

# CORAL CAY CONSERVATION & JFA EDUCATIONAL AIDS

## TEACHERS WORKBOOK

### ECOLOGY, RELATIONSHIPS & INTERACTIONS

- Prepared by -

**Alexia Tamblyn**, Senior Ecologist, JFA  
**Craig Turner**, Director of Ecology, JFA  
**Peter Raines**, Managing Director, CCC

2007



## Contents

<b>THE WORLD AROUND US</b> .....	<b>3</b>
<b>LOCATION OF TROPICAL RAINFORESTS</b> .....	<b>11</b>
<b>TROPICAL RAINFORESTS</b> .....	<b>12</b>
<b>DIFFERENT RAINFOREST TYPES</b> .....	<b>14</b>
<b>PAPUA NEW GUINEA</b> .....	<b>16</b>
<b>BIODIVERSITY</b> .....	<b>19</b>
<b>WHY IS BIODIVERSITY IMPORTANT?</b> .....	<b>20</b>
<b>ENDEMIC SPECIES</b> .....	<b>22</b>
<b>SPECIAL PNG SPECIES</b> .....	<b>23</b>
<b>BIRDS OF PARADISE</b> .....	<b>28</b>
<b>BIOGEOGRAPHY</b> .....	<b>29</b>
<b>ECOLOGY</b> .....	<b>31</b>
<b>ECOSYSTEMS</b> .....	<b>36</b>
<b>RAINFOREST QUESTIONS</b> .....	<b>38</b>
<b>DEFORESTATION</b> .....	<b>42</b>
<b>ENVIRONMENTAL CHANGE AND DAMAGE</b> .....	<b>44</b>
<b>WHAT IS CONSERVATION?</b> .....	<b>45</b>
<b>REFERNCES</b> .....	<b>46</b>
<b>GLOSSARY</b> .....	<b>48</b>

## THE WORLD AROUND US

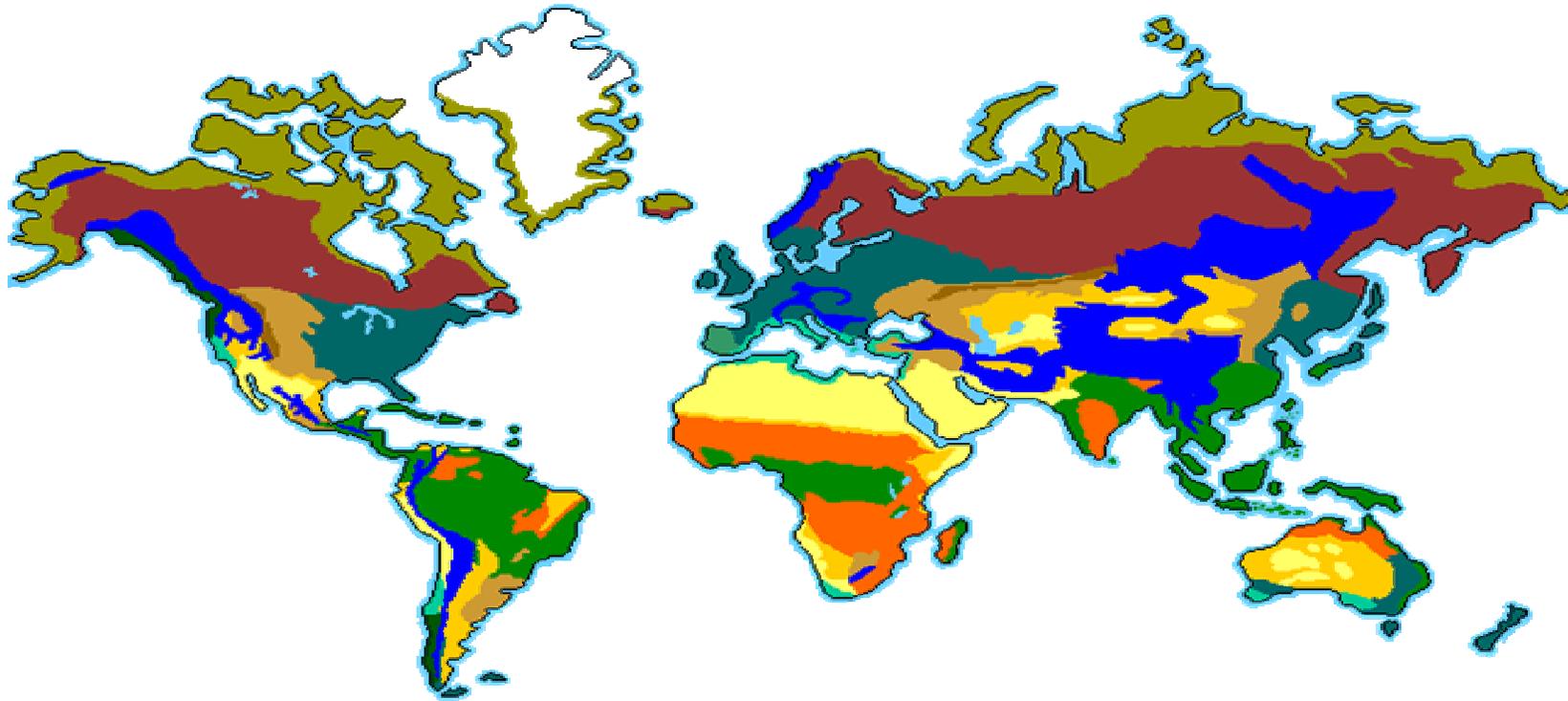
Our planet Earth is quite small with 71% of the earth's surface covered by sea, leaving only 29% of the total surface area as land that humans can live on. However there are only certain areas where people can live. Areas such as Antarctica and the dry deserts of Africa cannot support many people.

The available resources of our planet can be summarised below:

- 75% of the Earth's surface is covered by water
- 29% is therefore dry land - of which:
  1. 20% of the land surface is too dry for agriculture
  2. 20% of the land surface is too cold for agriculture
  3. 20% of the land surface is too mountainous for agriculture
  4. 20% of the land surface is forested or marshy
  5. 20% of the Earth's land surface is left available for growing food and all the other crops that we need for our ever-increasing population.

The world is split into several regions called 'Biomes'. These are shown below.

### Biomes of the World



 Tundra

 Taiga

 Grasslands

 Deciduous  
Forest

 Chaparral

 Desert

 Desert-scrub

 Savanna

 Rainforest

 Alpine

These zones are called BIOMES. A biome is a large geographical area of distinctive plant and animal groups, which are adapted to that particular environment. The climate and geography of a region determines what type of biome can exist in that region. Each biome consists of many ecosystems whose communities have adapted to the small differences in climate and the environment inside the biome.

Each of the illustrated biomes are described below:

**Tundra:** Located at latitudes 55° to 70° North, the tundra is a vast and treeless land that covers about 20% of the Earth's surface, circumnavigating the North Pole. It is usually very cold, and the land is stark. Almost all tundras are located in the Northern Hemisphere. The ground is permanently frozen 10 inches to 3 feet (25 to 100 cm) down so that trees can't grow there. The bare and sometimes rocky ground can only support low growing plants like mosses, heaths, and lichen. In the winter it is cold and dark and in the summer, when the snow and the top layer of permafrost melt, it is very soggy and the tundra is covered with marshes, lakes, bogs and streams that breed thousands of insects and attract many migrating birds.

The main seasons are winter and summer. Spring and fall are only short periods between winter and summer. The tundra is the world's coldest and driest biomes. The average annual temperature is -18° F (-28° C). Nights can last for weeks when the sun barely rises during some months in the winter, and the temperature can drop to -94° F (-70° C). During the summer the sun shines almost 24 hours a day, which is why the Arctic is also called the Land of the Midnight Sun. Summer are usually warm. Temperatures can get up to 54° F (12° C), but it can get as cold as 37° F (3° C). Average summer temperatures range from 37° to 60°F (3° to 16°C).



Map to show the location of the Tundra regions.

**Taiga:** The taiga is the biome of the needle leaf forest. It stretches over Eurasia and North America. The taiga is located near the top of the world, just below the tundra biome. The winters in the taiga are very cold with only snowfall. The summers are warm, rainy, and humid. A lot of coniferous trees grow in the taiga. The average temperature is below freezing for six months out of the year. The winter temperature range is -54 to -1° C (-65 to 30° F). The high in summer can be 21° C (70° F). The summers are mostly warm, rainy and humid. They are also very short with about 50 to 100 frost free days. The total precipitation in a year is 30 - 85 cm (12 - 33 in). The

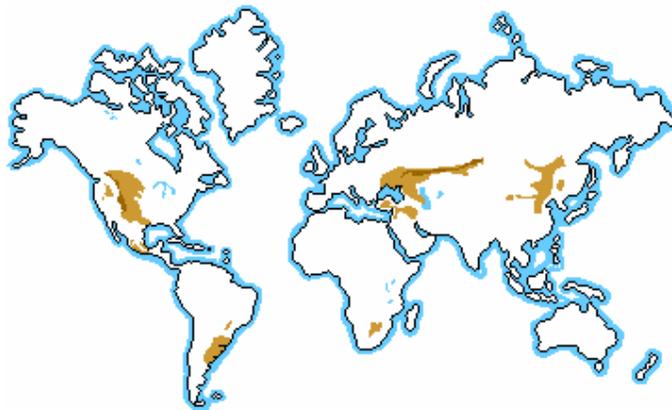
forms the precipitation comes in are rain, snow and dew. Most of the precipitation in the taiga falls as rain in the summer.



Map to show the location of the Taiga regions.

**Grasslands:** Grassland biomes are large, rolling terrains of grasses, flowers and herbs. Latitude, soil and local climates for the most part determine what kinds of plants grow in a particular grassland. A grassland is a region where the average annual precipitation is great enough to support grasses, and in some areas a few trees. The precipitation is so erratic that drought and fire prevent large forests from growing. Grassland biomes can be found in the middle latitudes, in the interiors of continents. They can have either moist continental climates or dry subtropical climates.

In the winter, grassland temperatures can be as low as  $-40^{\circ}$  F, and in the summer it can be as high  $70^{\circ}$  F. There are two real seasons: a growing season and a dormant season. The growing season is when there is no frost and plants can grow (which lasts from 100 to 175 days). During the dormant (not growing) season nothing can grow because its too cold.



Map to show the location of the Grassland regions.

**Deciduous Forest:** Deciduous forests can be found in the eastern half of North America, and the middle of Europe. There are many deciduous forests in Asia. Some of

the major areas that they are in are southwest Russia, Japan, and eastern China. South America has two big areas of deciduous forests in southern Chile and Middle East coast of Paraguay. There are deciduous forests located in New Zealand, and south eastern Australia also.

The average annual temperature in a deciduous forest is 50° F. The average rainfall is 30 to 60 inches a year.

The deciduous forest has four distinct seasons, spring, summer, autumn, and winter. In the autumn the leaves change colour. During the winter months the trees lose their leaves.



Map to show the locations of deciduous forests.

**Chaparral:** The chaparral biome is found in a little bit of most of the continents - the west coast of the United States, the west coast of South America, the Cape Town area of South Africa, the western tip of Australia and the coastal areas of the Mediterranean.

Chaparral is characterized as being very hot and dry. As for the temperature, the winter is very mild and is usually about 10 °C. Then there is the summer. It is so hot and dry at 40 °C that fires and droughts are very common.

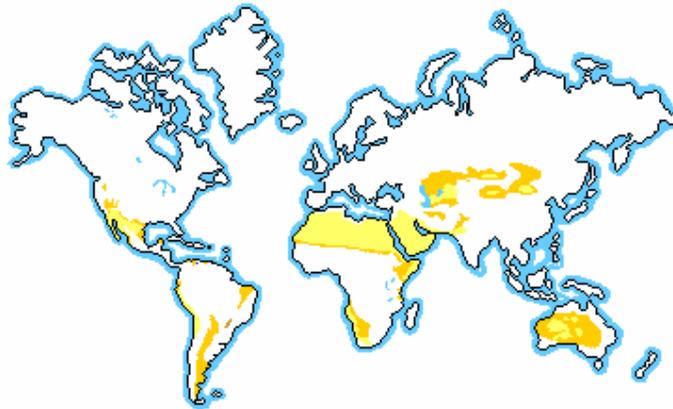
Fortunately, the plants and animals are adapted to these conditions. Most of the plants have small, hard leaves that hold moisture. Some of these plants are poison oak, scrub oak, Yucca and other shrubs, trees and cacti.



Map to show the locations of the Chaparral biomes.

**Deserts/Desert scrub:** Deserts cover about one fifth of the Earth's land surface. Most Hot and Dry Deserts are near the Tropic of Cancer or the Tropic of Capricorn. Cold Deserts are near the Arctic part of the world.

Hot and Dry Deserts temperature ranges from 20 to 25° C. The extreme maximum temperature for Hot Desert ranges from 43.5 to 49° C. Cold Deserts temperature in winter ranges from -2 to 4° C and in the summer 21 to 26° C a year.



Map to show locations of the cold and hot desert biomes.

**Savanna:** A savanna is a rolling grassland scattered with shrubs and isolated trees, which can be found between a tropical rainforest and desert biome. Not enough rain falls on a savanna to support forests. Savannas are also known as tropical grasslands. They are found in a wide band on either side of the equator on the edges of tropical rainforests.

Savannas have warm temperature year round. There are actually two very different seasons in a savanna; a very long dry season (winter), and a very wet season (summer). In the dry season only an average of about 4 inches of rain falls. Between December and February no rain will fall at all. It is actually a little cooler during this dry season but it is still around 70° F.

In the summer there is lots of rain. In Africa the monsoon rains begin in May. An average of 15 to 25 inches of rain falls during this time. It gets hot and very humid during the rainy season. Every day the hot, humid air rises off the ground and collides with cooler air above and turns into rain. In the afternoons on the summer savanna the rains pour down for hours. African savannas have large herds of grazing and browsing hoofed animals.



Map to show the locations of the savanna biomes.

**Rainforests:** The tropical rain forest is a forest of tall trees in a region of year-round warmth. An average of 50 to 260 inches (125 to 660 cm.) of rain falls yearly.

Rain forests belong to the tropical wet climate group. The temperature in a rain forest rarely gets higher than 93 °F (34 °C) or drops below 68 °F (20 °C); average humidity is between 77 and 88%; rainfall is often more than 100 inches a year. There is usually a brief season of less rain. In monsoonal areas, there is a real dry season. Almost all rain forests lie near the equator.

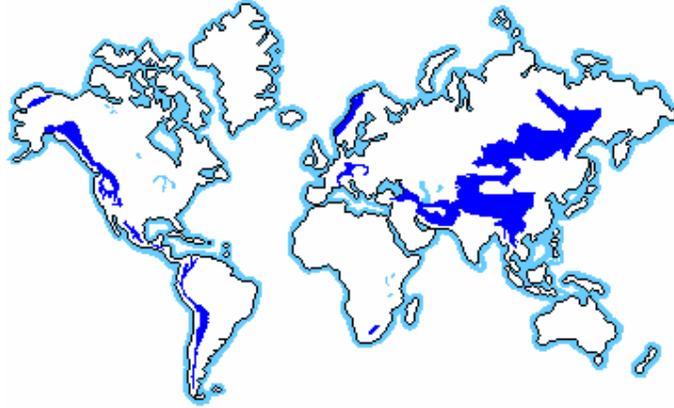
Rainforests now cover less than 6% of Earth's land surface. Scientists estimate that more than half of the entire world's plant and animal species live in tropical rain forests. Tropical rainforests produce 40% of Earth's oxygen.



Map to show locations of the rainforests biomes.

**Alpine:** Alpine biomes are found in the mountain regions all around the world. They are usually at an altitude of about 10,000 feet or more. The Alpine biome lies just below the snow line of a mountain. As you go up a mountain, you will travel through many biomes. As you climb you go through a deciduous forest biome, grassland biome, steppe biome, and taiga biome before you reach the cold Alpine biome.

In the summer average temperatures range from 10 to 15° C. In the winter the temperatures are below freezing. The winter season can last from October to May. The summer season may last from June to September. The temperatures in the Alpine biome can also change from warm to freezing in one day.



Map to show locations of alpine biomes.

## LOCATION OF TROPICAL RAINFORESTS

The tropical rainforests of the world are shown on the map below. Papua New Guinea is one of the areas where the tropical forests are found.



Why are tropical rainforests considered to be so important to the world? This is because the tropical rainforests, as shown on the above map, support over 50% of all the species that live on the earth. It is important that we conserve these forests to ensure the health of our planet.

Before humans started destroying the rainforests, they covered 15% of the Earth's land area. Today, they cover less than 7%. In the last 200 years, the total area of rainforest has decreased from 7.1 billion acres to less than 3.5 billion acres. More than 30 million acres of tropical forest are destroyed each year, which means at current rates of destruction there will be no rainforest at all in just 40 years.

Because of the continual destruction of the forests it is estimated that over 21,000 different species of animals threatened or endangered. Some 50% of the world's flora and fauna could be extinct within 100 years. It is said that the world is already losing an estimated 137 species each DAY.

The disappearance of the forest is called DEFORESTATION. As populations have grown and demands for land and timber have grown greater, so the deforestation has accelerated. Asia lost almost a third of its tropical forest cover between 1960 and 1980 - the highest rate of deforestation in the world. In Thailand, 80% of the country's original forest has been cut down in the last 40 years. In the tropics alone, 38 million acres of forest are lost each year

## TROPICAL RAINFORESTS

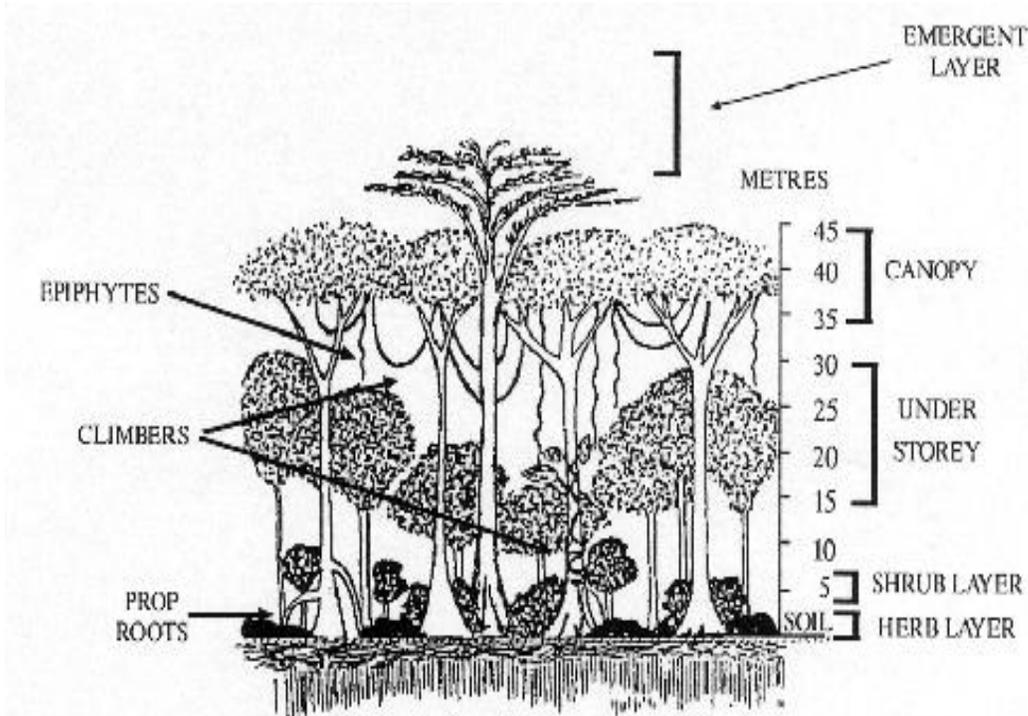
The tropical rainforest is earth's most complex biome in terms of both structure and species diversity. It occurs under optimal growing conditions: abundant precipitation and year round warmth. There is no annual rhythm to the forest; rather each species has evolved its own flowering and fruiting seasons. Sunlight is a major limiting factor. A variety of strategies have been successful in the struggle to reach light or to adapt to the low intensity of light beneath the canopy.

Rainforests are forests that grow in areas of high rainfall. Tropical rainforests are found between the Tropic of Cancer and the Tropic of Capricorn. There are other, temperate rainforests in areas such as the northwest Pacific coast of America. These are much cooler, but experience very high rainfall.

Rainforests are the world's most spectacular ecosystems. An ecosystem is not just the plants, but also the birds, mammals, reptiles, fish, amphibians, invertebrates, bacteria, and even the non-living elements like soil, water and air. In some cases their climates have remained stable for the last 65 million years. This means that they have developed arrays of life unequalled by any other ecosystems on the planet. The destruction of the rainforests will affect other ecosystems throughout the world

**Climate:** Mean monthly temperatures are above 64 ° F; precipitation is often in excess of 100 inches a year. There is usually a brief season of reduced precipitation. In monsoon areas, there is a real dry season, but that is more than compensated for with abundant precipitation the rest of the year.

**Vegetation:** A vertical stratification of three layers of trees is apparent. These layers have been identified:



- The emergents (the top layer). Widely spaced trees 100 to 120 feet tall and with umbrella-shaped canopies extend above the general canopy of the forest. The trees are the largest of all rainforest species.
- A closed canopy of 60-80 foot trees (below the emergent layer). Light is readily available at the top of this layer, but greatly reduced below it.
- Closed canopy of smaller trees make up the under storey layer. There is little air movement in this zone and consequently humidity is constantly high. There is less light here than on the other higher tree layers. Trees and shrubs in the lower canopy have elongated crowns as the leaves reach for light. Shade tolerant species flourish here. Leaves are set at the best angle to receive light.
- Shrub/sapling layer: Less than 3 percent of the light intercepted at the top of the forest canopy passes to this layer. Arrested growth is characteristic of young trees capable of a rapid surge of growth when a gap in canopy above them opens.
- Herb/Ground layer: sparse plant growth. Less than 1 percent of the light that strikes the top of the forest penetrates to the forest floor. In such darkness few green plants grow. On the forest floor the soil is shallow with most nutrients close to the surface. Leaf litter and dead trees are quickly consumed and broken down by fungi, insects, and other decomposers. The nutrients decomposition creates are immediately taken up by the biomass of the forest. Because the nutrients are close to the surface, roots don't grow down very far, and trees have adapted by growing buttressed roots up to 30 ft high, or stilt roots which hang down from their trunks and branches.

Different types of animals live in the different layers of the rainforest, each specially adapted to live in these layers.



The echidna is well adapted to life on the forest floor, with sharp claws to dig and burrow for worms and termites, and spines for protection against predators

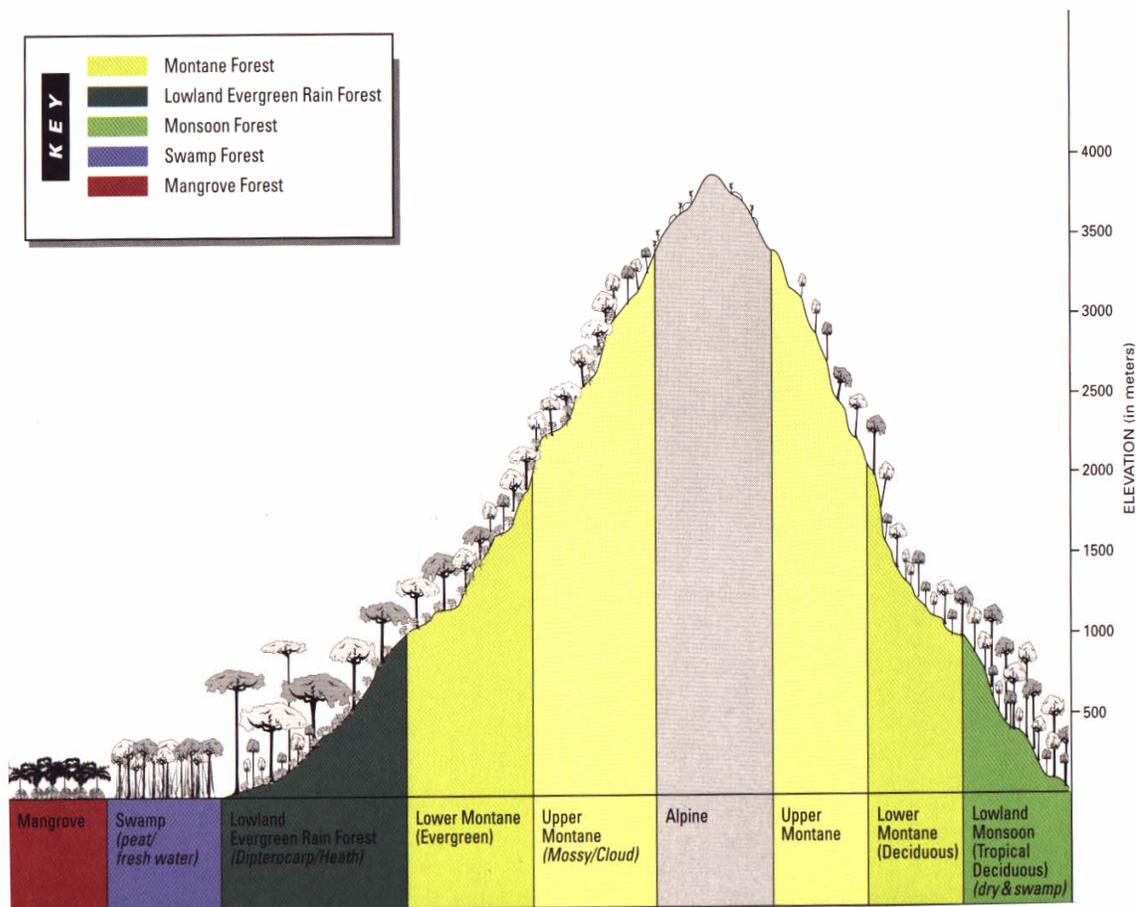


Sugar gliders are well adapted to life in the forest canopy as they can glide from tree to tree to find food.

## DIFFERENT RAINFOREST TYPES

There are 5 main forest types in that form in the rainforest regions and are found at different heights (or elevations). These are:

- Mangrove forest
- Swamp forest
- Monsoon forest
- Lowland evergreen rainforest
- Montane forest



Each of the different forest types are discussed below:

**Mangroves** are woody, specialised types of trees of the tropics that can live where rainforests meet oceans. Found on sheltered coastlines and river deltas, they grow in brackish wetlands between land and sea where other plants cannot grow. Mangrove trees look as if they grow on stilts. The stilts are their specialised aerial roots that hold the trunk and leaves above the water line. Mangrove forests are affected by the rising and falling of the ocean's tides. The aerial roots and tap roots can filter out the salt in the brackish water they grow in. Support roots grow directly into the mud to anchor the

tree. Other roots snake up and down with the upward loops rising above the salt water level. Salt crystals taken up by the roots are stored in the leaves. The mangrove rids itself of the salt by shedding its leaves after a while.

Mangroves are a very important forest ecosystem. They protect the coast from erosion by waves and filter out sediment from water that could otherwise suffocate coral reefs and fish. Economically they are important for fisheries as many fish breed here. There are under threat due to deforestation.

**Swamp forests** are areas of waterlogged forests where pandans, sago trees and other special adapted trees survive.

**Lowland rainforest** are similar to those found in Asia, where large number of species are found, with crowns rising to 50 metres and buttress roots growing to compensate for the heavy crown growth. Reinforced with buttresses that flare out from the base of the tree, the trunk grows straight and is 25 to 30 meters long, characteristics that make these trees especially desirable as timber. There are several species that are fairly common in primary lowland forests in many parts of the country have been decimated by logging and slash-and-burn agriculture. Waterfowl, heron, eagle and hornbill inhabit the lowland forests as well as parrots, cockatoo and extraordinary bird of paradise. Tree kangaroos, foxes, bats, possums, cuscus also are found to inhabit the lowland pristine tropical rainforest.

**Upper rainforests** are found at elevations of 650-1,000 m. Different tree species dominate at these elevations with many trees becoming smaller in crown size and height.

**Mossy upper montane forest** generally is found at elevations over 1,200 m, where humidity is constantly high. This stunted, single-story moss- and epiphyte-covered forest contains tree ferns up to 10 m high. Wildlife is still plentiful here, with birds prevalent in all shapes and sizes. Tiny finches are found here, as well as rare swiftlets and Birds of Paradise. Occasional raptors can be seen. This area is also home of the ringtails, tree kangaroos, cuscus, dasyurids, quolls and many species of rats. Bats are also extremely common.

**Alpine forest** is found on the peaks of higher hills above an altitude of 4000 m up to 5500m above timberline. For major part of the year, the area is covered by snow and plant activity is restricted to a few months when snow melts. As a rule there are no tall trees but dwarf branches and shrubs and mainly herbs with deep roots and cushioned leaves and branches.

## PAPUA NEW GUINEA

New Guinea lies at a cross roads between Asia, Australia and the Pacific and because of this animals and plants have invaded the island from all directions and once on the island of PNG have evolved in their own separate ways.

PNG is formed from the continents of Asia and Australia that have pushed against each other. Large mountains and active volcanoes that have formed from the collision of these two major earth plates have developed to form the island of New Guinea. This island has some of the steepest and most rugged land in the world, with peaks so high that glaciers have formed but also lush rainforest, river valleys and mangroves. Because of the way the island has formed animals and plants have become isolated from each other allowing for species to evolve in their own unique way.

PNG is also special as there are no primates (monkeys) on the island, limited predators (there are no large mammalian predators), which has allowed for birds and other species to utilise parts of the forest that otherwise would be filled. For example, instead of monkeys there are tree kangaroos. The birds of paradise have been able to develop such elaborate plumage, as there are limited predators.



Within the abundant assortment of habitats and landscapes spread over an altitudinal range of nearly 5,000 meters, the island of New Guinea contains a wealth of plant life. A conservative estimates of floral diversity of all Papuasias - including all the families - is thought to number well over 20,000 species. Mainland New Guinea by far holds the largest store of this diversity with an estimated 16,000 species. At least 124 genera of flowering plants are endemic to New Guinea. Although most of the plants represent well-known family and generic groups, species endemicity in New Guinea is exceptionally high at about 90%.

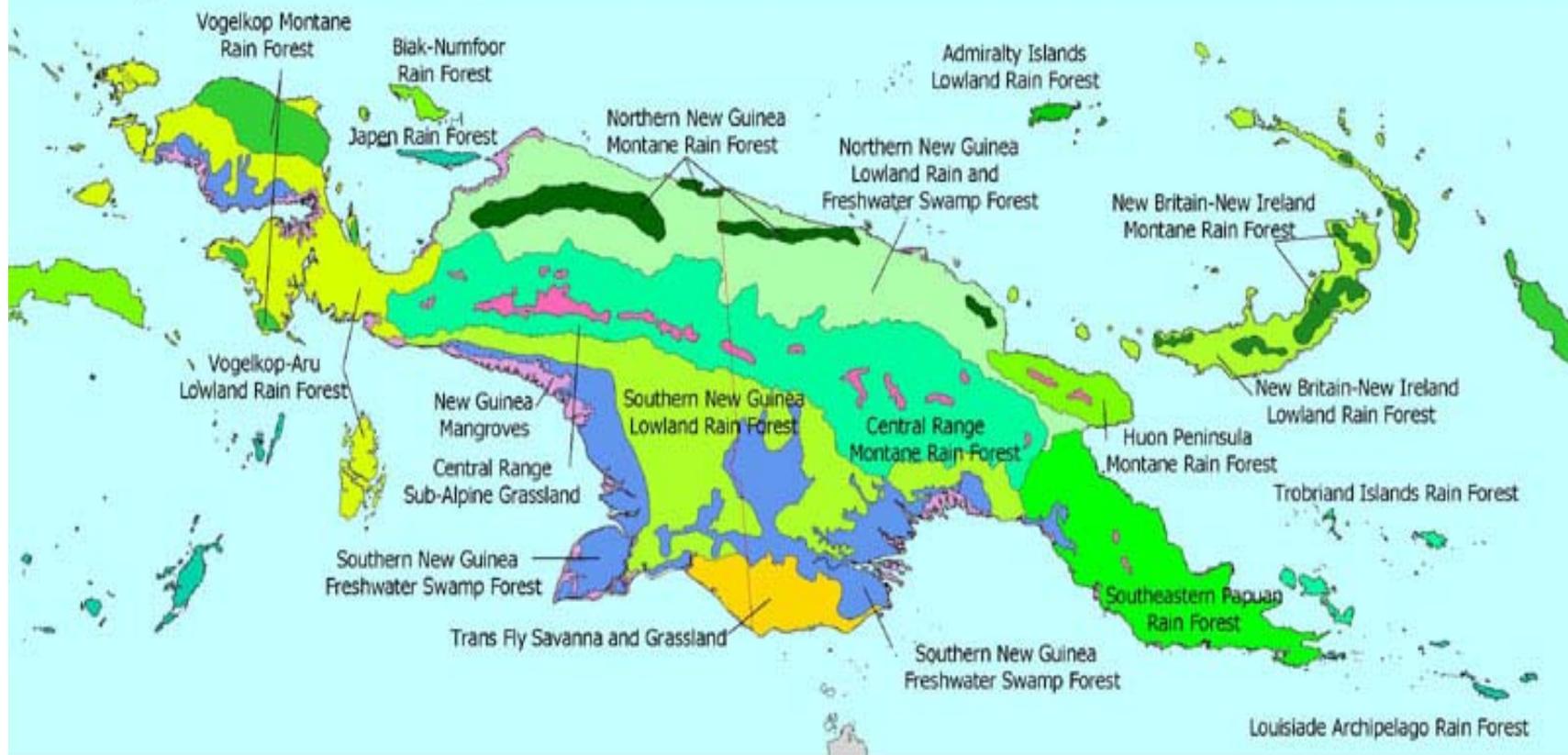
The lowlands, which contain the widest expanses of tropical rainforest to be found in Southeast Asia, are dominated by taxa of the Indo-Malayan area. However, unlike forests elsewhere in Malaya, members of Dipterocarpaceae are rare with only three genera (eight species) compared with nine genera and 262 species in Borneo (FAO, 1981; MacKinnon and MacKinnon, 1968). Dipterocarp elements such as oak (*Quercus junghunii*), red cedar (*Toona sereni*) and vatica (*Vatica papuana*) are most frequently encountered between the elevations of 600-1400 m (Richardson, 1968). The montane flora, however, is dominated by distinct southern elements of Australasia, sometimes termed sub-antarctic, which include the expansive forests of Antarctic beech (*Nothofagus*). Conifers are represented by the southern gymnosperms, including the podocarps (*Podocarpus*), kauri pine (*Agathis*) and the hoop and klinki pines (*Araucaria*), all valuable timber species.

New Guinea's great floral diversity and rarity of dipterocarps are generally disadvantageous to timber exploitation. Its most valuable species are the cabinet timbers, New Guinea walnut (*Dracontomelum mangiferum*) and black ebony (*Diospyros*), along with conifers and pencil cedars (*Palaquium*). The popular export construction timbers are ironwood (*Intsia bijuga* and *I. palembanica*), taun (*Pometia pinnata* and *P. tomentosa*) and a variety of others, which include *Octomelus*, *Canarium*, *Calophyllum* and *Mastiziodendron*. Other important tree species include sago, which is widespread and extremely important palm of swampy area. It is the basic staple of all lowland peoples, who process its starchy pith which is then prepared in a variety of ways. Its leaves are used in house construction. The casuarinas (*Casuarina equisetifolia*, *C. papuana*, *C. nodiflora*) are employed both to increase soil fertility and as wood crops in shelter belts between gardens in some highland areas under rotational agriculture. The high stilt-rooted *Pandanus* is a widespread genus very common in all types of forests up to 3050 m, with some species producing edible fruits. Pandan leaves are variously dried and used as building materials or cigarette papers, or stitched together as rain-capes and sleeping mats.

Orchids are the major and most fascinating group of colourful plants in New Guinea. More than 2770 species have been documented for 134 genera, dominated by *Dendrobium* and *Bulbophyllum* (Millar, 1978). This group alone represents nearly one-third of all the species of flowering plants on the island. They have a wide altitudinal range but their greatest variety occurs in the lowland rainforest.

The flora and fauna of this Papua holds the riches and most diverse storehouse of genetic resources in the entire Indonesian archipelago. It represents one of the greatest challenges to scientists, to unravel the complexities that it contains, and a great responsibility of the government to protect this natural wealth.

# Ecoregions of New Guinea



## BIODIVERSITY

When we talk about all the species in the world we tend to call the large amount of variation of all living things 'BIODIVERSITY'. The definition of biodiversity is:

*'The variability among living organisms from all sources, including land based and aquatic ecosystems, and the ecosystems of which they are part. These include diversity within species, between species, and of ecosystems. Diversity is the key to ensuring the continuance of life on Earth. It is also a fundamental requirement for adaptation and survival and continued evolution of species.'*

This sounds complicated. Biodiversity just means the variety of life and all living things. When we say that an area has high levels of biodiversity we simply mean that there are many different living things and different ecosystems for these to live. Papua New Guinea is an area that is a 'biodiversity hotspot'.

Tropical rainforests are more biologically diverse, more so than other ecosystems (e.g. temperate forests) on the Earth and because of this loss of rainforests through deforestation has a profound and devastating effect on the world.

Consider these facts:

- A single pond in Brazil can sustain a greater variety of fish than is found in all of Europe's rivers.
- A 25-acre plot of rainforest in Borneo may contain more than 700 species of trees - a number equal to the total tree diversity of North America.
- A single rainforest reserve in Peru is home to more species of birds than are found in the entire United States.
- One single tree in Peru was found to harbour forty-three different species of ants - a total that approximates the entire number of ant species in the British Isles.
- The number of species of fish in the Amazon exceeds the number found in the entire Atlantic Ocean.

The biodiversity of the tropical rainforest is so immense that less than 1 percent of its millions of species have been studied by scientists. When an acre of tropical rainforest is lost, the impact on the number of plant and animal species lost and their possible uses is staggering.

Surprisingly, scientists have a better understanding of how many stars there are in the galaxy than they have of how many species there are on Earth. Estimates vary from 2 million to 100 million species, with a best estimate of somewhere near 10 million; only 1.4 million of these species have actually been named. There is so much that needs to be studied in all the forests of the world. This is also true of the rainforests of Papua New Guinea.

## WHY IS BIODIVERSITY IMPORTANT?

The natural environment provides the basic conditions without which humans could not survive. The reason why biodiversity is so important can be broken into several aspects:

### Ecological importance:

- Trees provide habitat and food for birds, insects, other plants and animals, fungi, and micro-organisms;
- Insects, bats, birds, and other animals serve as pollinators;
- Parasites and predators act as natural population controls;
- Various organisms, such as earthworms and bacteria, are responsible for recycling organic materials and maintaining the productivity of soils;
- Green plants remove carbon dioxide from the atmosphere and replenish it with oxygen. Forests, for example, are particularly important "sinks" for the absorption of carbon dioxide and thus are key factors in reducing global climate change;
- Wetlands serve as sponges to reduce the impacts of floods and to cleanse streams by filtering sediments, nutrients, and contaminants from inflowing waters.

The interaction of all these natural processes forms a complex web of life. If any part of this web suffers or breaks down, the future of the other parts is threatened. Humans are in many cases degrading and destroying the ability of biological diversity to perform the services mentioned above.

### Economical importance:

- **Food:** species are hunted (e.g. antelopes, birds), fished (e.g. cod, tuna fish), and gathered (e.g. fruits, berries, mushrooms), as well as cultivated for agriculture (e.g. wheat, corn, rice, vegetables) and aquaculture (e.g. salmon, mussels). It is interesting to know that, of the about 80,000 available comestible plants, humans use less than 30 to satisfy 90% of our planet's food needs;
- **Fuel:** timber and coal are only two examples of natural resources used to produce energy;
- **Shelter and warmth:** timber and other forest products (e.g. oak, beech, pine) are used as building materials and for shelter. Fibres such as wool and cotton are used to make clothes;
- **Medicines:** both traditional medicines and processed drugs are obtained from biodiversity: penicillin is produced by a mould, codeine is obtained from poppies, digitalis from foxglove and quinine from the bark of cinchona trees;
- **Other goods** such as paper and pencils come from raw materials provided by the Earth's diversity.

### **Indirect services:**

- **Clean** and drinkable water: only a small amount - about 1% - of the water on our planet is usable directly. The rest is either salty (97%) or frozen (2%). Forests around the world filter our usable water again and again, constantly replenishing the water we use for drinking, bathing, and growing crops;
- **Air to breathe:** plants around the world take carbon dioxide out of the air and put oxygen into it - oxygen that almost all creatures need to breathe;
- **Fertile soils:** micro-organisms recycle the soil's organic matter and maintain its fertility;
- **Pollination:** insect, bird and bat species carry pollen from one plant to another (or from one part of a plant to another), thus fertilising fruit crops and flowers.

### **Cultural importance:**

- Plants and animals are often used as **symbols**, for example in flags, paintings, sculptures, photographs, stamps, songs and legends.
- Finally, biodiversity is also **beautiful**: it is a pleasure to see and smell flowers in a field, to listen to birds singing, etc.

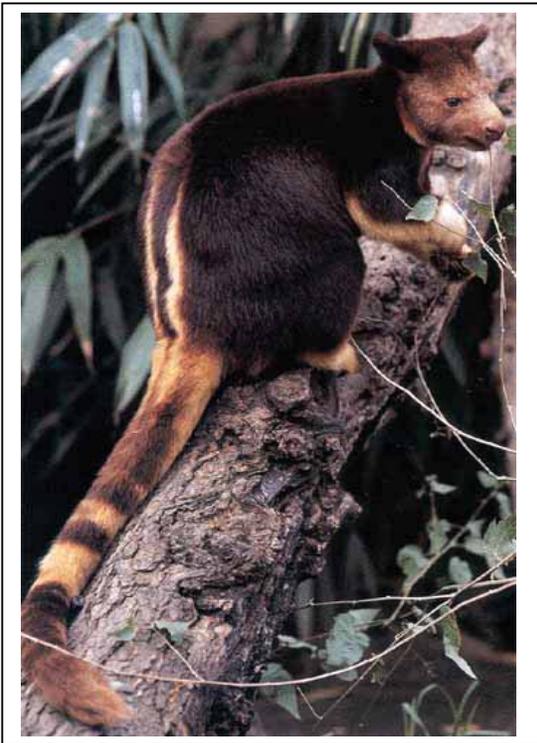
## ENDEMIC SPECIES

What are Endemic Species? The definition of an endemic species:

*'A species that is only found in a given region or location and now where else in the world.'*

The term endemic is usually used in reference to national level scales, e.g. a species that is endemic to PNG is found in PNG only and now where else on the earth. For example, Goodfellow's Tree Kangaroo is only found in PNG.

By definition, species endemic to a given site occur nowhere else. The smaller the area of endemism (i.e. the smaller the land mass), the more is the risk that the endemic species are to become extinct. This means that endemic species which are only found in very limited areas are much more likely to become extinct than species which are widespread.



Endemic  
Species to  
PNG:  
Goodfellow's  
Tree Kangaroo  
and the  
Northern  
Cassowary



## SPECIAL PNG SPECIES

### **Boelen's Python** (*Morelia boeleni*)

A non-venomous snake that is on average 6-8 feet in length, the coloration of this species is striking. The upper part of the snake is a shiny black with a purple-blue iridescence. It has white, diagonal markings on the lower part of its body which cover the first third of the snake, white "bars" on its lips. Endemic to New Guinea (it's found only there), Boelen's python lives in the mid-montane rainforests of PNG and seems to favour humidity and low light - almost nothing is known of its activities in the wild.

Due to its striking coloration and rarity, Boelen's python is the most protected reptile in PNG (it has the same status of protection as the bird of paradise) and it is therefore illegal for any non-national person to kill this snake or buy or possess anything derived from it. It is listed in CITES Appendix II, a global precaution against trade.

### **Bulmer's Fruit Bat** (*Aproteles bumerae*)

Bulmer's fruit bat, endemic or unique to New Guinea, is one of many species of fruit bats found on the island. The Bulmer's fruit is black and has a naked back, formed by the wing membranes that join along it, which allows the bat to have great maneuverability. True to its name, the Bulmer's fruit bat is an obligate frugivore, which means it only eats fruit.

Interestingly, the first record of the Bulmer's fruit bat was found as fossils excavated from Mount Erimbari, Chimbu dating back 12,000 years. It appears to have disappeared there. Finally, a living population was discovered in 1975 in the Hindenburg Wall area of Western Province, Papua New Guinea.

Today, Bulmer's fruit bats are found only in one location - a cave in Luplupwintem. The bat is very cautious and will only leave the cave if undisturbed, and then only after one or two scouts survey the area and call back to the group. The bats then leave the cave at dusk or dark and return to roost before light.

Bulmer fruit's bat, now listed as Critically Endangered by the IUCN, was thought to be extinct twice, and only a few surviving bats remain at Luplupwintem Cave.

### **Cassowaries**

Cassowaries are very large, flightless, ostrich-like birds that have a short bill, stout legs, and glossy, hair-like drooping plumage. The head of the cassowary is crowned with a horny helmet, or casque. The male carries out incubation alone. Cassowaries are frequently kept in villages but can be dangerous. When attacking, the bird strikes with its inner claw. There are three species of cassowary in New Guinea, two of which are endemic, or restricted to the island of New Guinea. Cassowaries are monogamous and build their nests on the forest floor. The incubation period lasts about 50 days and the young remain with their parents for a further nine months after hatching. Cassowaries, which are considered a major food source and whose feathers are sought for use in headdress, are threatened by hunting, as well as habitat loss due to extensive logging.

The double wattle, or southern cassowary (*Casuarius casuarius*) can reach up to six feet in height and is the largest land animal in New Guinea. It has a black, coarse plumage. The adult male is black with a naked bright blue neck, red on lower nape and has a red, double wattle hanging from its foreneck. It also has a high, blade like casque on its head. The cassowary will make a booming sound when mad or ready to attack. They are found in the lowlands of PNG, are elusive and prefer dense forest. Cassowaries are solitary and sedentary (but will readily swim across creeks) and have a diet of fallen fruit, fungi and small dead animals (which the cassowary can swallow whole). This species is also found in Australia.

The single wattle or northern cassowary (*Casuarius unappendiculatus*) is endemic to northern New Guinea. It is a bit smaller than the southern cassowary, reaching about five feet in height. The northern cassowary also has black glossy plumage and bright blue, naked neck - it has only a single wattle, which can be blue or red, and its casque is high and triangular. Scared and shy, this bird is rarely seen. However, it has a cultural importance because its feathers and bones are used in ceremonies, and as tools and decorations.

The IUCN Red List of Threatened Species lists both the northern and southern cassowaries as Vulnerable, because in Australia the cassowary is believed to have undergone a rapid decline of more than 20 percent in the last 30 years. This decline was the result of an extraordinary rate of habitat destruction.

#### **Victoria Crowned Pigeon (*Goura victoria*)**

The Victoria crowned pigeon is tame, curious, and gregarious, and can reach up to 30 inches in size. This bird is steely gray in colour with a maroon breast. Its head is adorned with a white tipped, laterally compressed crest. Victoria crowned pigeons are endemic to northern New Guinea in its lowland forests and swamps. They feed on the forest floor in small groups of 2-10 birds foraging for fallen fruits and berries, and lay a single egg for which incubation lasts 30 days.

Adult birds are prized by hunters for meat and sometimes feathers while nestlings are taken and reared for food. Logging is a major threat to the Victoria crowned pigeon. In addition to habitat destruction, the logging roads also open up access areas for bird hunters. The birds are easily shot by hunters due to their large size and to the fact that when scared, they fly to the trees and roost on low-lying branches, making them easy targets. Like the bird-of-paradise, there are laws in PNG to help protect the Victoria crowned pigeon.

#### **Southern Crowned Pigeon (*Goura scheepmakeri*)**

The southern crowned pigeon is another large, terrestrial pigeon (28-31 inches), and has an unpatterned pale gray crest, rich maroon breast and a fan-like crown on its head.

This bird is usually only seen with the help of local guides in remote, uninhabited areas. It inhabits the southern lowlands of PNG and its undisturbed dry and flooded forest. Like the Victoria crowned pigeon, it feeds on the ground in flocks of 2-10 birds and roosts on low hanging branches in trees. It is hunted for meat and feathers, threatened by logging, and captured for trade.

Both the Victoria and southern crowned pigeons are listed as vulnerable according to IUCN's Red List.

**Fire-maned Bowerbird** (*Sericulus bakeri*)

Found only in the Adelbert Mountains of northeastern New Guinea, the strikingly colored male fire-maned bowerbird is black with a blazing orange crown and mane, has a yellow patch on its wing, and reaches about 10 inches in length. The female is less brilliantly decorated than the male with mostly dark brown with white under parts.

The fire-maned bowerbird is rarely seen, but can occasionally be found feeding on fruits and insects in upper- and mid-level trees. It occupies a only a small range of habitat, mostly between 3000-4500 feet, and can be heard making a raspy hissing and it also mimics other calls.

The fire-maned bowerbird is listed as Vulnerable on the IUCN Red List of Threatened Species, based on its small range and the suspicion that it is in a continuous decline.

**Long Beaked Echidna** (*Zaglossus bruijni*)

The long beaked echidna is a large mammal with fur and spines of varying length that weighs between 13-35 pounds. It has tubular snout with a small mouth and a long tongue that is rapidly extruded and retracted. Surprisingly, Echidnas have big brains and relatively high intelligence. It is one of the few mammals that lays eggs - the female normally lays one egg at a time into a pouch. It was originally thought there was but one echidna species in New Guinea but this species was recently split into three.

The echidna does not have teeth, rather it has rows of spikes (horny teeth-like projections on the tongue) perfectly suited to its diet of earthworms. Worms are probed with the beak until the end is found, the tongue is then extruded and the worm is impaled with backward pointing spines on the tip of the tongue. The worm and the tongue are then withdrawn and the worm is swallowed by muscular action of the tongue.

The echidna finds its home in hollow logs and cavities under roots or rocks and burrows. It is found in the Vogelkop and Fak Fak mountains of western New Guinea. While inquisitive and relatively unafraid of humans, it is often found where human population densities are low.

One of the island's largest surviving indigenous animals, the echidna has a highly protected status in PNG but it is still threatened by hunters (it is a highly prized game animal) and loss of habitat due to logging, mining and farming

**New Guinea Eagle, or New Guinea Harpy Eagle** (*Harpyopsis novaeguineae*)

The New Guinea eagle is an elusive raptor with grayish brown feathers and whitish coloring on its under parts. It is a large forest eagle with a broad wingspan of up to three feet, with a short head ruff.

Endemic to New Guinea, the eagle is fairly solitary and moves around the upper forest canopy as much as 100-200 feet above ground, but does not soar. It is commonest in undisturbed forest but has been recorded from forest clearings and gallery forest from sea-level to 3,700m. The eagle perches on limbs in the canopy with a distinctive upright posture, and curves its tail forward. The New Guinea eagle mainly eats larger animals including possums, rats, wallabies, lizards, and on occasion, birds.

The New Guinea eagle usually calls at dawn or dusk with a deep, resonant sound of "bung," similar to the sound of a bowstring being released. Sometimes a short "buk" notes follow.

The wing and tail feathers are still used in headdresses by the New Guinea highlanders. The IUCN Red List of Threatened Species classifies the New Guinea eagle as Vulnerable, based on its small population and the continual threats of habitat destruction and hunting.

#### **New Guinea Quoll (*Dasyurus albopunctatus*)**

While, usually weighing just over a pound, the New Guinea quoll is the largest surviving marsupial carnivore of New Guinea's rainforests. The New Guinea quoll is small and brown, with white spots on its back and a somewhat hairy tail. It lives throughout the forested areas of New Guinea at elevations usually around 3,280 feet, but can be found at elevations up to 11,000 feet.

Said to eat prey as large as or larger than itself, most New Guineans acknowledge the quoll as a fierce predator and some refer to it as "stilman," a Pidgin term meaning "thief," because it often steals their prey.

The New Guinea Quoll is listed as Vulnerable on the IUCN Red List of Threatened species and reports indicate that its numbers have declined since the introduction of domestic cats and dogs. Other threats to the New Guinea quoll include habitat degradation and loss.

#### **Queen Alexandra's Birdwing Butterfly (*Ornithoptera alexandrae*)**

With a wingspan of 10 inches or more, the mature female Queen Alexandra's birdwing butterfly is the largest butterfly in the world. The male species is smaller in comparison to the female, but much brighter, and is colored differently - the male birdwing has iridescent yellow, pale blue and pale green markings on black wings and the female has cream markings on dark brown wings. Both sexes have yellow abdomens marked with red near their ventral wingbases.

The Queen Alexandra is dependent upon a genus of rainforest vine called aristolochia - the only plant on which the Queen Alexandra's birdwing butterfly will deposit eggs - as the larval food plants of the butterfly (the larva will consume these plants to successfully develop to the pupating stage). The eggs and larvae, however are often victims of predators like ants, toads, snakes, lizards, and birds.

The Queen Alexandra is found only in New Guinea, living in only a few valleys near Popondetta, and is listed as an endangered species on the IUCN Red List of Threatened

Species. Although a strong flier, it tends to stay within a very small range - making it even more susceptible to habitat loss due to agriculture, logging, and human encroachment.

While human degradation and destruction of habitat are the main causes of the butterflies' endangerment, because of its beauty and size, wildlife trade has also played a role. Collection of the Queen Alexandra is now prohibited under CITES Appendix I (threatened with extinction) however illegal trade to meet the demand of private collectors continues.

### **Tree Kangaroos**

Nine of the world's eleven species of tree kangaroos are found in New Guinea. These species have basically forsaken the ground and taken to the trees. This is possible due to the absence of primates and other arboreal competition in Australasia. Though most of the species are poorly studied, they generally feed on leaves, roots, and fruit.

#### **Goodfellow's Tree Kangaroo** (*Dendrolagus goodfellowi*)

Goodfellow's tree kangaroos are large mammals, weighing about 15 pounds, with an overall warm brown color, a long mottled golden brown tail, and two golden stripes on its rump. A very agile animal that can leap down to the ground from up to 30 feet, it eats leaves and fruit that it gets from the trees and the ground. This tree kangaroo is mostly restricted to PNG where it is considered Endangered (according the IUCN's Red List) due to overhunting.

#### **Doria's Tree Kangaroo** (*Dendrolagus dorianus*)

Doria's tree kangaroo has a sombre, brown coat and a short tail that is much paler than its body. This mammal is very powerful and has even been known to kill hunting dogs. Doria's tree kangaroo is listed as Vulnerable on IUCN's Red List because its large size makes it particularly susceptible to hunting, and it suffers habitat destruction in the central highlands of New Guinea.

#### **Agile Wallaby** (*Macropus agilis*)

The agile wallaby has large ears and is sandy-colored with light stripes on its face and hips. The wallaby is a member of the macropodid (kangaroo) family, which is the second largest family of marsupials. The agile wallaby is also found in Australia, where individuals can weight over 50 pounds. In fact, it is the largest mammal in New Guinea (though not in Australia). Little is known about the New Guinean variety of the agile wallaby. The species prefers to graze but will also dig up edible roots and eat figs and leaves. On a good feeding ground groups of up to ten wallabies will congregate to graze.

The wallaby is still threatened by overhunting in some areas of PNG but its overall status is currently secure.

## **BIRDS OF PARADISE (PNG National Emblem)**

There are 42 species of Birds of Paradise in 17 genera distributed mainly across the Islands of Papua New Guinea and Irian Jaya as well as in North Eastern Australia. Birds of Paradise are related to crows and bower birds and all species have 10 primaries and 12 tail feathers. Many species have greatly elongated and elaborate sets of feathers arising from the tail, wings or head. These trailing plumes, short velvet-like feathers and beautiful collars are used by the male in their courtship dances to gain female attention.

Birds of Paradise are relatively large birds that for the most part occupy distinct habitats. Many species show an altitude controlled distribution. This ranges from above 3000m in Macgregor's Bird of Paradise; 2000m-3000m *Cnemophilus macgregorii*, *Astrapia* sp, *Epimorchus* sp; 1000m-2000m *Laphorina*, *Paratia*, *Loboparadisea*, *Drepanornis albertisi*; 1000m-500m *Paradisaea*, *Ptiloris*, *Cicinnurus magnificus*; below 500m *Manucodia*, *Seleucidis*, *Cicinnurus regina*, *Drepanornis bruijnii*. Birds of Paradise, as far as is known, are relatively long-lived birds with lives extending well over 15 and perhaps up to 25 years. The males of some species take up to 5 years to mature and attain their splendid plumage, females, however, breed in their second year.

In the lowland rainforests, Birds of Paradise typically forage in the forest at a height of between 20 to 30 m above ground. They are often seen in mixed flocks of birds also containing Babblers and Drongos. Birds of Paradise feed on a variety of foods with some species being entirely frugivorous (fruit eating) including Loria's Bird of Paradise and the Crested Bird of Paradise, to species that almost entirely eat arthropods.

Many Birds of Paradise are highly sexually dimorphic with the males being larger and much more brightly coloured than the females. Some of the Birds of Paradise are monogamous (i.e. 1 male with 1 female), whilst some are polygynous with males mating with a number of females. The males have established territories where they dance for the females. The dances are as remarkable as the birds. Perched on a branch, the birds sway and crouch or stand erect, tilt forward and backward, some even hang upside down. Every species has its own type of dance.

All species, as far as is known, are solitary nesters. Nests come in 3 general types; at ground level, on moss-covered rocks (Loria's Bird of Paradise); on tree branches (Manucodes, Parotias and others); in dense foliage (Ribbon-tailed *Astrapia*, Victoria's Riflebird). Birds of Paradise nests also occur in 3 forms; domed nests (Crested Bird of Paradise); bulky cup nest on a forked branch (*Astrapia* sp.) and suspended cup nests (*Manucodia* sp.). Most species lay 1-2, occasionally 3, eggs. The young are born with no or few feathers and can not stand or walk and are basically helpless and are fed by one or both parents until they fledge.

Birds of Paradise populations are threatened by habitat destruction and hunting.

## BIOGEOGRAPHY

The study of how islands formed and why some species can move and some can not is called BIOGEOGRAPHY.

### What is Biogeography?

- It is the study of the distribution and dynamics of animals and plants.
- This theory attempts to describe and understand patterns in the distribution of species and ecosystems.

Biogeography was first talked about in the 17<sup>th</sup> century. Alfred Russell Wallace was one of the first people to identify patterns linking species to specific geographical locations and identifying the underlying principles connecting biology and geography. He did most of his work in South East Asia.

He observed that biological distribution was caused by many forms of geographical boundaries, i.e. big rivers and mountain ranges, or changes in underlying geology (soil, rock), which changes the vegetation.

There are three fundamental processes in biogeography that cause species to change over time and gives rise to different species occurring in different areas, and of the development of endemic species.

- **Evolution:** any irreversible change in the genetic composition of a population. Evolution causes changes to occur in species. This change makes species different from others. This also give rise to endemic species. This is seen in the Philippine islands where there are many species that are found nowhere else on the earth. Evolution happens over long periods of time.
- **Extinction:** the process of a species becoming permanently eliminated with no more living individuals on earth. Many species are now threatened with extinction. Remember extinction means that the animals or plants that become extinct will never be seen again.
- **Dispersal:** the movement of organisms away from their point of origin. Dispersal can occur over short distances or over long distances depending on the species that is involved. For example: mammals may need to walk, birds and bats can fly.

Islands are unique because they are isolated, evolutionary processes work at different rates that can give rise to lots of endemic species. This is true of the island of New Guinea.

However, isolation also makes island populations and species more vulnerable to habitat change and extinction. Introduction of a single predator or herbivore can have dramatic impacts on the local community. This is what is happening to many countries in the world.

## Species Dispersal

Colonisation, and therefore the species composition of islands are affected by the dispersal (movement) abilities of mainland flora and fauna. **Dispersal** is the capacity of organisms to move from their birthplace to a new site. Dispersal is an ecological process that is part of the life history of every species. Without dispersal, species do not have a chance to adapt to a new environment. Dispersal is an important part of the process of evolution. Animals achieve dispersal by walking, swimming, flying.

There are many **barriers to dispersal**. Without these barriers, every species would be everywhere. Barriers are species-specific: they affect different species differently. A vast body of water can be a significant barrier to a land dweller, but none at all to a fish.

- **Physiological barriers** are those so different from that of the original environment that a species can't survive in them for very long. Example: most freshwater fish can't survive very long in salt water.
- **Ecological barriers**: if there's a big guy waiting to eat you next door, you will probably stay at home. Predation and competition are barriers to dispersal.
- **Physical barriers**: it may be too far away or too difficult to get to a new site. Mountain ranges and large rivers are example of physical barriers to dispersal.

## Biogeography and Conservation

Habitat fragmentation is a major problem associated with the loss and reduction of tropical rainforests and the continuous landscape that was once in place. The loss and isolation of natural habitats are considered to have two components:

1. Reduction of the total amount of habitat type in a landscape
2. Reduction of remaining habitats into smaller, more isolated patches.

Human induced habitat fragmentation is the biggest cause of habitat loss and fragmentation. Humans threaten the survival of many species. Small fragments, or 'islands' of habitat can only support small populations of fauna and that small populations of fauna are more vulnerable to extinction. Fragments of habitat that are separated from each other are unlikely to be re-colonised.

Many species require relatively undisturbed (out of the influence of humans) patches of habitat to thrive. The interior of a habitat type is the area most likely to support undisturbed or pristine conditions. However as the area influenced by fragmentation increases, a habitat becomes susceptible to the edge effect. The edge of a given habitat, due to a higher proportion of disturbance experiences changes in microclimate; e.g. temperature, wind effects. As the proportion of edge in a given habitat increases, the availability of interior habitat decreases.

## ECOLOGY

The term *oekologie* (ecology) first used and defined in 1866 by the German biologist, Ernst Haeckel from the Greek *oikos* meaning "house" and *logos* meaning "science" or "study"—thus, ecology is the "study of the household of nature". Today we define ecology:

***‘Ecology is the study of animals and plants in their relations to each other and to their environment.’***

Breaking this down, this means:

- Looking at energy and how energy affects the world.
- The study of interactions between plants and animals and their environment.
- The importance of plants.
- The distribution and abundance of organisms.
- Involves all components of ecosystems that include the living organisms as well as the non-living (abiotic factors) parts such as soil, rocks, rainfall, sunlight and water. This is the ‘ecosystem’ concept.
- All the components (the living animals and plants and the non living parts) of an ecosystem are all inter-linked and rely one each other.
- Food chains and food webs in an ecosystem.

All ecosystems are open systems. This means that they can exchange chemicals and nutrients with other ecosystems). For example rain falls over many ecosystems and rivers transports this water to the sea. Water evaporates from the sea and forms clouds. These clouds will move over the land and rain again.

Water and many other things, such as carbon dioxide and oxygen gases, get moved through different ecosystems. However all ecosystems require energy in the form of sunlight. It is the sunlight that allows everything to grow, to move and to live.

Energy pours down onto the Earth from the sun. It moves from the sun to the earth that is over 93 million miles of space and it only takes sunlight eight and a half minutes to get here. It heats the oceans and landmasses and the air. It makes wind and ocean currents. It evaporates water and forms clouds.

Plants, on the land and in the water, absorb the energy from the sun, and then use it along with water and carbon dioxide (which is a gas) to make more energy for themselves. They store this energy in the form of molecules such as sugars in their cells. This process is called PHOTOSYNTHESIS. It is the green colour in the plants leaves that ‘trap’ the energy in the form of sunlight.

Animals then eat the plants. They use the energy that was stored in the plant molecules to breathe, move, stay warm, and to grow by combining the plant material with water. Then other animals eat the animals that ate the plants. Again the energy is used and changed. Energy keeps moving and changing. It exists in many forms. Over and over again it is transformed from one form to another.

To study and explain the movement of energy through an ecosystem, ecologists concentrate on issues of just who is eating whom. There are a variety of terms used to identify the position of a species within the eating relationships of a community.

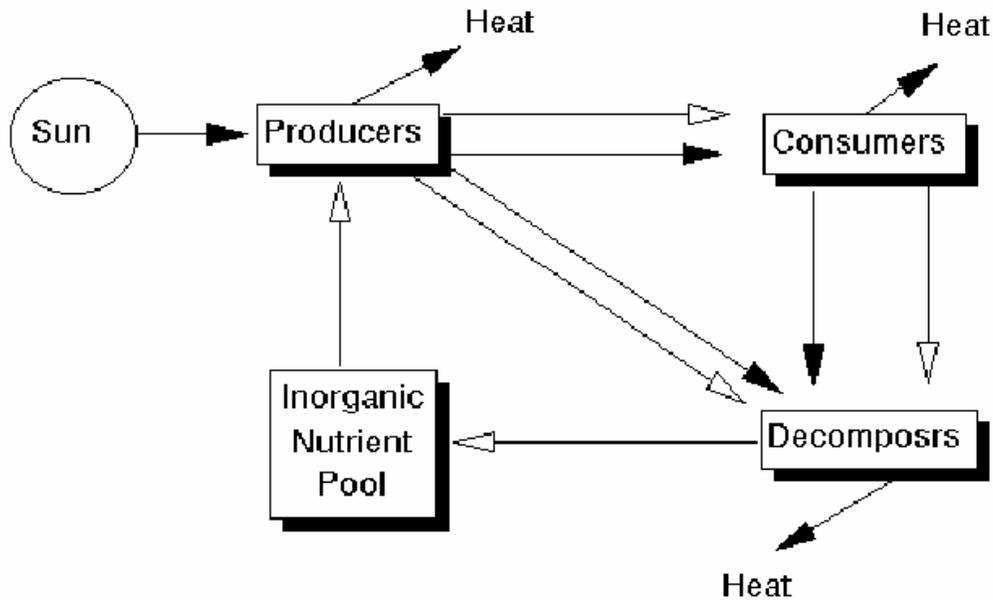
First, we divide organisms that consume other organisms into a variety of different 'vores'. 'Vore' means 'eater'. Organisms are divided into four different groups:

- **Carnivores** eat only meat (carni=muscle, which is what meat is made from).
- **Herbivores** eat only plants or plant-like materials (herbi=plant).
- **Omnivores** (like us) eat both animal and plant material on a regular basis (omni=everything).
- **Detrivores** take care of all kinds of waste materials (detri=gabrage/rubbish) such as rotting plant and animal materials.

A rather different (and often more useful) system divides all organisms into producers and consumers. The substance being "produced" or "consumed" is carbohydrate (sugars and related molecules) that is a chemical that is an energy store.

- **Producers** are also often called autotrophs (auto=self; troph=eater or feeder) the most familiar producers to us are the photosynthesizers (photo=light; synthesize=build) such as the green plants. All producers make their own food from sunlight and water and carbon dioxide. Photosynthesis explains how energy from the sun is captured by green plants and used to make food. Most of this energy is used to carry on the plant's life activities. The rest of the energy is passed on as food to the next level of the food chain.
- **Consumers** are often called heterotrophs (hetero=other or different). These are animals such as the herbivores, carnivores and omnivores. All consumers must eat ready-made foods whether plant or animal matter.

Consumers come in a variety of types, typically called primary, secondary, tertiary and quaternary consumers. The differences among these different kinds of consumers are tied to exactly what they eat. Primary consumers usually eat only plants. Animals like rabbits, horses and cows are exclusively primary consumers. They can also be seen as herbivores. Secondary, tertiary and quaternary consumers are carnivores or omnivores, although the distinction is less.



The diagram above shows how both energy and inorganic nutrients flow through the ecosystem. Energy "flows" through the ecosystem. When respiration occurs, the carbon-carbon bonds are broken and the carbon is combined with oxygen to form carbon dioxide. This process releases the energy, which is either used by the organism (to move its muscles, digest food, excrete wastes, etc.) or the energy may be lost as heat. The dark arrows represent the movement of this energy. Note that all energy comes from the sun, and that the ultimate fate of all energy in ecosystems is to be lost as heat.

The other components shown in the diagram are the inorganic nutrients. These inorganic nutrients include the phosphorous in your teeth, bones, and cellular membranes; the nitrogen in your amino acids (the building blocks of protein); and the iron in your blood (to name just a few of the inorganic nutrients). The movement of the inorganic nutrients is represented by the open arrows. Note that the autotrophs obtain these inorganic nutrients from the inorganic nutrient pool, which is usually the soil or water surrounding the plants or algae. These inorganic nutrients are passed from organism to organism as one organism is consumed by another. Ultimately, all organisms die and become detritus, food for the decomposers. At this stage, the last of the energy is extracted (and lost as heat) and the inorganic nutrients are returned to the soil or water to be taken up again. The inorganic nutrients are recycled, the energy is not.

Ecologists study what eats what. The way that food is eaten involves the exchange of energy. At each level of energy transfer is called a 'trophic level'. Food chains show ecologists what eats what.

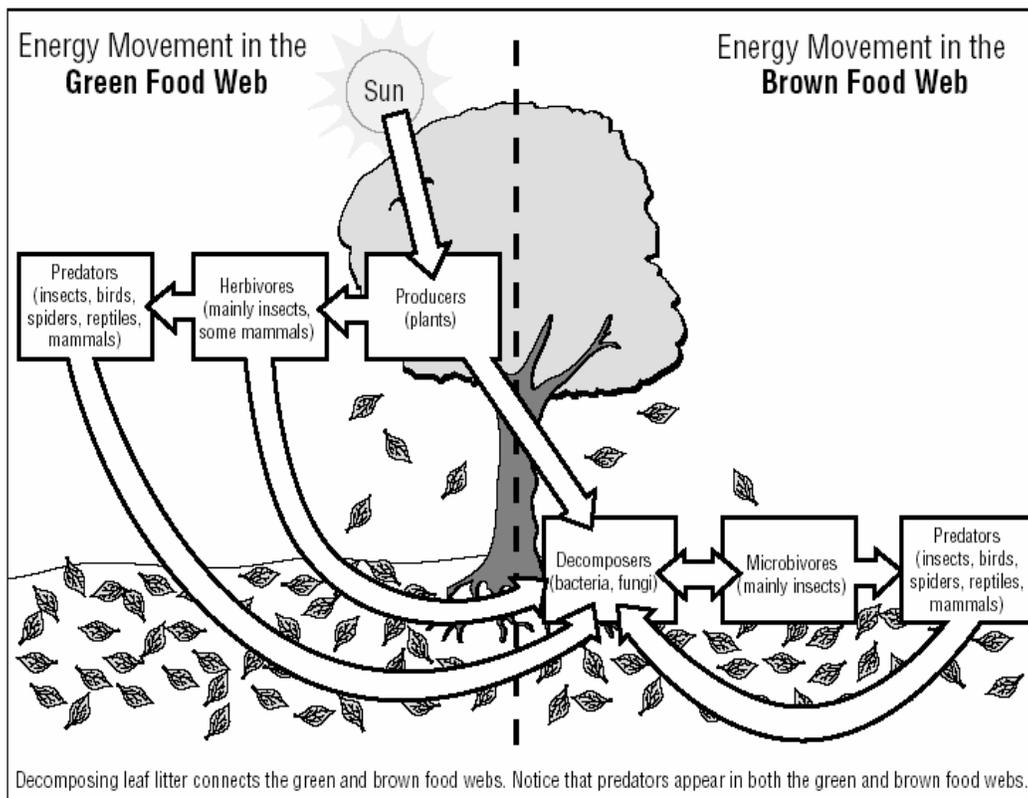
## Food Chains

- The source of all food is the activity of autotrophs, mainly photosynthesis by plants. They are called **producers** because only they can manufacture food from inorganic raw materials.
- This food feeds **herbivores**, called **primary consumers**.
- **Carnivores** that feed on herbivores are called **secondary consumers**.
- Carnivores that feed on other carnivores are **tertiary** (or higher) consumers.

Such a path of food consumption is called a **food chain**. Each level of consumption in a food chain is called a **trophic level**. The table gives one example of a food chain and the trophic levels represented in it.

<b>Grass</b> →	<b>Grasshopper</b> →	<b>Toad</b> →	<b>Snake</b> →	<b>Eagle</b> →	<b>Bacteria and decay</b>
In general,					
<u>Autotrophs</u> (Producers) →	Herbivores (Primary Consumers) →	Carnivores (Secondary, tertiary, etc. consumers) →			Decomposers

This chain can also be illustrated below:

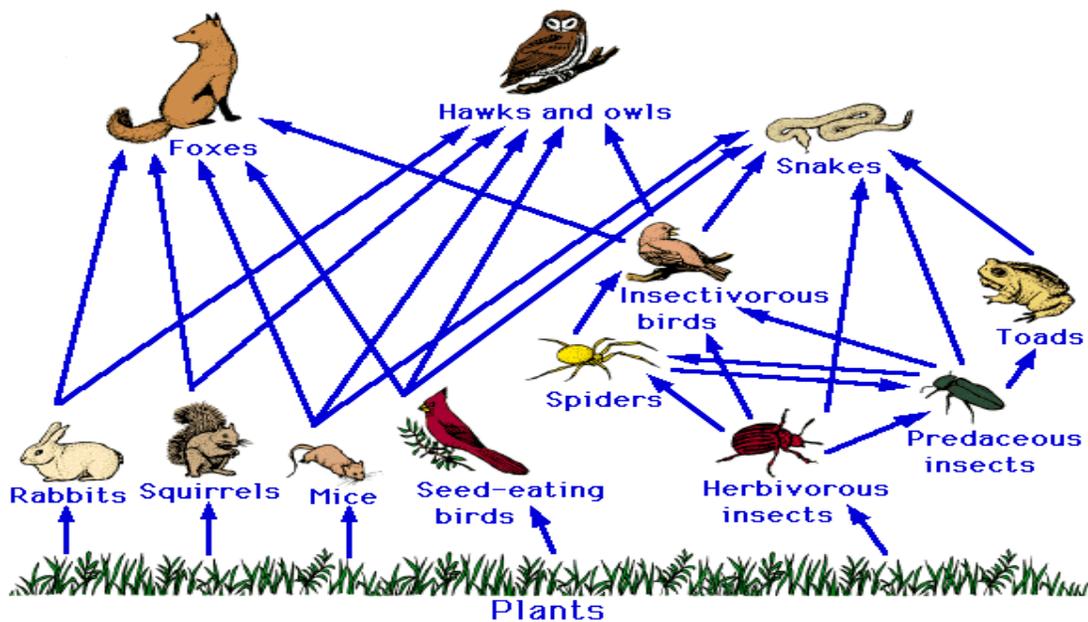


Do you know why there are **more herbivores than carnivores**? In a food chain, energy is passed from one link to another. When a herbivore eats, only a fraction of the energy (that it gets from the plant food) becomes new body mass; the rest of the energy is lost as waste or used up (by the herbivore as it moves, breathes and grows). Likewise, when a carnivore eats another animal, only a portion of the energy from the animal food is stored in its tissues. In other words, organisms along a food chain pass on much less energy (in the form of body mass) than they receive. This means that the further up the food chain you go, the more energy has been lost and less becomes available.

### Food Webs

Most food chains are interconnected. Animals typically consume a varied diet and, in turn, serve as food for a variety of other creatures that prey on them. These interconnections create **food webs**.

A change in the size of one population in a food chain will affect other populations. This interdependence of the populations within a food chain helps to maintain the balance of plant and animal populations within a community.



To summarize: In the flow of energy and inorganic nutrients through the ecosystem, a few generalizations can be made:

- The ultimate source of energy (for most ecosystems) is the sun
- The ultimate fate of energy in ecosystems is for it to be lost as heat.
- Energy and nutrients are passed from organism to organism through the food chain as one organism eats another.
- Decomposers remove the last energy from the remains of organisms.
- Inorganic nutrients are cycled, energy is not.

## ECOSYSTEMS

Scientists have recognized that life can be organized into several different levels of function and complexity. These functional levels are: *species*, *populations*, *communities*, and *ecosystems*.

Species are the different kinds of organisms found on the Earth. A more exact definition of species is *a group of interbreeding organisms that do not ordinarily breed with members of other groups*. If a species interbreeds freely with other species, it would no longer be a distinctive kind of organism.

Populations comprise all the individuals of a given species in a specific area or region at a certain time. Its significance is more than that of a number of individuals because not all individuals are identical. Populations contain *variation* within themselves and between other populations. There are many different populations of humans for example. Whilst we are all from the same species, different populations differ due to our environment.

Communities refer to all the populations in a specific area or region at a certain time. Its structure involves many types of interactions among species. Some of these involve the acquisition and use of food, space, or other environmental resources. Others involve nutrient cycling through all members of the community and mutual regulation of population sizes. In all of these cases, the structured interactions of populations lead to situations in which individuals are thrown into life or death struggles.

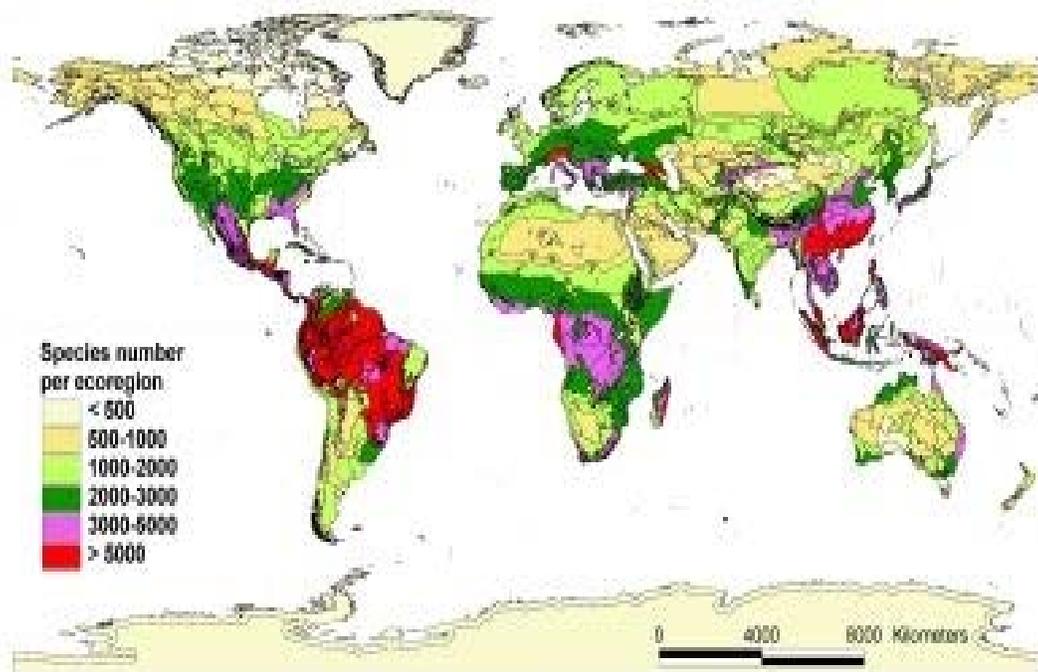
In general, ecologists believe that a community that has a high diversity is more *complex* and *stable* than a community that has a low diversity. This theory is founded on the observation that the food webs of communities of high diversity are more interconnected. Greater interconnectivity causes these systems to be more *resilient* to disturbance. If a species is removed, those species that relied on it for food have the option to switch to many other species that occupy a similar role in that ecosystem. In a low diversity ecosystem, possible substitutes for food may be non-existent or limited in abundance. This may cause animals to starve.

**Ecosystems** composed of the biological *community* and the abiotic environment. An ecosystem's abiotic (non-living) and biotic (living) composition and structure is determined by the number of interrelated environmental factors. Changes in any of these factors (for example: nutrient availability, temperature, light intensity, grazing intensity, and species population density) will result in changes to the nature of these systems. For example, a fire in a forest completely changes the structure of that ecosystem. There are no longer any large trees, most of the mosses, herbs, and shrubs that occupy the forest floor are gone, and the nutrients that were stored in the plants are quickly released into the soil, atmosphere and hydrologic system.

An ecosystem can be as small as a field or as large as the ocean, depending on the scale that the researcher is examining. The borders of an ecosystem may be clear, such as a pond; other borders may be less easy to define, such as grassland that gradually changes into brush.

Just as there is an immense diversity of individual species on the planet, so is there a rich diversity of ecosystems, from the icy arctic zones to tropical forests lush with plants and animals. Even the depths of the oceans, once thought to be barren, are now known to be teeming with living micro-organisms and other life. There is much that remains to be discovered. Biologists do not know with any certainty how many species there are or even why some areas, such as the tropics, are richer in biological diversity than others.

The destruction of ecosystems can have a very serious effect both on local and global levels. Rainforests, for example, contribute both to the process of soil formation and help to regulate the climate through photosynthesis – both producing oxygen and absorbing carbon dioxide. Wetlands act as sponge-like reservoirs in dry weather and help to filter and purify water. Coral reefs and mangrove swamps protect the land that they surround by reducing the effects of erosion. Every ecosystem is important and it is important that we learn to protect and care for the ecosystems around us.



## RAINFOREST QUESTIONS

### **Q: Where can you find tropical rainforests?**

A: Tropical rainforests are located around the equator—from the Tropic of Cancer in the north, to the Tropic of Capricorn in the south. The Amazon rainforest in South America is the world's largest, covering an area about two-thirds the size of the continental United States.

### **Q: Why are they called "rainforests?"**

A: Because they're wet! Tropical rainforests are defined by their wet and dry seasons. Tropical rainforests receive 160 to 400 inches (400-1000) cm) of rain each year. Also because rainforests lie near the equator, temperatures stay near 75-80 degrees Fahrenheit all year-round.

### **Q: Why do more animal species live in the rainforest than other parts of the world?**

A: Scientists believe that there is a great diversity of animals because rainforests are the oldest ecosystems on earth. Some rainforests in Southeast Asia have been around for at least 100 million years, when dinosaurs roamed the earth. During the Ice Ages, the last of which ended about 10,000 years ago, the frozen areas of the North and South Poles spread over much of the earth, causing a high rate of animal extinction. But the giant freeze did not reach a number of refuges in tropical rainforests. Therefore, rainforest plants and animals continued to evolve, developing into the most diverse and complex ecosystems on earth.

The nearly perfect conditions for life also helped contribute to the great number of species. With temperatures constant at 75 -80 degrees F. year-round, animals don't have to worry about freezing during cold winters or finding shade in the hot summers. They rarely have to search for water, as rain falls almost every day in tropical rainforests.

Some rainforest species have populations that number in the millions. Other species consist endemic, or found nowhere else on earth. of only a few dozen individuals. Living in limited areas, most of these species are

### **Q: Which type of rainforest species is most numerous?**

A: If you were to visit a rainforest, you probably wouldn't run into many jaguars or monkeys. The only living animals you could be sure to see are the millions of insects creeping and crawling around in every layer of the rainforest.

Scientists estimate that there are more than 50 million different species of invertebrates living in rainforests. One scientist found 50 different species of ants on a single tree in Peru! You would probably only need a few hours of poking around in a rainforest to find an insect unknown to science. Insects are often beautiful and always fascinating. Have you ever heard of an ant that farms? Or ants that act as security guards? Leaf-cutter, or parasol ants, can rightfully be called the world's first farmers. They climb

trees up to 100-feet tall and cut out small pieces of leaves. They then carry these fragments, weighing as much as 50 times their body weight, back to their homes. Sometimes they need to travel 200 feet, equal to an average human walking about 6 miles with 5,000 lbs. on his/her back! The forest floor is converted to a maze of busy highways full of these moving leaf fragments. These ants don't eat the leaves they have collected, but instead bury them underground. The combination of leaves and substances that the ants produce such as saliva allows a type of fungus to grow. This fungus is the only food that they need to eat.

**Q: How do all these species manage to live together without running out of food?**

A: The constant search for food, water, sunlight and space is constant competition. The main secret lies in the ability of many animals to adapt to eating a specific plant or animal, which few other species are able to eat.

**Q: Do animals ever help each other out?**

A: Many animals species have developed relationships with each other that benefit both species. In some cases both species are so dependent upon each other that if one becomes extinct, the other will as well.

**Q: How do rainforest animals protect themselves?**

A: Every animal has the ability to protect itself from being someone's next meal. Each species has evolved with its own set of unique adaptations, ways of helping them to survive. This includes:

- Blending in to the surroundings. The colouring of some animals acts as protection from their predators for example some butterflies, when they close their wings, look exactly like leaves. Camouflage also works in reverse, helping predators, such as boa constrictors, sneak up on unsuspecting animals and surprise them.
- Staying out of site, this includes only coming out at night or hiding in trees.
- Being armed and dangerous. Other animals want to announce their presence to the whole forest. Armed with dangerous poisons used in life-threatening situations, their bright colours warn predators to stay away.

**Q: Is it true that dozens of animal species a day become extinct in tropical rainforests?**

A: An average of 137 species of life forms are driven into extinction every day in the world's tropical rainforests. The forces of destruction such as logging, cattle ranching have all contributed to the loss of millions of acres of tropical rainforest. Pollution from mining also kills fish populations in rivers and seas. Today humans are altering their habitats too quickly for animals to adapt. So many species become extinct in such a short period of time.

**Q: What does a rainforest look like?**

A: A tropical rainforest consists of several layers: the emergent trees, canopy, the understory, and the forest floor. The emergent and canopy layers make up the very top of the rainforest, where a few trees, called emergents, poke out above the green growth to reach the sun. Most of the plant growth is here in the sun, so most rainforest animals, including monkeys, birds and tree frogs, live in the canopy.

Below the canopy are the young trees and shrubs that make up the understory. The plants in this layer rarely grow to large sizes because the canopy blocks most of the sunlight. The forest floor is almost bare because very little light can get through the canopy and understory to the ground. This is where fallen leaves and branches rot quickly to release nutrients for other plants to grow.

**Q: How do rainforest plants and animals depend on each other?**

A: In all of nature, and especially in rainforests, plants and animals depend on each other for survival. This is called interdependence. For example, some insects can only survive in one type of tree, while some birds only eat one type of insect. If this tree is destroyed, the insects will have no home. If these insects die, the birds who rely on them for food will starve to death. Because of this interdependence, if one type of plant or animal becomes extinct, several others could be in danger of extinction as well.

**Q: What is the secret to making this system work?**

A: One secret to this lush environment is that the rainforest reuses almost everything that falls to the ground and decays. When leaves fall from the trees, when flowers wilt and die, and when any animal dies on the forest floor - it decays and all of the nutrients in the decayed species are recycled back into the roots of the trees and plants.

Only the top few inches of the rainforest soil has any nutrients. Most of the nutrients are in the biomass, the bulk of animal and plant life above the ground. The roots of the rainforest trees are not very deep; that way they can collect all of the nutrients in the top few inches of the soil. Rainforests even recycle their own rain! As water evaporates in the forest it forms clouds above the canopy that later fall as rain.

**Q: How do humans depend on rainforests?**

A: Rainforests are essential-not just to those who live in or near them, but to everyone on the whole planet. They help control the world's climate. People also use many rainforest materials. Many of our medicines come from plants that grow in rainforests. Many products, such as medicines and Brazil nuts, can be taken from rainforests without destroying them; but other products-such as timber, gold, and oil-require a more destructive method of extraction. Logging for tropical timber and gold mining have contributed to much of the destruction of tropical rainforests.

**Q: What happens to a rainforest when the trees are logged or cleared with fire?**

A: About 80% of the rainforests nutrients comes from trees and plants. That leaves 20% of the nutrients in the soil. The nutrients from the leaves that fall are instantly recycled back up into the plants and trees. When a rainforest is clear-cut, conditions change very

quickly. The soil dries up in the sun. When it rains, it washes the soil away, leaving the land barren and desert-like.

**Q: Can rainforests grow back once they have been destroyed?**

A: A rainforest cannot be replaced. Once it has been destroyed it will be gone forever. Once the web of interdependence has been broken, plants and animals have no way to rebuild their complex communities. Rainforests have been evolving for 70 to 100 million years. They contain plants and animals that live nowhere else on earth. When a rainforest is destroyed, so are the plants and animals who have lived there for millions of years. Once they are destroyed, they will be gone forever.

## DEFORESTATION

More than 30 million acres of tropical forest are destroyed each year, which means at current rates of destruction there will be no rainforest at all in just 40 years. The disappearance of the forest is called DEFORESTATION. In the tropics, 38 million acres of forest are lost each year.

Rainforests are the world's most diverse ecosystems. An ecosystem is not just the plants, but also the birds, mammals, reptiles, fish, amphibians, invertebrates, bacteria, and even the non-living elements like soil, water and air. When the forest is destroyed it means that all the animals and plants that live in the forest will have nowhere to live. This means that they are most likely to become extinct.

There are many reasons why forests are chopped down. Below are a few of these reasons:

- Logging for commercial purposes
- Agriculture Cash Crops
- Cattle Ranching
- Fuelwood
- Paper and other wood products
- Large Dams
- Mining and Industry
- Poverty
- Overpopulation

Here are some deforestation facts:

- Rainforests once covered 14% of the earth's land surface; now they cover a mere 6% and experts estimate that the last remaining rainforests could be consumed in less than 40 years.
- One and one-half acres of rainforest are lost every second with tragic consequences for both developing and industrial countries.
- Nearly half of the world's species of plants, animals and microorganisms will be destroyed or severely threatened over the next quarter century due to Rainforest deforestation.
- Experts estimate that we are losing 137 plant, animal and insect species every single day due to rainforest deforestation. That equates to 50,000 species a year.

In the current economy, people obviously have a need for all of these resources. But almost all experts agree that, over time, we will suffer much more from the destruction of the rainforests than we will benefit. There are several factors involved in this scientific assessment:

- To begin with, the land in rainforest regions is not particularly suited for crops and livestock. Once the forest is cleared, it is even less so -- without any decomposing plant life, the soil is so infertile that it is nearly useless for growing anything. Generally, when people clear-cut a forest, they can only

use the land for a year or two before the nutrients from the original plants are depleted, leaving a huge, barren tract of land.

- Cutting large sections of rainforest may be a good source of lumber right now, but in the long run it actually diminishes the world's lumber supply. Experts say that we should preserve most of the rainforests and harvest them only on a small scale. This way, we maintain a self-replenishing supply of lumber for the future.
- Rainforests are often called the world's pharmacy, because their diverse plant and animal populations make up a vast collection of potential medicines (not to mention food sources). More than 25 percent of the medicines we use today come from plants originating in rainforests, and these plants make up only a tiny fraction of the total collection of rainforest species.

The world's rainforest are an extremely valuable natural resource, to be sure, but not for their lumber or their land. They are the main cradle of life on Earth, and they hold millions of unique life forms that we have yet to discover. Destroying the rainforests is comparable to destroying an unknown planet - we have no idea what we're losing. If deforestation continues at its current rate, the world's tropical rainforests will be wiped out within 40 years.

## ENVIRONMENTAL CHANGE AND DAMAGE

We must learn to look after our environment. It is earth that is supporting us and we need it to be healthy. However we are destroying our environment all the time and this destruction is happening across all the biomes in the world.

The earth is rapidly losing many of its plants and animals. When an animal or plant becomes 'EXTINCT' it means that these species will disappear from the earth forever. There are many species that only have small populations left on the earth; for example the orang-utan; and they are more likely to become extinct than other species.

Humans are causing many problems with the health of the earth and our environment. Some of the changes humans have caused are extremely dangerous, especially those we regard as irreversible. Among the better known examples are:

1. Atmospheric pollution
2. Pollution of fresh and salt waters
3. Deforestation
4. Erosion
5. Species loss

Among the most important areas of environmental losses are the forests of the world. Rain forests are being destroyed at the rate of at least 60,000 square kilometres per year. Half the Earth's woodland cover has disappeared since 1950.

We can protect the environment through conservation.

## WHAT IS CONSERVATION?

*'The preservation and protection of the environment and the wise use of natural resources'*

Conservation is about ensuring the long-term survival of species and areas such as tropical rainforests. Conservation is about humans living in harmony with nature. This means that future generations will be able to use the earth's resources too.

Every one of us, whatever age we are, can do something to help slow down and reverse some of the damage. Everyone can become involved in conservation and do their bit to help. We all have a responsibility for our environment and by changing something small about us, we can all make change for the best.

How can we all help?

- Recycle and use recycled paper
- Try not to use plastic
- Plant trees that are natural to the area
- Conserve electricity
- Do not litter
- Do not use chemicals in the garden
- Never buy wildlife that has been taken from the forest
- Learn more about the environment
- Join or become involved with environmental programmes in your local area

## REFERENCES

- Bibby, C., Jones, M. & Marsden, S. (1998) *Expedition Field Techniques: Bird Surveys*. Royal Geographic Society, London.
- BirdLife International. (2002)
- Beccaloni, G.W. & Gaston, K.J. (1995) Predicting the species richness of Neotropical forest butterflies-Ithomiinae (Lepidoptera, Nymphalidae) as indicators. *Biological Conservation*, **71**, 77-86.
- Blau, W.S. (1980) The effect of environmental disturbance on a tropical butterfly population. *Ecology*, **61**, 1005-1012.
- Brooks, T.M., Pimm, S.L. & Collar, N.J. (1997) Deforestation predicts the number of threatened birds in Insular Southeast Asia. *Conservation Biology*, **11**, 382-394.
- Convention on Biological Diversity. (2003) *The Ecological and Socio-Economic Impact of Invasive Alien Species on Island Ecosystems*. (<http://www.issg.org/cii/info.html>). [accessed 22/02/05].
- D'Abrera, B. (1986) Butterflies of the Oriental Region. Part III. Hill House, Melbourne.
- Davis, S.D (1995) Identifying the sites of global importance for conservation: The IUCN/WWF centres of plant diversity project. In: Primack RB and Lovejoy TE (Eds) *Ecology, Conservation and Management of Southeast Asian Rainforests*, pp 176-203. *Yale University Press, New Haven, CT*.
- Dinerstein, E., Wikramanayake, E.D. & Forney, M. (1995) Conserving the reservoirs and remnants of tropical moist forest in the Indo-Pacific region. In: Primack RB and Lovejoy TE (Eds) *Ecology, Conservation and Management of Southeast Asian Rainforests*, pp 176-203. *Yale University Press, New Haven, CT*.
- Francis, C.M. 2001. *A Photographic Guide to Mammals of South-east Asia*. *New Holland Publishers, London*.
- Ghazoul, J. (1997) The pollination and breeding system of *Dipterocarpus obtusifolius* (Dipterocarpaceae) in dry deciduous forests of Thailand. *Journal of Natural History*, **31**, 901-916.
- Gilbert, L.E. (1984) The biology of butterfly communities. *The Biology of Butterflies* (eds. R.I. Vane-Wright & P.R. Ackery), pp. 41-54, Academic Press, London.
- Hamer, K.C., Hill, J.K., Lace, L.A. & Langan, A.M. (1997) Ecological and biogeographical effects of forest disturbance on tropical butterflies of Sumba, Indonesia. *Journal of Biogeography*, **24**, 67-75.
- Hammond, P.C. & Miller, J.C. (1998) Comparison of the biodiversity of Lepidoptera within three forested ecosystems. *Annals of the Entomological Society of America*, **91**, 323-328.

Haribon Foundation. (2002) Available at: <http://www.haribon.org.ph/>

Heaney, L. R., Balete, D. S., Rickart, E. A., Josefa Veluz, M. & Sarmiento, J. (2005) *Welcome surprises from Mt. Banahaw*. (<http://www.haribon.org.ph/?q=node/view/128>). [Accessed 16/02/05].

Hill, J.K., Hamer, K.C., Lace, L.A. & Banham, W.M.T. (1995) Effects of selective logging on tropical forest butterflies on Buru, Indonesia. *Journal of Applied Ecology*, **32**, 754-760.

Ingle, N. R. and Heaney, L. R., (1992) A key to the bats of the Philippine Islands. *Fieldiana: Zoology*, **69**, 1-44. Chicago Field Museum of Natural History.

Ingle, N. R. (1993) Vertical Flight Stratification of Bats in a Philippine Rainforest. *Asia Life Sciences*, **2**, 215 – 222.

IUCN Regional Biodiversity Programme Asia. (2001). *Alien Invasive Species: Report of Workshop on Alien Invasive Species Global Biodiversity Forum. South and Southeast Asia*. IUCN. Columbo.

IUCN. (2004) The IUCN Red List of Threatened Species. Available at: <http://www.redlist.org>. [accessed 04/04/05].

Kunz, T.H., Thomas, D.W., Richards, G.C., Tidemann, C.R., Piersom, E.D. & Racey, P.A. (1996) Observational Techniques for Bats. In *Measuring and Monitoring Biological Diversity: Standard Methods for Mammals*. (edited by Wilson, D.E., Cole, F.R. Nichols, J.D., Rudran, R, & Foster, M.S.). Smithsonian Institution Press, Washington.

Mickleburgh, S. P., Hutson, A. M. & Racey, P. A., (eds) (1992) *Old World Fruit Bats. An Action Plan for their Conservation*. IUCN/SSC Chiroptera Specialist Group. IUCN, Gland, Switzerland.

Pollard, E. & Yates, T.J. (1993) *Monitoring Butterflies for Ecology and Conservation*. Conservation Biology Series, Vol.1, Chapman & Hall, London.

Stattersfield, A.J., Crosby, M.J., Long, A.J. & Wege, D.C. (1998) *Endemic Bird Areas of the World: Priorities for Biodiversity Conservation*. *BirdLife Conservation Series* No.7. Cambridge.

SPREP. (2000). *Invasive Species in the Pacific: A technical Review and Draft Regional Strategy*. SPREP. Samoa. ([http://www.issg.org/database/species/reference\\_files/SPREP.pdf](http://www.issg.org/database/species/reference_files/SPREP.pdf)). [Accessed 21/02/05].

Walpole, M.J. (1999) Sampling butterflies in tropical rainforest: an evaluation of a transect walk method. *Biological Conservation*, **87**, 85-91.

## GLOSSARY

- **Biomass:** Living and dead matter produced, including plants and animals.
- **Canopy:** The highest layer of the rainforest, made up of the tops of trees.
- **Community:** A group of populations living and interacting with each other in a habitat
- **Ecology:** The study of relationships between living organisms and between them and their environment
- **Ecosystem:** A community and its abiotic (non living) environment
- **Equator:** An imaginary circle around the earth, equally distant at all points from the North and South poles. It divides the earth into two halves - the Northern and Southern Hemispheres.
- **Emergent:** The tops of the tallest trees in a rainforest.
- **Evaporate:** When moisture changes from liquid to gas in the air.
- **Extraction:** To remove something.
- **Forest Floor:** The ground layer, made up of tree roots, soil and decaying matter. Mushrooms, earthworms, and elephants all make their homes here.
- **Habitat:** The environment in which a species normally lives or the location of a living organism
- **Interdependence:** The concept that everything in nature is connected to each other, and cannot survive without the help of other plants, animals and abiotic factors (such as sun, soil, water and air) around it.
- **Nutrients:** Food needed for growth by living things.
- **Population:** A group of organisms of the same species living in the same area at the same time and capable of interbreeding
- **Species:** A distinct kind of plant or animal that has many common characteristics or qualities.
- **Sustainable:** Using products of the forest in a way that does not permanently destroy them, so that people in the future can also use them.
- **Species:** A group of organisms that could interbreed and produce fertile offspring
- **Tropic of Cancer:** A circle around the earth, parallel and to the north of the equator.
- **Tropic of Capricorn:** Similar to the Tropic of Cancer, but to the south of the equator.
- **Understory:** The second layer of rainforests, made up mostly of young trees and shrubs.