avoided. Only primitive tribespeople and adventurous travellers entered the rainforest. Nowadays, the rainforest is being conquered by bulldozers, chain saws and massive fires. The valuable rainforest resources are being exploited intensively. More than 40% of the world's tropical rainforests have been destroyed since 1945.

Human activities in the tropical rainforest

In the past, tropical rainforests were home to shifting cultivators and hunter-gatherers. These people lived in small groups scattered throughout the rainforest. Using only primitive technology (hand axes, spears and fire), they had a minimum impact on the rainforest ecosystem. Rainforest resources were harvested sparingly to ensure a plentiful supply. Cultivated land was rested (fallowed) after several seasons of crops. This practice allowed the impoverished soil to regain some of its nutrients. Shifting cultivators mimicked the rainforest by planting a mixture of crops.

Traditional shifting cultivators cleared small plots of rainforest by a slash and burn technique. A mixture of crops was then grown in the ash-enriched soil. After 3-4 years of cultivation soil productivity declined and the plot was abandoned. The clearing quickly regenerated with rainforest plants as seed trees surrounded it.

In recent times, exploitation of the tropical rainforest has been more widespread. The growth of population has placed an increased demand on rainforest resources. Amongst the people now exploiting the rainforest are farmers, loggers, miners and developers. Let's consider each of these activities in turn.

Agriculture

Agriculture is the major cause of rainforest destruction. The need to feed increased numbers of people has brought changes to traditional farming practices. Shifting cultivators no longer restrict their cropping to small plots of land. More and more of the rainforest is being cleared. Nor do shifting cultivators rest the land after growing several food crops. The soil is no longer given time to recover from nutrient depletion. In Africa, shifting cultivators are responsible for 70% of all rainforest destruction.

Another major change has been the introduction of European farming practices to the rainforest. Large tracts of rainforest have been cleared for the commercial production of crops or livestock. Rainforest has been exchanged for lines of rubber trees in plantations and the grasslands of cattle ranches. In commercial enterprises such as these, the land is farmed continuously. This European farming practice is unsuited to the tropical rainforest environment. Rainforest soil is quickly impoverished under these conditions. Insect attack and plant diseases also become more widespread when **monoculture** (single crop farming) is practised.

A more suitable form of commercial agriculture for the rainforest is tree farming. Deep-rooted native trees such as beach palm and brazil nut trees protect the soil from erosion. Non-mechanised cultivation of rubber, cocoa, coffee and cassava are also better adapted to the environment.

Forestry

Currently, the world demand for rainforest timbers is high. That is why forestry has become such a valuable industry for countries with tropical rainforest. Significantly, many of the nations located in the rainforest biome are developing countries. These poorer countries rely on the export of raw materials (such as timber) to earn foreign revenue. At times, the eagerness to earn income has overshadowed careful management of their rainforest resource. The use of large machinery has also encouraged greater rates of logging than in the past.

Trees of many species grow in the tropical rainforest, only some of which have commercial value. Mahogany and meranti are two rainforest trees especially prized for their timber. Loggers face a difficult task extracting these trees for they are scattered throughout the forest. To reach these trees, loggers destroy other less valuable trees in their path. Even more destructive is the **clear-felling** technique used to harvest poorer quality timber for pulpwood. This method involves felling all the trees within a section of rainforest.

Logging creates holes in the rainforest canopy. Given time, the forest will regenerate but its composition will have changed. The abundant sunlight in a clearing favours fast-growing tree species and woody lianas. This secondary regrowth or **jungle** is often of limited commercial value. In West Africa this is especially true. The valuable mahogany trees only grow in shade and will not regenerate in large clearings. South-East Asia's rainforests are more suited to intensive logging, for there, the most valued timber trees readily regenerate in cleared areas. However, it is important that the rainforest is not logged too frequently.

Tropical rainforests which are carefully managed, provide a sustainable source of timber. Most Asian rainforests, as well as managed African and South American forests, are exploited in a polycyclic system. The **polycyclic** (or selection) system removes only mature trees, leaving younger trees for future logging. This system is compatible with rainforest conservation and is also favoured by the business community. Logging can occur more frequently, and the larger logs are more suited for peeling into veneers.

Unfortunately, not all tropical rainforests are logged by the sustainable methods described above. These rainforests are the ones most at risk. To ensure a continuing supply of timber, forest managers must consider these factors:

- young trees must not be destroyed during logging
- logging roads must be sited to minimise erosion
- recutting must not take place too frequently
- hunters and farmers should be refused access to logged areas allowing the ecosystem to regenerate.

Perhaps also there should be a changed emphasis in timber marketing. Instead of selling high volumes of low value timber, this situation should be reversed. Low volume sales of high value timber would encourage better management of the world's tropical rainforests.

Mining

Mining is another cause of rainforest destruction. This is largely because the latosolic soils which lie beneath tropical rainforests are rich in bauxite, gold, iron ore, tin and copper. In their quest for these minerals, miners have denuded sizeable tracts of land. After the rainforest has been cleared, deep pits are dug into the ground. Access roads and work sites have also been carved from the forest. Mining activity like this completely destroys the complex ecosystem. There is little chance that these areas will ever be restored to their original state.

Development

Many of the countries in the tropical biome have begun to develop their sparsely settled rainforests. The reasons for development vary from political to strategic (military) and economic considerations. You should recall that many of the rainforest nations are developing countries with booming populations. Governments of these countries now view the rainforest as the key to their future prosperity. The rainforest provides much-needed land and untapped resources ready for exploitation.

Brazil, which is currently developing vast tracts of its rainforest, is a much-publicised example. The government's 'Operation Amazon' is a project to develop rainforest areas of the Amazon basin. Landless slum-dwellers from coastal Brazil have been resettled in Manaus, the Amazon's major urban centre. The surrounding rainforest has been cleared by massive fires. Annually, an area of 42 000 square kilometres has been deforested. The burnt-out areas have been converted into pastureland for cattle ranches. At first, government subsidies (assistance) encouraged cattle ranchers to burn the rainforest. Now, however, the government subsidies have been stopped due to worldwide concern for the future of the rainforest.

In addition, the Brazilian government has also encouraged logging, mining and industry in its rainforest. Many new sawmills have been built with government assistance. To fuel the pig iron industry, large quantities of timber are being burnt to manufacture charcoal. Large dams have also been constructed to provide hydro-electric power for the new industries. Easier access to the area has been provided by the Trans-Amazon Highway and air strips. All of these developments make the rainforest more vulnerable to change.

Check your understanding

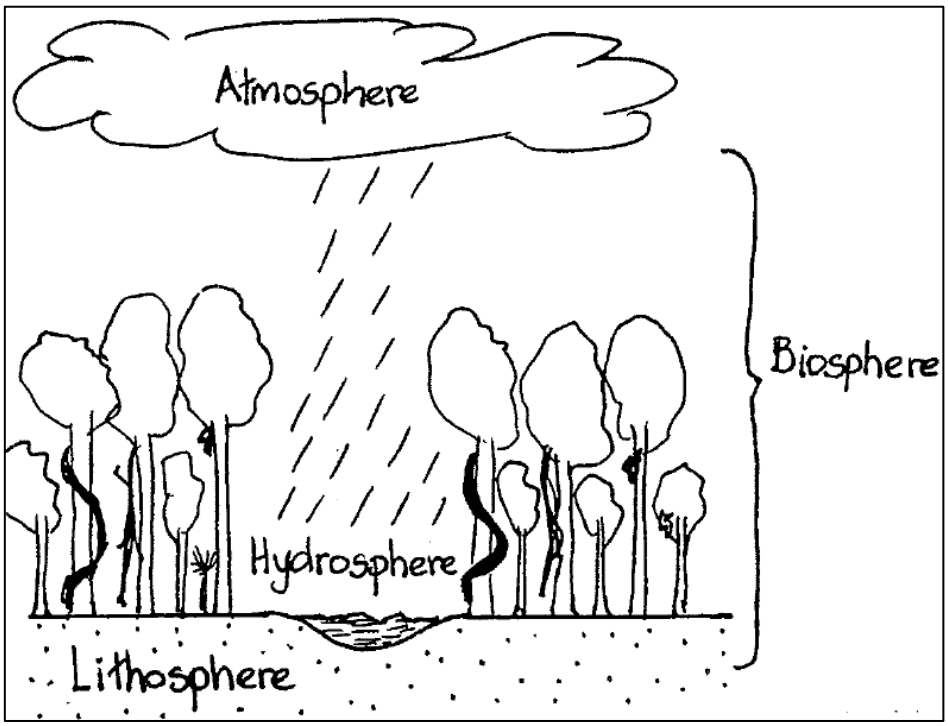
It is now time to summarise!

Compile your own brief notes on the impact of human activity on the world's tropical rainforest by answering the following questions. For this activity you must use your own file paper and take the time to write full sentence answers.

1. List five types of agriculture practised in the world's tropical rainforest.
2. Select one low impact farming practice and explain why it causes limited environmental damage.
3. Explain why European farming practices cause serious damage to the tropical rainforest ecosystem.
4. Explain the difference between the forestry techniques of clear felling and polycyclic (selection) system.
5. Compare the results of clear felling in West Africa with clear felling in South-East Asia.
6. List the minerals most commonly mined in the world's tropical rainforests.
7. Suggest ways that developed countries, like Australia, could encourage developing countries (eg Papua New Guinea) to reduce rainforest destruction. (You will have to think about this question.)

Human impact on the tropical rainforest ecosystem

Worldwide it is estimated that 15·3 million hectares of tropical rainforest are being destroyed each year. The greatest loss of tropical forest is occurring in Brazil and Indonesia. This deforestation is causing changes to all other components of the tropical rainforest ecosystem. Let's consider the human impact on each of the components of the tropical rainforest ecosystem illustrated below.



The components of the tropical rainforest ecosystem.

Lithosphere

The removal of the trees has an immediate impact on rainforest soil. With the trees gone, the soil is unprotected and vulnerable to erosion and the soil is robbed of its nutrient source.
Nutrients in the soil are rapidly leached out of reach of plant roots. With the soil surface now unshaded, the higher temperatures cause the soil to harden and crack. Gully erosion becomes a problem when these weakened soils are hit by heavy rainfall. No wonder rainforest soils rapidly become unproductive when put under crop cultivation or pasture. The cattle ranches in Brazil's Amazon basin are an example. Within two years of their establishment much of the grassland reverts to useless scrub. Such areas are often abandoned to become wastelands.

Hydrosphere

Slopes cleared of rainforest become vulnerable to erosion. Instead of soaking into the ground, rainfall runs across the surface of the hardened soil. The increased run off causes rivers to flood their banks.

Run off from cleared slopes usually carries a great deal more silt than from forested areas. Rivers, dams and canals downslope of cleared areas suffer from silting problems. The Panama Canal in Central America is an example. The sloping banks overlooking the canal have been logged. The bare slopes have caused an increased amount of run off and silt to enter the canal. This excess silt has clogged the machinery which controls the opening and closing of the canal's locks. In time the canal could become unnavigable if the locks are permanently silted up.

Atmosphere

Although unproven, it is believed that widespread deforestation of tropical areas could lead to climatic changes.

The albedo effect occurs when solar energy is reflected from the earth's surface. The amount of reflection (albedo) from an area of tropical rainforest is only 9%. (Compare this with desert areas which have an albedo of 37%.) Clearing the rainforest is likely to increase the amount of reflection from the land surface. This means less solar energy will be absorbed by the earth. With less energy available there would be a reduction in evaporation. Without trees there would also be less transpiration of moisture from leaves. As a result, convectional rainfall may be reduced. The climate may gradually become drier. Changes in the atmospheric circulation of heat and moisture could even affect areas north and south of the tropical zone.

Rainforest fires are also creating concern for the atmosphere. The Amazon region alone stores at least 75 billion tonnes of carbon in its trees. When trees are burnt, carbon dioxide is released into the atmosphere. Too many large-scale fires could lead to atmospheric accumulations of carbon dioxide. It has been suggested that such fires contribute to global warming through the 'greenhouse effect'. However, currently there is no scientific proof to support this suggestion.

Biosphere

The clearing of tropical rainforest affects all living things within the ecosystem. Loss of habitat means many animals will die. There is a limit to how many animals can move to neighbouring rainforest. Animals with very specialised habitats are the first to become extinct.

Loss of habitat also means a changing lifestyle for the human inhabitants. There are fewer animals to hunt and the fish have been killed by the silt-polluted rivers. Food provided by the rainforest plants is also more difficult to find. No longer does the rainforest supply enough food to support a hunter-gatherer lifestyle. Increasing numbers of hunter-gatherers are being forced to abandon their traditional way of life.

The rainforest is a storehouse rich in plant and animal life. Much is still unknown about the life that exists here. In ignorance, rainforest destruction could be causing the extinction of many thousands of species. Each of these species is the result of millions of years of evolution. We may be destroying genetic material of future benefit to humankind without even knowing it!

Check your understanding

1. Complete this table by summarising human impact on the tropical rainforests.

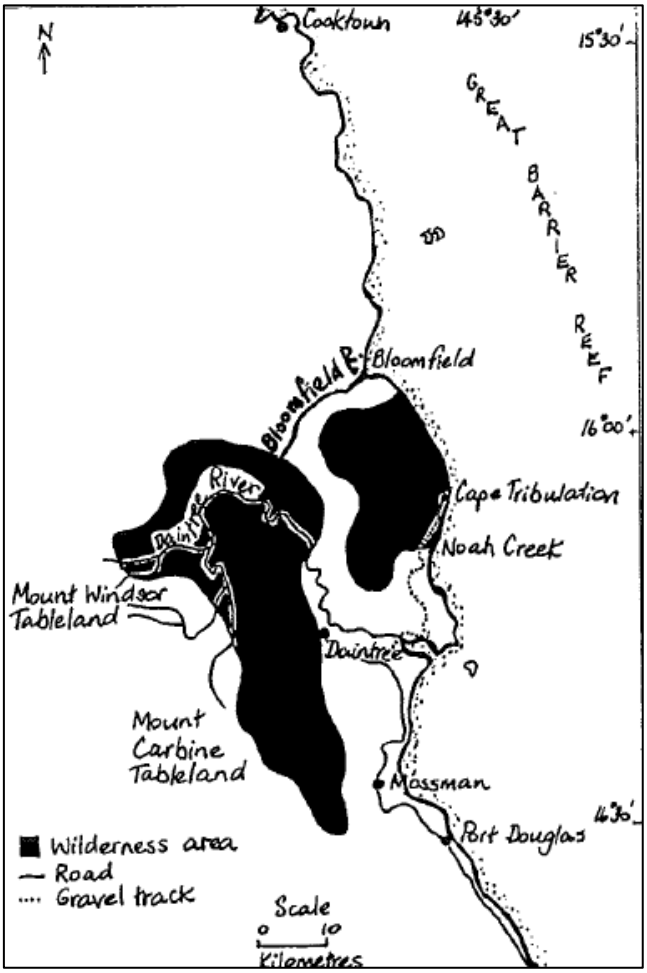
Human impact on the tropical rainforests

Lithosphere	
Hydrosphere	
Atmosphere	
Biosphere	

WEEK THREE

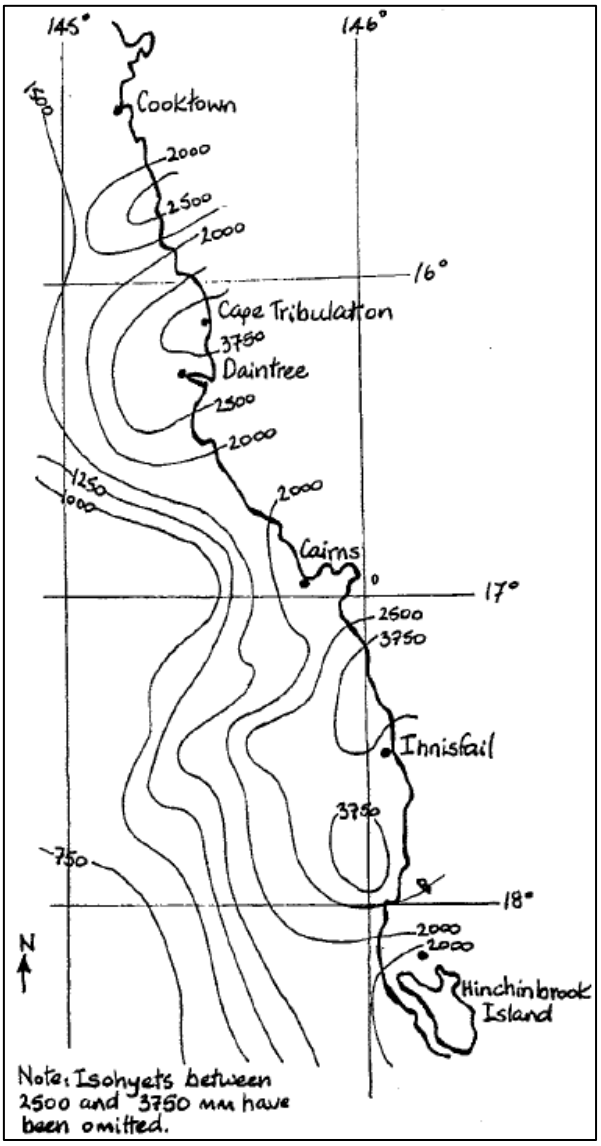
Australian tropical rainforest

Now we have an overview of the world's tropical rainforests, it's time for some fieldwork. In Australia we have a small area of tropical rainforest in north-eastern Queensland. You can see the location in the map below. Covering an area of approximately 6 000 square kilometres, these rainforests extend from Cooktown to Townsville. In this lesson we'll take a visit to the Daintree - Cape Tribulation rainforest.



The Location of Australia's tropical rainforest.

The Daintree - Cape Tribulation rainforest is just north of Cairns. This is where Australia's rainforest is at its optimum development due to high rainfall and high temperatures. From a world perspective, Australia's rainforests are on the margin of the tropical zone. Their southerly latitude causes temperatures to be more variable than at the equator. The southerly location also influences rainfall. Although rainfall occurs year-round there is a distinctly wetter season between December and April. Most of the rainfall is created by orographic means rather than convection. This explains why the areas of highest rainfall correspond to hills lying in the path of moist onshore winds. Study the following map to locate these areas of high rainfall.



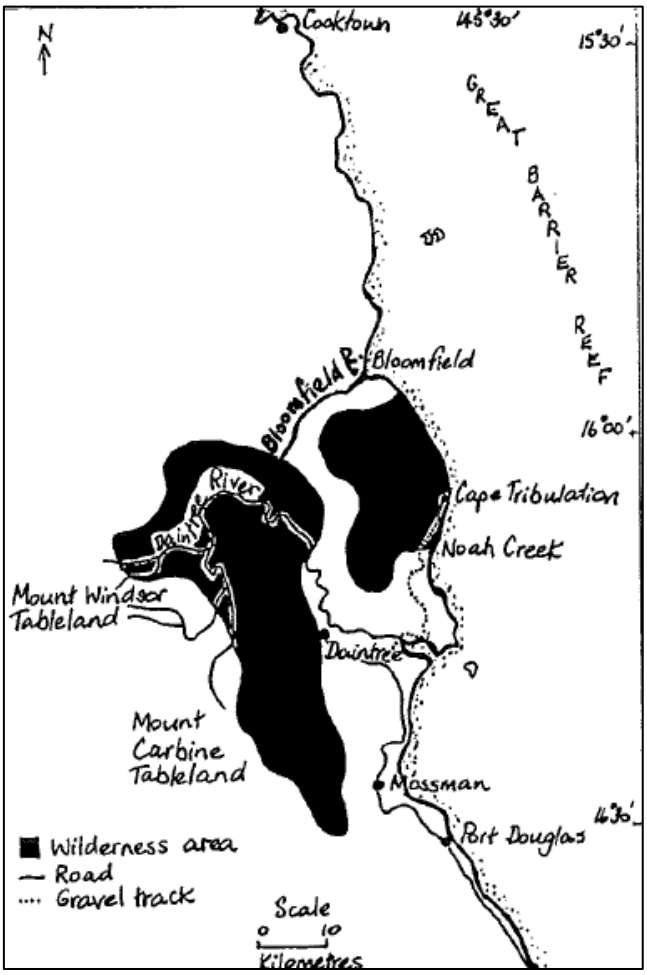
Annual average rainfall isohyets (mm) in the tropical rainforest of northern Queensland.

Fieldwork in the Daintree rainforest

Our excursion begins in Cairns, a popular starting point for exploring Australia's tropical rainforest. From Cairns, we'll travel northwards to the heart of the rainforest at Cape Tribulation. Whilst there, our aim is to record observations about the plant and animal life we see. Are you all set to go?

As we travel northwards, our teacher gives us some background information about the Daintree rainforest. The rainforest we'll be exploring lies between the Daintree and Bloomfield rivers. (See the map below.) We are told that this is one of the last remaining coastal lowland rainforests in Australia.

Everywhere else this rainforest type has been cleared for sugarcane cultivation or grazing. There is a great diversity of plant and animal life in the Daintree rainforest. Several hectares of rainforest yield up to 50 different species of trees! Thirty per cent of all Australia's marsupial animals live there. For these reasons the Daintree rainforest is especially valuable.



Location of the Daintree rainforest in northern Queensland

Cape Tribulation

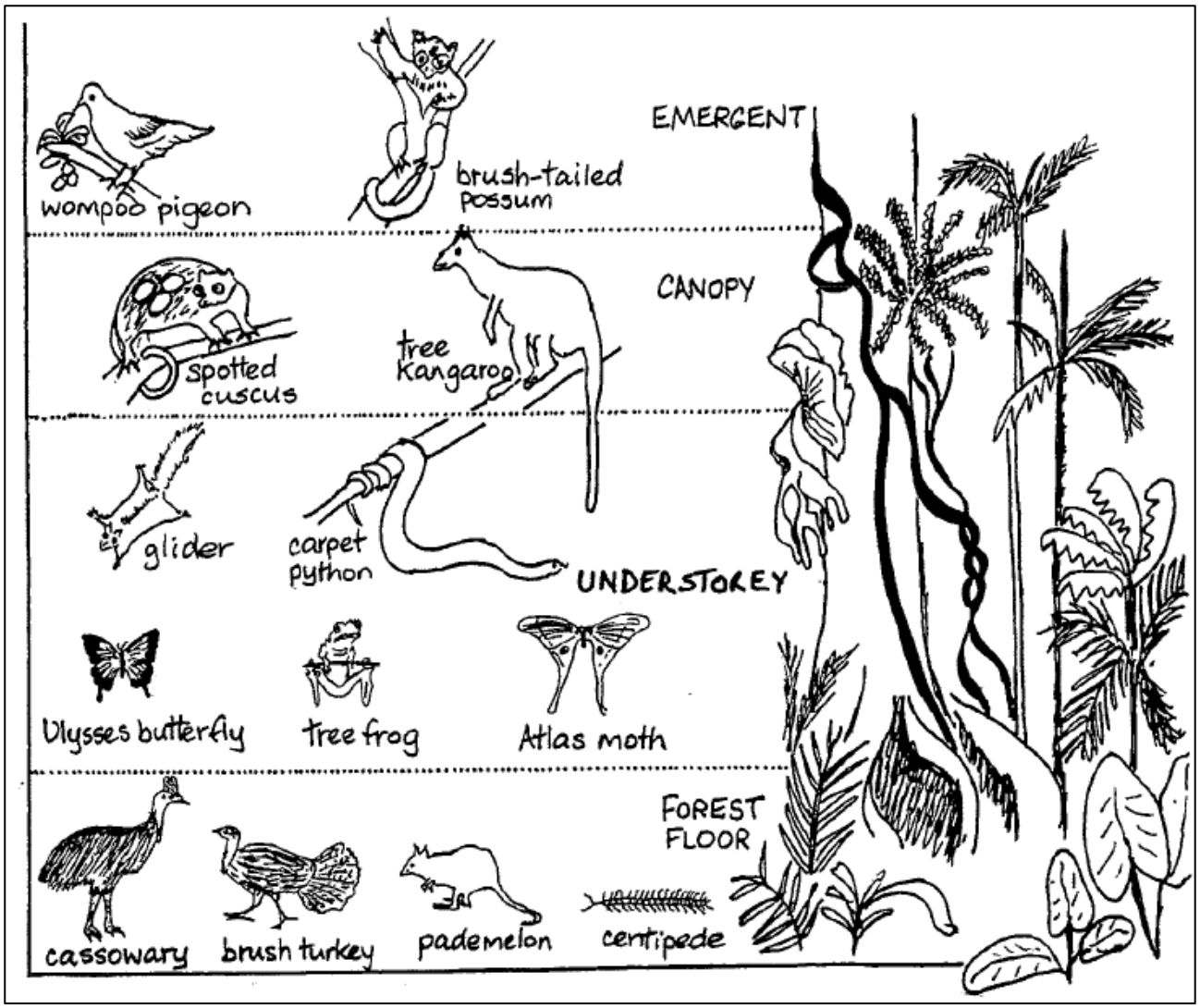
Now we've arrived at our destination, near Cape Tribulation. The rest of the afternoon and early evening will be spent exploring the surrounding rainforest. Before we set off, our teacher gives us a few more details about this ecosystem.

Table 2. Cape Tribulation physical features.

Cape Tribulation	
Latitude:	16°05’S
Longitude:	145°27’E
Climate:	very wet (annual rainfall more than 3 000 mm with more than 750 mm of rain between May and October)
Landform:	lowland
Soil:	sand on a beach ridge
Vegetation:	complex tropical vine forest

During the afternoon, we concentrate on observing the plant life. Fan palms, strangler figs, pandanus and tree ferns are abundant. We soon become aware of the lawyer cane (or 'wait-a-while') twining around trunks. This liana creeper is armed with vicious hooks which latch onto our skin if we're not careful! Growing on the tree trunks there are many different epiphytes. Examples include the bird's nest, elkhorn and staghorn ferns. All these epiphytes have broad leaves designed to capture water since they lack a root system.

Rainforest animals are more difficult to observe than plants. Many of the animals are nocturnal or so secretive that they remain hidden from view. The animals we do see are brightly coloured. Camouflage is not as necessary in the Australian rainforest where predators are few in number. The diagram on the next page illustrates some of the animals we are likely to encounter in an Australian tropical rainforest.

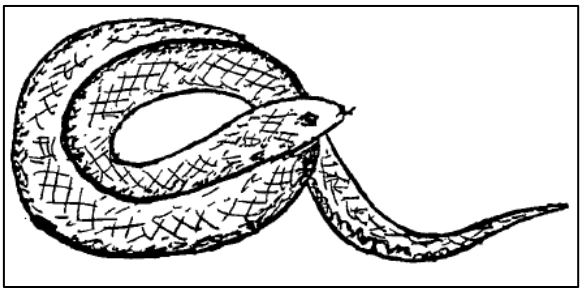


Animals of the Australian tropical rainforest

During daylight we mainly see insects and butterflies. The iridescent green of the Cairns birdwing butterfly and the bright blue Ulysses butterfly are particularly striking. On the forest floor we see trails of green ants busily moving to and fro. In the leaf litter we hear the rustle of centipedes, millipedes and beetles. Occasionally we even glimpse a fast-moving skink. Birds are active in the treetops, but these cannot be seen from the ground. In the distance we hear the heavy thumping of a cassowary. One bird we do see fleetingly is the brightly coloured noisy pitta hopping on the forest floor feeding on snails, insects and small insects.

We go on an evening foray into the rainforest to sight some of the nocturnal creatures with a spotlight. We can hear the scuffling of animals such as possums and tree kangaroos feeding up in the branches. The soft whirr of bats' wings can also be heard above. Many of these bats feed on fruit. Other bats feed on blossoms or insects. Over half of all Australia's sixty bat species live in the Daintree rainforest.

Tree snakes are the main predators in the rainforest. The bright green tree snake is one example. These tree snakes prey upon frogs, birds' eggs, young possums and birds. Predators on the forest floor include skinks, geckos and rainforest dragons. Up in the branches there are also pythons and tree frogs. High flying wedge-tailed eagles sometimes prey upon creatures feeding at the top of the canopy.



Tree snakes are one of the main predators in the Australian rainforest.

Check your understanding

1. Complete these field notes.

Plants of the Daintree rainforest
Animals of the Daintree rainforest

Human impact on the Daintree rainforest

During our return journey to Cairns we make observations about changes to the rainforest. Perhaps the most visible change is the four-wheel drive track upon which we are travelling. The closed canopy of foliage has been broken by the 100-metre-wide road construction. Deep cuttings have been made into the steep hillslopes exposing the latosol to erosion. Creeks have become blocked with earth fill and pipes. This area receives daily rainfall of 250 millimetres during the wet season (between December and March). No wonder then that large scale erosion washes away this road each year! The road is also an avenue of infection along which introduced weeds and animals disperse.

We also notice some subdivisions for urban settlement as well as clearings for agriculture. Tropical fruit, tea and sugarcane are being grown. Some cattle are also being grazed on introduced pastures. Inland we are told that logging and tin mining are taking place. Both of these activities involve the use of bulldozers which are very destructive in the rainforest. Clear-felling and tailing dams from mines are causing increased siltation of streams. In these ways the rainforest is gradually being degraded.

Check your understanding

1. Make a summary of the impact human activity has had on the Daintree Rainforest by completing the table below. (The first one has been partially done for you.)

Human action	**Changes to the environment**
Road construction	• natural vegetation removed • habitats destroyed • soil erosion from excess run off
Urban subdivisions	

Sustainable development

Sustainable land management aims to implement effective strategies to address the environmental issues and at the same time work to achieve economic and social sustainability.

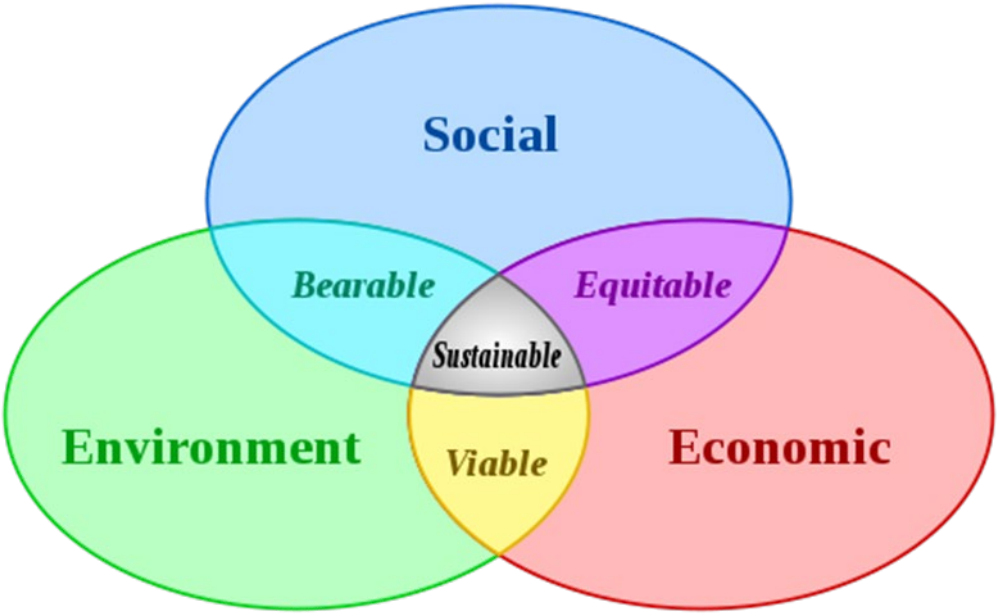


Image by original: Johann Dréo (talk · contribs)translation: Pro bug catcher (talk · contribs) - Own work Inspired from Developpement durable.jpgTranslated from Developpement durable.svg, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=1587372

The Amazon rainforest

The Amazon rainforest is the world's largest tropical rainforest – spanning 6.7 million km^2 (the area of the forest is approximately the same size of Australia!). Since 1970, an area of the size of NSW has been cleared in the Amazon rainforest (18% has been lost). To slow down the rate of deforestation for agricultural farms (cattle and soy), forestry, mines and dams, some mitigation strategies (actions put in place to reduce the impacts of human activity) are in place. These strategies are joint ventures between volunteer wildlife organisations, the communities and the governments of South American counties.

Responsible agricultural and forestry activities generate income for communities and ensure that the forest continues to be ecologically functional. Exploitation, however, of the forest does occur. Illegal logging is widespread in the Amazon. The World Wildlife Fund (WWF) in partnership with communities, governments and forest companies are trying to improve forest management practices to stop illegal logging. These practices include:

- educating the industry to source responsibly produced and certified timber and timber products

- creating relationships between producers and buyers
- improving forestry rules and regulations
- reducing slash and burn activities
- reducing the impacts of agriculture, especially the soy cultivation.

The Amazon Soy Moratorium

During 2004 to 2005, the Amazon rainforest was being destroyed at the second highest rate ever recorded, due to the rise in demand for land to grow soy (and cattle). People were concerned globally and wanted to ensure that their product was not connected to Amazon deforestation. The soy moratorium was developed in 2006 in partnership with the industry, organisations and governments. The agreement ensures that companies do not buy soy from soy traders who get their supply from farmers who clear the Amazon rainforest. Since 2006, soy-related deforestation has decreased while soy production has increased by 400%. This shows that responsible agriculture can exist while protecting tropical forests.

The Round Table on Responsible Soy

The Round Table on Responsible Soy (RTRS) is community organisation that promotes responsible production, processing and trading of soy on a global level. A number of organisations from South American counties are members of RTRS, ensuring their soy production is produced responsibly to reduce the environmental impacts on the Amazon.

The **Amazon Region Protected Areas Program** (**ARPA**) aims to protect 600 000 km^2 of rainforest, predominantly in the Brazilian part of the Amazon biome. The program, led by the Brazilian Ministry for the Environment and funded by a number of organisations such as the World Wildlife Fund, World Bank and the German Government aims to create and support a system of well-managed protected areas and sustainable natural resource management reserves over a 10-year period.

ARPA has been successful. By 2012, an area of 518 000 km^2 has been protected by Brazilian law. The Tumucumaque Mountains National Park has been established to protect the high biodiversity of the area. This area protects threatened species such as the jaguar, macaw and harpy eagles.

Check your understanding

1. How does the Amazon Soy Moratorium work to save the Amazon rainforest?

……

……

……

……

……

2. What is the Amazon Region Protected Areas Program (ARPA)?

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2019 Amazon Fires

Fires do occur in the Amazon during the dry season between July and October. Fires can be caused by naturally occurring events, such as lightning strikes. The 2019 Amazon fires were mostly thought to have been started by farmers and loggers clearing land for crops or grazing.

These fires were of global concern. There were protests in many cities, threats of financial penalties, and broad criticism of Brazilian President Jair Bolsonaro's environmental policies.

Check your understanding

There are different values and viewpoints in which people value our world.

1. Using the speech bubbles below, what would you say about the 2019 Amazon Fires if you were a farmer, Brazilian President Jair Bolsonaro and a member for WWF?

Farmer

Brazilian President Jair Bolsonaro

member for WWF

Well done, you have completed the depth study on tropical rainforests.