Energy Engineering – Energy, Environment and Sustainable Development

Module 2C The Land Environment

Acknowledgement

- The first half of the materials in this module is based on Dr Dave McShaffrey's BIOL 102 course materials at Marietta College.
- http://www.marietta.edu/~biol/biomes/mangroves.htm

Learning Outcomes

- Know the shore environments – wetland, mangroves, sandy shore, rocky shore
- Know the volcanoes
- Appreciate the rainforests
- Realize the problem of deforestation
- Realize the problem of desertification
- Know the stress on the land environment
- Relate the land environment with sustainability

This we know:

The earth does not belong to man,
man belongs to the earth.
All things are connected
like the blood that unites us all.
Man did not weave the web of life,
he is merely a strand in it.
Whatever he does to the web,
he does to himself.

Chief Seattle

http://www.starpulse.com/Notables/Chief_Seattle/Pictures/

Shore Environment

Wetlands

Wetland

- Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season.
- Water saturation (hydrology) largely determines how the soil develops and the types of plant and animal communities living in and on the soil.
- Wetlands may support both aquatic and terrestrial species.
- The prolonged presence of water creates conditions that favor the growth of specially adapted plants (hydrophytes) and promote the development of characteristic wetland (hydric) soils.
- Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance.
- Wetlands are found from the tundra to the tropics and on every continent except Antarctica. Two general categories of wetlands are recognized: coastal or tidal wetlands and inland or non-tidal wetlands.

Coastal Wetlands

- **Coastal wetlands** are closely linked to estuaries, where sea water mixes with fresh water to form an environment of varying salinities.
- The salt water and the fluctuating water levels (due to tidal action) combine to create a rather difficult environment for most plants.
- Consequently, many shallow coastal areas are unvegetated mud flats or sand flats.

a **cypress swamp**

Inland Wetlands

- **Inland wetlands** are most common on floodplains along rivers and streams (riparian wetlands), in isolated depressions surrounded by dry land (for example, playas, basins, and "potholes"), along the margins of lakes and ponds, and in other low-lying areas where the groundwater intercepts the soil surface or where precipitation sufficiently saturates the soil (vernal pools and bogs).
- Inland wetlands include marshes and wet meadows dominated by herbaceous plants, swamps dominated by shrubs, and wooded swamps dominated by trees.

Singer Lake Bog, Ohio

Functions of Wetlands

- Although wetlands are often wet, a wetland might not be wet year-round. In fact, some of the most important wetlands are only seasonally wet.
- Wetlands are the link between the land and the water. They are transition zones where the flow of water, the cycling of nutrients, and the energy of the sun meet to produce a unique ecosystem characterized by hydrology, soils, and vegetation—making these areas very important features of a watershed.
- Using a watershed-based approach to wetland protection ensures that the whole system, including land, air, and water resources, is protected.
- A watershed includes all the land that drains to a common body of water. Using a watershed-based approach to wetland protection ensures that the whole ecosystem is protected.
- The term *watershed* describes an area of land that drains downslope to the lowest point. The water moves through a network of drainage pathways, both underground and on the surface. Generally, these pathways converge into streams and rivers, which become progressively larger as the water moves on downstream, eventually reaching an estuary and the ocean.

Functions of Wetlands

- Wetlands do more than provide habitat for plants and animals in the watershed.
- When rivers overflow, wetlands help to absorb and slow floodwaters.
- This ability to control floods can alleviate property damage and loss and can even save lives.
- Wetlands also absorb excess nutrients, sediment, and other pollutants before they reach rivers, lakes, and other waterbodies.
- They are great spots for fishing, canoeing, hiking, and bird-watching, and they make wonderful outdoor classrooms for people of all ages.

Maple Swamp - Ohio

Functions of Wetlands

- Wetlands are some of the most biologically productive natural ecosystems in the world, comparable to tropical rain forests and coral reefs in their productivity and the diversity of species they support.
- Abundant vegetation and shallow water provide diverse habitats for fish and wildlife. Aquatic plant life flourishes in the nutrient-rich environment, and energy converted by the plants is passed up the food chain to fish, waterfowl, and other wildlife and to us as well.
- This function supports valuable commercial fish and shellfish industries.
- Scientists are beginning to realize that atmospheric maintenance may be an additional wetlands function.
- Wetlands store carbon within their plant communities and soil instead of releasing it to the atmosphere as carbon dioxide. Thus wetlands help to moderate global climate conditions.

Potential Benefits of Wetlands

- The Great Flood of 1993 in the upper Mississippi River Basin caused billions of dollars in property damage and resulted in 38 deaths.
- Historically, 20 million acres of wetlands in this area had been drained or filled, mostly for agricultural purposes. If the wetlands had been preserved rather than drained, much property damage and crop loss could have been avoided.

Threats to Wetland

One threat to wetlands everywhere is having them filled and **converted** to other, more urban uses. An example is seen to the right, with **estuarine wetlands** in **San Francisco Bay** being converted to housing. This is done by bringing in fill from construction elsewhere, or, more commonly, **dredge spoils** from dredging used to make other parts of the bay navigable for large ships. This fill is then used to raise the level of the former wetlands enough to support housing and roads, as seen here. In addition to the loss of wetland habitat, such development removes a large portion of wetland from its other roles including **absorbing floods**, **groundwater recharge**, etc.

Muskrat

Spotted Turtle

Alligator

Mink

Wood Frogs

Northern Leopard Frog

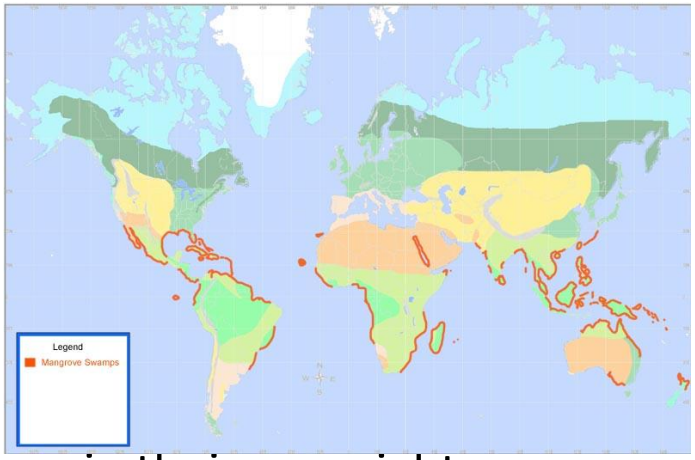
Water snake

Shore Environment

Mangroves

Mangrove Swamps

- The mangrove swamp is a wetland - submerged only at high tide - and its placement between the shore and the coral reef in tropical areas makes it a crucial part of the ecology of the coral reef itself.
- Mangroves are very important to the adjacent coral reefs in that they filter out silt and nutrients that would otherwise go out to the reef and smother corals and encourage algal growth.
- In addition, they serve as refuge and nursery for the young of many reef fish.



- Ecologically, mangroves are exciting systems in their own right.
- Mangroves are found along the shore in many of the same areas that coral reefs are found.

http://www.marietta.edu/~biol/biomes/mangroves.htm

- Mangroves require warm tropical conditions and a shallow slope – they don't do well along cliffs, for instance.
- They are particularly prominent at river mouths or estuaries. Unfortunately, these are some of the same places people like to build, and in order to do so they often cut down the mangroves.
- Hurricanes or tsunami can come ashore without the mangroves to buffer the coast. In the tsunami of 2004, many areas of Indonesia that were still protected by their mangroves had relatively little damage to human structures.

In the Caribbean, there are 3 common types of mangroves.
Each of them has its own unique way of dealing with high salt concentrations.
Closest to the water - in fact in the water at high tide - are the
Red Mangroves (*Rhizophora mangle*).

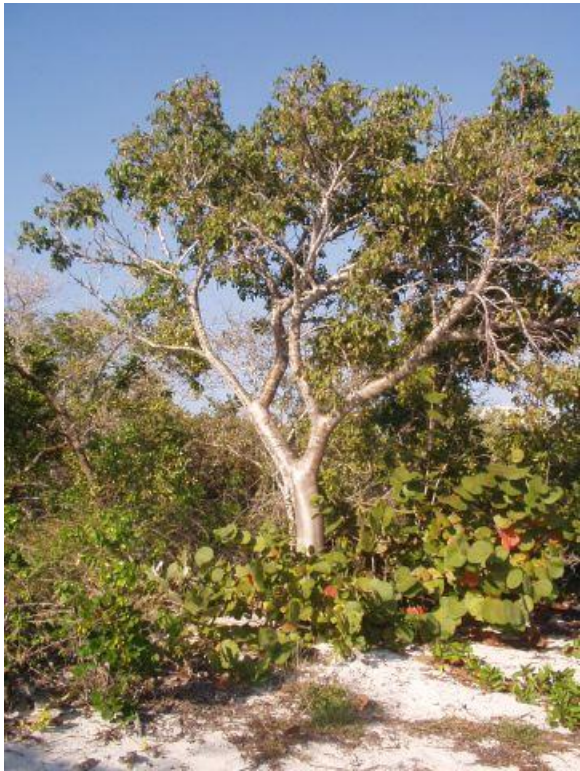
- The roots of the red mangrove are distinctive, with long arching aerial prop roots that help anchor the plant in the sediment. These roots are firmly mired in the organic muck; decomposition in this muck releases nutrients that the tree can use, but there is no oxygen.

- The roots of the red mangrove are able to obtain water from the ocean by pumping magnesium ions into the root. These positive ions force other positive ions, such as sodium, out of the root. The high concentration of magnesium in the root creates a high osmotic potential, and this in turn attracts water in from the surrounding seawater. The net effect is to set up "reverse osmosis" or to exclude salt from the root.
- Oxygen to support the cells moving all those magnesium ions is provided through air channels in the roots.

- Next inland, usually above the high tides, are the **Black Mangroves** (*Avicennia germinans*). These trees deal with salt by excreting it onto the leaves; also, like the red mangroves, the roots of the black mangrove are metabolically very active. To supply the roots with oxygen in the oxygen-poor sediments the black mangrove has an extensive development of pneumatophores. These structures grow up out of the soil and their spongy construction helps convey oxygen down to the roots.

- Unlike the red mangrove which actively excludes ocean salts from entering at the root, the black mangrove allows the salt to enter but excretes it on the surface of the roots and the leaves. You can often find salt crystals on the leaves of the black mangrove. It can survive the higher salinities then the red mangrove; such higher salinities might be expected further up on the beach where the black mangroves are found.

- Furthest inland are the ***White Mangroves*** (*Laguncularia racemosa*). Neither aerial prop roots or pneumatophores are usually visible (but either may be present if conditions warrant; the pneumatophores take the form of peg roots). Like the black mangrove, the white mangrove excretes salts on the leaf surface.



Down in the roots. Above, red mangrove prop roots arch down to the water. Note that there is very little vegetation on the ground itself. This is due to flooding by high tides and the high salt concentration, as well as the effect of shading by the dense mangrove canopy above.

In the image, a black mangrove at Tamarindo in Costa Rica sends out its roots through the muck; **pneumatophores** stick up to obtain oxygen for the roots.

- A look through the red mangrove roots at low tide reveals various color bands resulting from the effects of high and low tides. At high tide this area will be submerged and fish will be free to forage through the roots for prey feeding in turn on the organic sediments. One of the key detrital components in those sediments are the leaves of the mangroves themselves. The roots also trap and hold soil.

Crabs are important parts of the mangrove ecosystem playing a key role in the cycling of nutrients. A fiddler crab is pictured below; these crabs have one large claw and one small claw. They live in burrows in the sand; the burrows bring oxygen into the soil and the excavated soils are nutrient rich.

The endangered **American Crocodile** (*Crocodylus acutus*) is an inhabitant of the mangrove swamp. As the swamps are cut, the crocodiles lose their habitat.

http://www.flmnh.ufl.edu/natsci/herpetology/brittoncrocs/csp_cacu.htm

Many, many species of birds live in, on or among the mangroves.

Reddish Egret (*Egretta rufescens*)

Roseate Spoonbill (*Ajaia ajaja)* uses its unique bill to strain small invertebrates from the mud.

Yellow Crowned Night Heron (*Nyctanassa violacea)*

The individual to the right has caught a crab; the heavy beak of these birds makes short work of the tough crab exoskeleton.

The ***Cassiopeia* jellyfish** - also known as the upside-down jellyfish - is found in the waters of a mangrove swamp. These unique jellyfish lie on their backs in shallow, clear water. They harbor endosymbiotic algae (much like corals); the algae photosynthesize and pass extra sugars on to the jellyfish. If it weren't for the filtration supplied by the mangrove roots, silt and other agents would cloud the water and ruin the habitat for these invertebrates.

Ecological Role of Mangroves

Example: Florida Keys

- The coral reefs of the Florida Keys are quite sensitive to nutrient enrichment and sediment, and both of these are made worse by the increasing urbanization and intensive agriculture that have taken over much of south Florida. Much of the everglades has been converted to agriculture, and in some places only a thin band of mangroves exists to absorb the released nutrients.
- The two photos below show what happens when the system is no longer able to keep the nutrients under control. Note the development of a "black zone" of dead algae and other phytoplankton of the southwestern coast of Florida over the period of a few weeks in the winter of 2002.

What's at stake - extensive eutrophication (algal growth fueled by nutrients running off agricultural fields and from urban areas) spreading into the Gulf of Mexico off the coast of Florida. Intact ecosystems, including mangrove swamps, help prevent eutrophication and the problems it caused.

Shore Environment

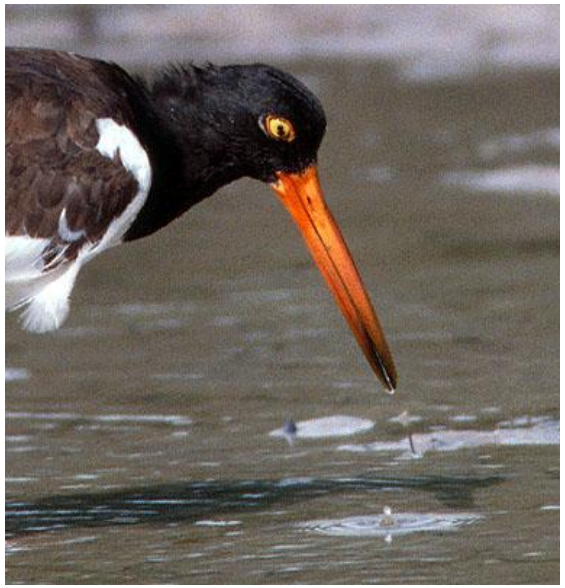
Sandy Shores

Sandy Shores

- On a sandy shore, wave action deposits sand or other sediments and periodically move these sediments around.
- At first glance, these areas seem devoid of life, but in reality the life is merely hidden - buried in the sand or even living between the grains of sand.

Bird Life

- Many fish approach sandy shores to feed on the life hiding in the sands below. These fish, in turn, are the targets of fishermen and their wild counterparts, such as the **Osprey** (*Pandion haliaetus*) or the gulls.



Left: The **American Oystercatcher** (*Haematopus palliatus*) uses its long, stout bill to probe for its prey. The **Black Skimmer** (*Rynchops niger*) uses its unique bill (with the lower jaw longer than the upper) to take its prey on the wing (below, left). The **Brown Pelican** (*Pelecanus occidentalis*) dives from a height of 10 meters or more to engulf fish in its greatly expandable throat pouch (below).

Sea Oats grow on coastal dunes along the eastern coast of the United States. They help to **stabilize** the dunes, **preventing erosion** during storms. Formerly seen as an eyesore limiting tourist access to the beaches, many resorts now protect the sea oats and rope off access routes to the beach. These resorts have come to see the value of plant-stabilized dunes between the expensive hotel and a hurricane.

Ghost Crabs are common on many beaches - their uncanny ability to run to their holes and disappear is doubtless the source of their common name.

Sand dollars are found offshore of sandy beaches. A radical, flattened form of a sea urchin, this echinoderm is commonly found off beaches in the southeastern US.

Hermit crabs find snail and other gastropod shells and use them as portable protection. As the crab grows, it must find a new shell; in some places shells of the proper size may limit the hermit crab population.

The **smooth bay shrimp** is found in shallow waters with sandy bottoms. P**orpoises** of various species are common sights off sandy shores, rocky shores, mangrove swamps, and of course in the open ocean. Some species hunt cooperatively and will drive a school of their prey into the shallow waters of a beach to facilitate catching them

Marshes are sandy shores where the sand and sediments have been stabilized by grasses. Ecologically, marshes are very similar to mangrove swamps and tend to occur in places where it is too cold for mangroves to grow.

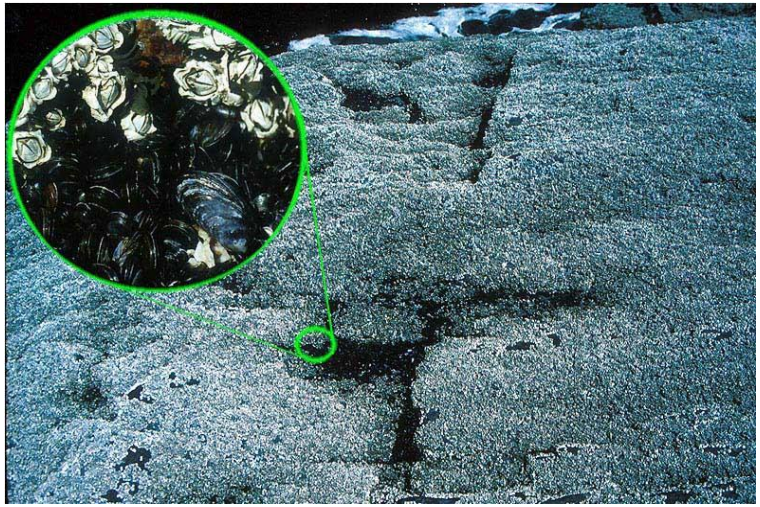
Shore Environment

Rocky Shores

Rocky Shores

- Many plants and animals compete for space at the rocky shores.
- A closer look at the rocks in the intertidal zone (the area between low and high tides) gives a glimpse into the intense competition for space that occurs on any hard substrate.

The bulk of the rock surface is coated by a layer of grayish **barnacles** (*Balanus* sp.), which are able to compete more effectively in that area.
A close examination of the crevices in the rocks, however, reveals that the **black mussels**, attached to the rock with **byssal** threads, are able to outcompete the barnacles.



Barnacles start out as small microscopic planktonic animals themselves. They settle onto a substrate, glue themselves down, and set up housekeeping. The large barnacle in the center is surrounded by a number of smaller barnacles, some of which are growing on the large barnacle's shell.

The picture below shows western barnacles with their legs extended. Barnacles in the intertidal zone may only be exposed for an hour or so a day and must do all their feeding in that short time.

Goose barnacles attach themselves to the substrate via a flexible structure that gives under the impact of strong waves.

- Seaweeds are multicellular algae that often grow attached to rocks along a coastline.
- They are from several different divisions of the algae. The rockweed is from the **brown algae** (Phaeophyta), the **red algae** (Rhodophyta) is *Chondrus crispus* (**Irish Moss**) and the *Codium* sp. (**Green Fleece Algae**) is a type of Chlorophyta (**Green Algae**).
- Among the differences between these groups are the types of chlorophyll and accessory pigments used.

Laminaria digitata is a type of **kelp** found on the eastern coast of the United States.
Western species of kelp are up to 40m

More rockweed (above) and *Ulva* sp., commonly called **Sea Lettuce**, a green algae (right)

Puffin *Fratercula arctica*.

A mixed flock of **Razorbills**
as well as **thin-billed** (*Uria aalge*)
and **thick-billed** (*Uria lomvia*) **murres**

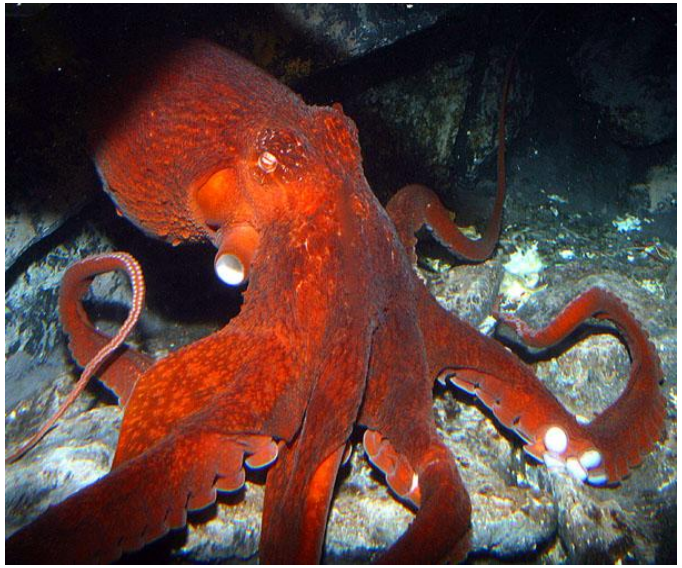
Anenomes can be found in the deeper waters, but some anenomes are found on rocks exposed at low tides.
An example of this is the **Giant Green Anemone** (*Anthopleura xanthogrammica)*, on the right.

Anemones in deeper waters

The **Frosted Nudibranch** (*Dirona albolineata*) is a gastropod which lives on the northwestern coast of the US.
It feeds on a variety of invertebrates including snails and anemones.
It can be found on the rocks below the low tide zone.

The **Purple Sea Star** (*Pisaster ochraeus*) ranges in color from purple to orange. An important predator, it is usually found on the rocks where it feeds on a variety of invertebrates, particularly mussels. Robert Paine, in landmark studies, determined that the Purple Sea Star is a keystone predator. He found that the sea stars tend to focus their predatory attentions on the most dominant competitors and thus opening up the ecosystem to other competitors which would otherwise be crowded out. In other words, presence of the sea star actually increases diversity at the next lower trophic level.

Another Echinoderm from the Pacific Northwest is the Purple Sea Urchin, which feeds on algae.



Octopii are important predators among the rocky inlets of the Pacific northwest.
The most highly developed of the molluscs (arguably of all the invertebrates) cephalopods like octopuses and squid are highly intelligent and alone among the invertebrates have eyes similar to those of the vertebrates.
Octopii are highly intelligent.

- http://www.arkive.org/species/ARK/invertebrates_marine/Eledone_cirrhosa/more_moving_images.html
- http://www.unoriginal.co.uk/footage33_2.html

The **Harbor Seals** and the **Sea Lion**: they feed on fish and invertebrates.

Environmental Considerations

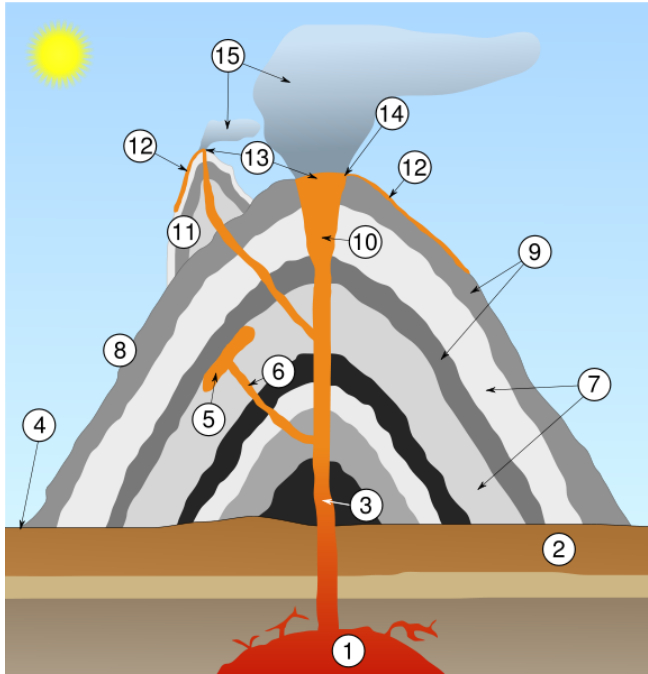
- A large and increasing percentage of the human population lives near the coast, and this puts a lot of pressure on the shore ecosystems.
- Mangrove swamps were destroyed in Louisiana (for oil and gas exploration) and in Indonesia (for shrimp farms and other aquaculture)
- The human shoreline inhabitants thus bore the brunt of Hurricane Katrina and the Indonesian tsunami.
- Boats leak (*Exxon Valdez*!).
- Fishing gear gets lost.
- Construction, agriculture and forest clearing bring pollution and sediment to the coasts through our rivers.

Volcanoes

Volcanoes

http://en.wikipedia.org

- A **volcano** is an opening, or rupture, in a planet's surface or crust, which allows hot, molten rock, ash,– and gases to escape from deep below the surface. Volcanic activity involving the extrusion of rock tends to form mountains or features like mountains over a period of time.
- Volcanoes are generally found where tectonic plates pull apart or are coming together.
- A mid-oceanic ridge, like the Mid-Atlantic Ridge, has examples of volcanoes caused by "divergent tectonic plates" pulling apart.
- The Pacific Ring of Fire has examples of volcanoes caused by "convergent tectonic plates" coming together.



Volcanoes

- Volcanoes can also form where there is stretching of the Earth's crust and where the crust grows thin (called "non-hotspot intraplate volcanism"), such as in the African Rift Valley.
- Volcanoes can be caused by “mantle plumes", so-called “hotspots"; these hotspots can occur far from plate boundaries, such as the Hawaiian Islands.

- **Mount Etna** is an active volcano on the east coast of Sicily, close to Messina and Catania.
- It is the largest active volcano in Europe, currently standing about 3,326 m (10,910 ft) high, though it should be noted that this varies with summit eruptions.
- The mountain is 21.6 m (71 ft) lower now than it was in 1865.
- It is the highest mountain in Italy south of the Alps. Etna covers an area of 1,190 km^2 (460 square miles) with a basal circumference of 140 km.
- This makes it by far the largest of the three active volcanoes in Italy, being nearly three times the height of the next largest, Mount Versuvius.

- Mount Etna is one of the most active volcanoes in the world and is in an almost constant state of eruption. Although it can occasionally be very destructive, it is not generally regarded as being particularly dangerous and thousands of people live on its slopes and in the surrounding areas. The fertile volcanic soils support extensive agriculture, with vineyards and orchards spread across the lower slopes of the mountain and the broad Plain of Catania to the south.

A crater near the Torre del Filosofo, about 450 metres below Etna's summit.

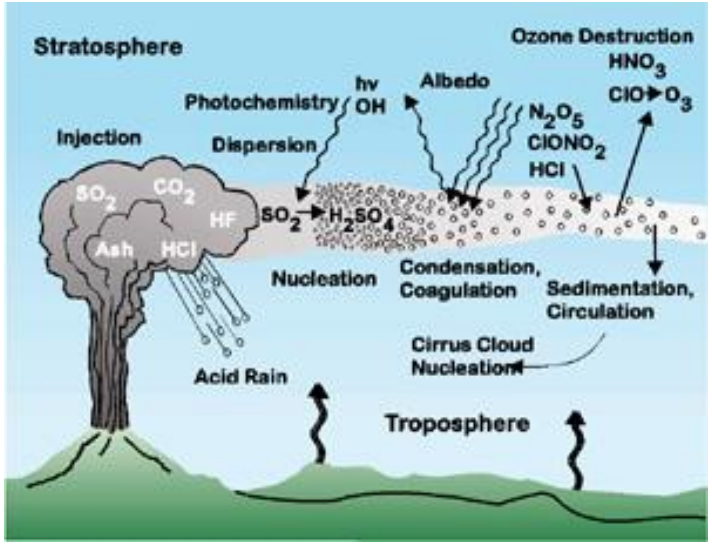
Effects of Volcanic Activity

- There are many different kinds of volcanic activity and eruptions: phreatic eruptions (steam-generated eruptions), explosive eruption of high-silica lava (e.g., rhyolite), effusive eruption of low-silica lava (e.g., basalt), pyroclastic flows, lahars (debris flow) and carbon dioxide emission.
- All of these activities can pose a hazard to humans. Earthquakes, hot springs, fumaroles, mud pots and geysers often accompany volcanic activity.
- The concentrations of different volcanic gases can vary considerably from one volcano to the next.

Effects of Volcanic Activity

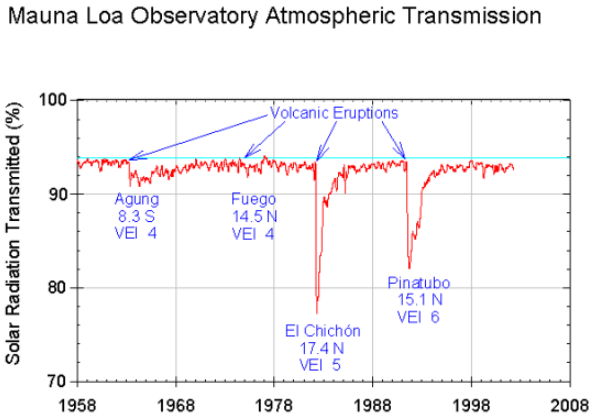
- Water vapor is typically the most abundant volcanic gas, followed by carbon dioxide and sulfur dioxide.
- Other principal volcanic gases include hydrogen sulfide, hydrogen chloride, and hydrogen fluoride.
- A large number of minor and trace gases are also found in volcanic emissions, for example hydrogen, carbon monoxide, halocarbons, organic compounds, and volatile metal chlorides.

Volcanic "injection"

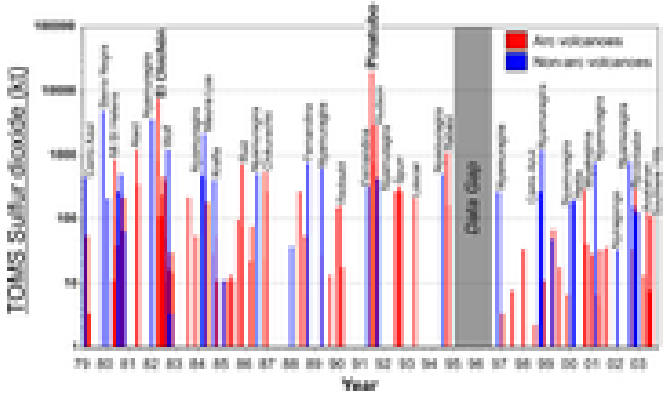


- Large, explosive volcanic eruptions inject water vapor (H_2O), carbon dioxide (CO_2), sulfur dioxide (SO_2), hydrogen chloride (HCl), hydrogen fluoride (HF) and ash (pulverized rock and pumice) into the stratosphere to heights of 10-20 miles above the Earth's surface.
- The most significant impacts from these injections come from the conversion of sulfur dioxide to sulfuric acid (H_2SO_4), which condenses rapidly in the stratosphere to form fine sulfate aerosols.
- The aerosols increase the Earth's albedo—its reflection of radiation from the Sun back into space - and thus cool the Earth's lower atmosphere or troposphere; however, they also absorb heat radiated up from the Earth, thereby warming the stratosphere.

Solar radiation reduction from volcanic eruptions



- The sulfate aerosols also promote complex chemical reactions on their surfaces that alter chlorine and nitrogen chemical species in the stratosphere.
- This effect, together with increased stratospheric chlorine levels from chloroflurocarbon pollution, generates chlorine monoxide (ClO), which destroys ozone (O3).
- As the aerosols grow and coagulate, they settle down into the upper troposphere where they serve as nuclei for cirrus clouds and further modify the Earth's radiation balance.
- Most of the hydrogen chloride (HCl) and hydrogen fluoride (HF) are dissolved in water droplets in the eruption cloud and quickly fall to the ground as acid rain.
- Explosive volcanic eruptions release the greenhouse gas carbon dioxide and thus provide a deep source of carbon for biogeochemical cycles.



Sulfur dioxide emissions by volcanoes.

http://hvo.wr.usgs.gov/gallery/kilauea/volcanomovies/movies/MLK%20fountain%20-%20Feb%209-10,%202005-small.mov

Lava Composition

If the erupted magma contains a high percentage (>63%) of silica, the lava is called felsic.

- Felsic lavas (or rhyolites) tend to be highly viscous and are erupted as domes or short, stubby flows.
- Viscous lavas tend to form stratovolcanoes or lava domes.
- Because siliceous magmas are so viscous, they tend to trap volatiles (gases) that are present, which cause the magma to erupt catastrophically, eventually forming stratovolcanoes.
- Pyroclastic flows (ignimbrites) are highly hazardous products of such volcanoes, since they are composed of molten volcanic ash too heavy to go up into the atmosphere, so they hug the volcano's slopes and travel far from their vents during large eruptions.
- Temperatures as high as 1,200 ° C are known to occur in pyroclastic flows, which will incinerate everything flammable in their path and thick layers of hot pyroclastic flow deposits can be laid down, often up to many meters thick.

Lava Composition

If the erupted magma contains 52-63% silica, the lava is of *intermediate* composition.

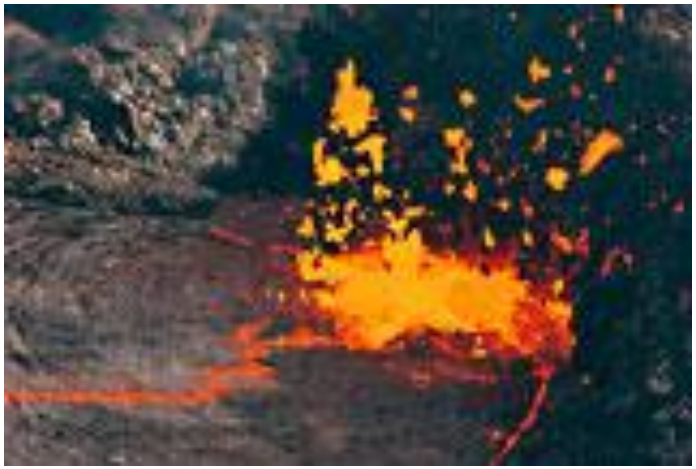
- These “andesitic" volcanoes generally only occur above subduction zones (e.g. Mount Merapi in Indonesia).
- If the erupted magma contains <52% and >45% silica, the lava is called mafic (because it contains higher percentages of magnesium (Mg) and iron (Fe)) or basaltic.
- These lavas are usually much less viscous than rhyolitic lavas, depending on their eruption temperature; they also tend to be hotter than felsic lavas.

Coast covered with hardened lava with a storm approaching. Hawaii Volcanoes National Park

Lava Composition

Some erupted magmas contain <=45% silica and produce lava called ultramafic.

- Ultramafic flows, also known as komatiites, are very rare;
- Indeed, very few have been erupted at the Earth's surface since the Proterozoic, when the planet's heat flow was higher. They are (or were) the hottest lavas, and probably more fluid than common mafic lavas.



Rainforests

Rainforests

http://www.nature.org/rainforests/

The rainforest is the most complex and diverse ecosystem on earth.

Fact: Covering less than 2 percent of the Earth's total surface area, the world's rainforests are home to 50 percent of the Earth's plants and animals.

- **Fact:** Rainforests can be found all over the world from as far north as Alaska and Canada to Latin America, Asia and Africa.
- **Fact:** Rainforests are found on every continent across the Earth, except Antarctica.
- **Fact:** There are two major types of rainforest: *temperate rainforests* and *tropical rainforests.*
- **Fact:** The largest temperate rainforests are found on North America's Pacific Coast and stretch from Northern California up into Canada.
- **Fact:** Temperate rainforests used to exist on almost every continent in the world, but today only 50 percent – 75 million acres – of these forests remain worldwide.

Facts about the Rainforest as Part of Our Global Environment and Well-being

- **Fact:** Rainforests act as the world's thermostat by regulating temperatures and weather patterns.
- **Fact:** One-fifth of the world’s fresh water is found in the Amazon Basin.
- **Fact:** Rainforests are critical in maintaining the Earth's limited supply of drinking and fresh water.

The forest of East Kalimantan, Indonesia

Facts about the Abundant Life and Important Resources that Rainforests Share with Us

- **Fact:** A typical four square mile patch of rainforest contains as many as 1,500 flowering plants, 750 species of trees, 400 species of birds and 150 species of butterflies.
- **Fact:** Rainforests provide many important products for people: timber, coffee, cocoa and many medicinal products, including those used in the treatment of cancer.
- **Fact:** Seventy percent of the plants identified by the U.S. National Cancer Institute as useful in the treatment of cancer are found only in rainforests.
- **Fact:** More than 2,000 tropical forest plants have been identified by scientists as having anti-cancer properties.
- **Fact:** Less than one percent of the tropical rainforest species have been analyzed for their medicinal value.

Facts about the Threats to Rainforests, Indigenous People and Species

- **Fact:** Rainforests are threatened by unsustainable agricultural, ranching, mining and logging practices.
- **Fact:** Before 1500 A.D., there were approximately 6 million indigenous people living in the Brazilian Amazon. But as the forests disappeared, so too did the people. In the early 1900s, there were less than 250,000 indigenous people living in the Amazon.
- **Fact:** Originally, 6 million square miles of tropical rainforest existed worldwide. But as a result of deforestation, only 2.6 million square miles remain.
- **Fact:** At the current rate of tropical forest loss, 5-10 percent of tropical rainforest species will be lost per decade.
- **Fact:** Nearly 90 percent of the 1.2 billion people living in extreme poverty worldwide depend on forests for their livelihoods.
- **Fact:** Fifty-seven percent of the world's forests, including most tropical forests, are located in developing countries.

Threats to the World's Rainforests

- Rainforests are among the most important and yet **threatened ecosystems** on the planet.
- Today, more than half of Earth's original rainforests have all been destroyed, victims of unsustainable agriculture, ranching, logging, mining and other destructive practices. These stresses have increased enormously in the last 50 years alone.
- Every year, 50 million acres — an area the size of England, Wales and Scotland combined — are cut down. Primary rainforests in India, Bangladesh, Sri Lanka and Haiti have been lost entirely, with the Ivory Coast fast approaching the same fate.
- Every second of every day, a slice of rainforest the size of a football field is mowed down. That’s 86,400 football fields of rainforest per day, or over 31 million football fields of rainforest lost each year.

Threats to Rainforests

- **Threat:** Less than seven percent remains of Brazil's Atlantic Forest which once covered 330 million acres. Expanding urban areas, increased agricultural and industrial development threaten this rich, fragile forest and in so doing threaten the well-being of the surrounding communities that rely on the forest for their economic prosperity and livelihoods.
- **Threat:** Along the green, rolling hills of Chile's Valdivian Coastal Range, highway construction, overharvesting native trees for firewood and unsustainable logging threaten to tear this unique forest apart. With the loss of the forest — the former home of the indigenous Mapuche people — Chile will lose an important part of its cultural heritage.
- **Threat:** Deep within the mist-shrouded trees and sparkling waters of Indonesia's East Kalimantan forests, unsustainable and illegal logging destroy the precious forest ecosystem and disrupt the lives of the surrounding local people.
- **Threat:** In South America's Amazon Rainforest, ranchers are turning forests into pastures and roads are slicing through dense tropical trees. This deforestation destroys the tremendous biological diversity just waiting to be discovered as well as the valuable resources we rely on from the Amazon like important medicines that treat cancer patients.

The Amazon Rainforest

- The Amazon Rainforest covers over a billion acres, encompassing areas in Brazil, Venezuela, Colombia and the Eastern Andean region of Ecuador and Peru. If Amazonia were a country, it would be the ninth largest in the world.
- The Amazon Rainforest has been described as the "Lungs of our Planet" because it provides the essential environmental world service of continuously recycling carbon dioxide into oxygen. More than 20 percent of the world oxygen is produced in the Amazon Rainforest.
- More than half of the world's estimated 10 million species of plants, animals and insects live in the tropical rainforests. One-fifth of the world's fresh water is in the Amazon Basin.
- One hectare (2.47 acres) may contain over 750 types of trees and 1500 species of higher plants.
- At least 80% of the developed world's diet originated in the tropical rainforest. Its bountiful gifts to the world include fruits like avocados, coconuts, figs, oranges, lemons, grapefruit, bananas, guavas, pineapples, mangos and tomatoes; vegetables including corn, potatoes, rice, winter squash and yams; spices like black pepper, cayenne, chocolate, cinnamon, cloves, ginger, sugar cane, tumeric, coffee and vanilla and nuts including Brazil nuts and cashews.

- At least 3000 fruits are found in the rainforests; of these only 200 are now in use in the Western World. The Indians of the rainforest use over 2,000.
- Rainforest plants are rich in secondary metabolites, particularly alkaloids. Biochemists believe alkaloids protect plants from disease and insect attacks. Many alkaloids from higher plants have proven to be of medicinal value and benefit.
- Currently, 121 prescription drugs currently sold worldwide come from plant-derived sources. And while 25% of Western pharmaceuticals are derived from rainforest ingredients, less than 1% of these tropical trees and plants have been tested by scientists.
- The U.S. National Cancer Institute has identified 3000 plants that are active against cancer cells. 70% of these plants are found in the rainforest. Twenty-five percent of the active ingredients in today's cancer-fighting drugs come from organisms found only in the rainforest.
- Vincristine, extracted from the rainforest plant, periwinkle, is one of the world's most powerful anticancer drugs. It has dramatically increased the survival rate for acute childhood leukemia since its discovery.
- In 1983, there were no U.S. pharmaceutical manufacturers involved in research programs to discover new drugs or cures from plants. Today, over 100 pharmaceutical companies and several branches of the US government, including giants like Merck and The National Cancer Institute, are engaged in plant research projects for possible drugs and cures for viruses, infections, cancer, and even AIDS.

- Experts agree that by leaving the rainforests intact and harvesting it's many nuts, fruits, oil-producing plants, and medicinal plants, the rainforest has more economic value than if they were cut down to make grazing land for cattle or for timber.
- The latest statistics show that rainforest land converted to cattle operations yields the land owner $60 per acre and if timber is harvested, the land is worth $400 per acre. However, if these renewable and sustainable resources are harvested, the land will yield the land owner $2,400 per acre.
- If managed properly, the rainforest can provide the world's need for these natural resources on a perpetual basis.
- Promoting the use of these sustainable and renewable sources could stop the destruction of the rainforests. By creating a new source of income harvesting the medicinal plants, fruits nuts, oil and other sustainable resources, the rainforests is be more valuable alive than cut and burned.
- Sufficient demand of sustainable and ecologically harvested rainforest products is necessary for preservation efforts to succeed. Purchasing sustainable rainforest products can effect positive change by creating a market for these products while supporting the native people's economy and provides the economic solution and alternative to cutting the forest just for the value of its timber.

The Biodiversity of the Rainforest

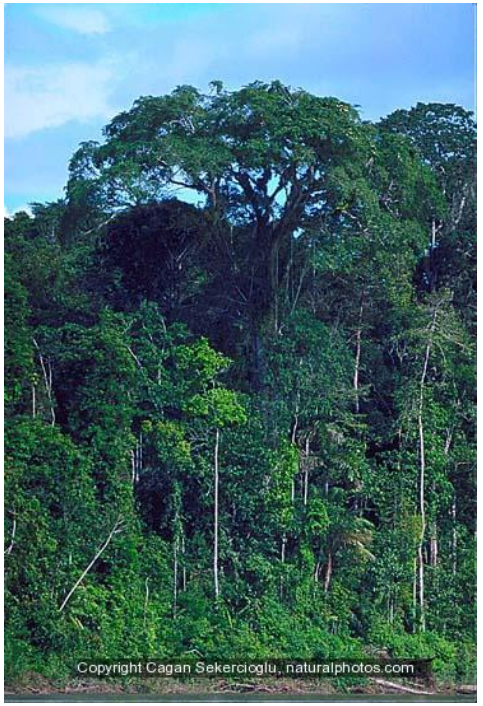
- The loss of tropical rainforests has a profound and devastating impact on the world because rainforests are so biologically diverse, more so than other ecosystems (e.g., temperate forests) on Earth.
- A single pond in Brazil can sustain a greater variety of fish than is found in all of Europe's rivers.
- 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 harbor 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.

Tufted-ear marmoset

The Amazons

Harvard's Pulitzer Prize-winning biologist Edward O. Wilson

"The worst thing that can happen during the 1980s is not energy depletion, economic collapses, limited nuclear war, or conquest by a totalitarian government. As terrible as these catastrophes would be for us, they can be repaired within a few generations. The one process ongoing in the 1980s that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly that our descendants are least likely to forgive us for."



The Driving Forces of Destruction

- Logging for Tropical Hardwoods
- Fuel Wood and the Paper Industry
- Grazing Land
- Subsistence Farming
- Infrastructure building

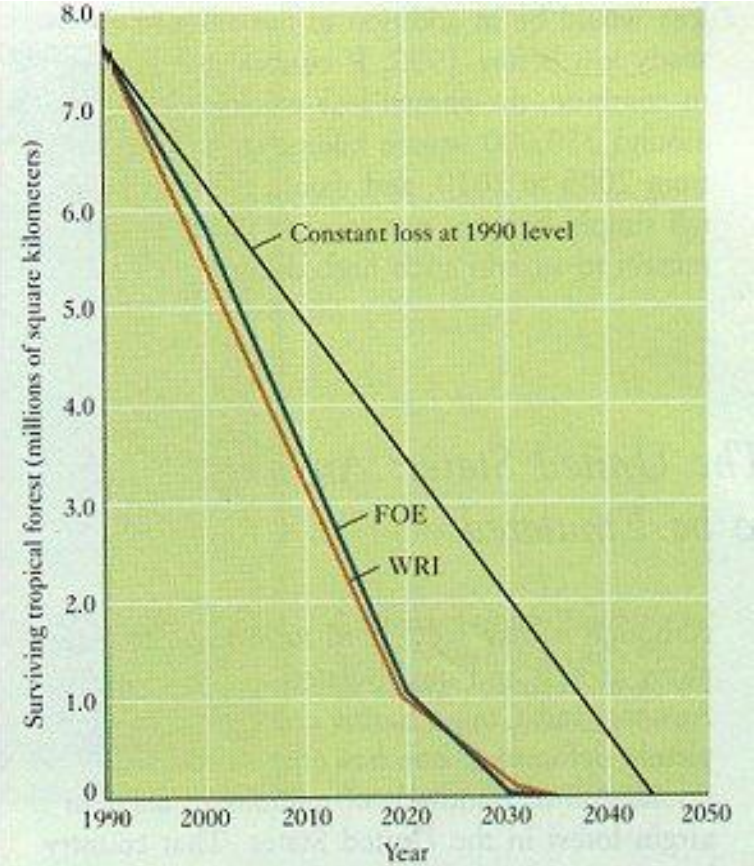
Deforestation

Deforestation

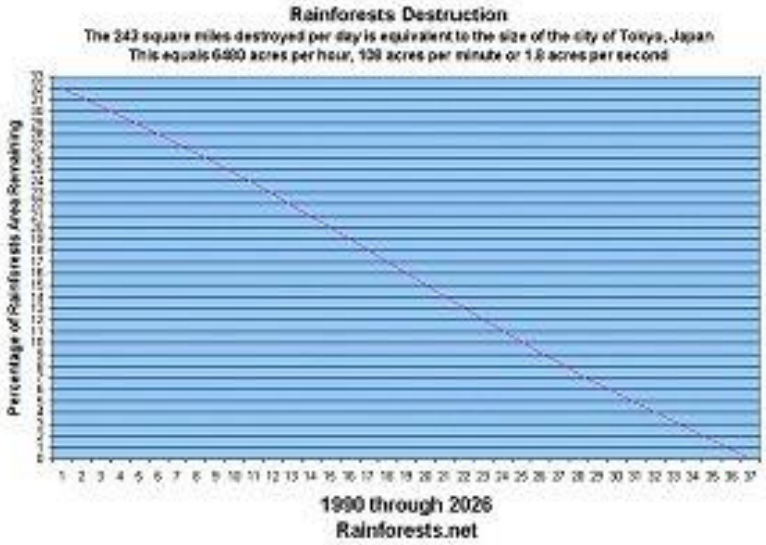
Oil company illegally clearing rainforest in Ecuador, South America

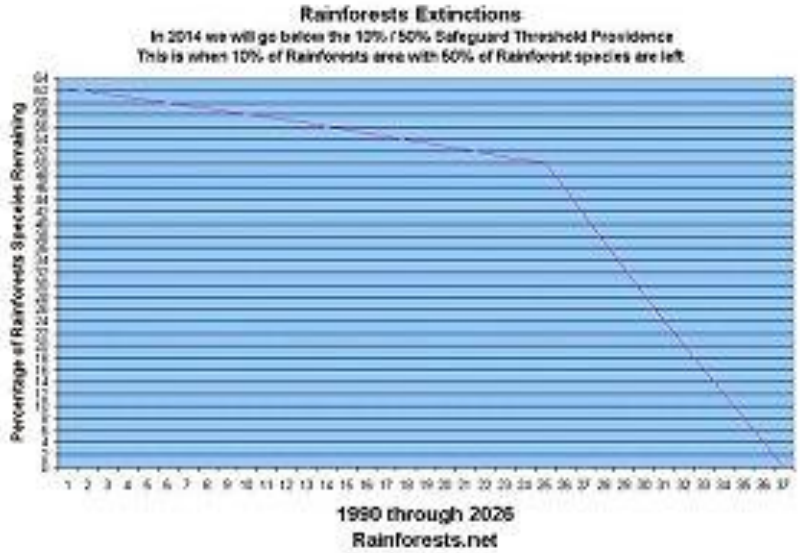
Between May 2000 and August 2006, Brazil lost nearly 150,000 square kilometers of forest—an area larger than Greece—and since 1970, over 600,000 square kilometers (232,000 square miles) of Amazon rainforest have been destroyed.

Deforestation



The richest environment on earth will not survive even 50 years unless drastic measures are instituted to curtail deforestation. The straight line projects the global decline in humid tropical forest if we assume no change after 1990 in the amount of forest cleared annually; the other two lines represent projections based on data from Friends of the Earth and the World Resources Institute.


Rainforests Destruction
The 243 square miles destroyed per day is equivalent to the size of the city of Tokyo, Japan
This equals 6480 acres per hour, 108 acres per minute or 1.8 acres per second
Percentage of Rainforests Area Remaining
1990 through 2026
Rainforests.net


Rainforests Extinctions
In 2014 we will go below the 10% / 50% Safeguard Threshold Providence
This is when 10% of Rainforests area with 50% of Rainforest species are left
Percentage of Rainforests Species Remaining
1990 through 2026
Rainforests.net

Burning of Forests

Deforestation

- Poor farmers use fire for clearing land and every year satellite images pick up tens of thousands of fire burning across the Amazon.
- Typically understory shrubbery is cleared and then forest trees are cut.
- The area is left to dry for a few months and then burned.
- The land is planted with crops like bananas, palms, manioc, maize, or rice.
- After a year or two, the productivity of the soil declines, and the transient farmers press a little deeper and clear new forest for more short-term agricultural land.
- The old, now infertile fields are used for small-scale cattle grazing or left for waste.

Rainforest cleared for maize

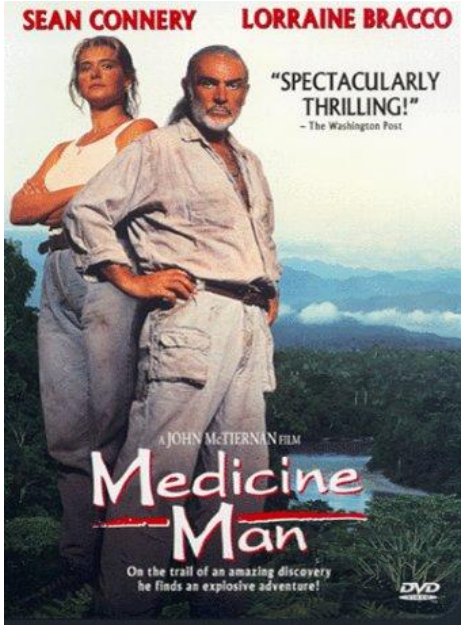
Plane view of deforestation in the Amazon

Indigenous People - A Valuable Resource

- Scientists have developed new technologies to assess the chemical makeup of plants, and they realize that using medicinal plants identified by Indians makes research more efficient and less expensive.
- With these new trends, drug development has actually returned to its roots: traditional medicine.
- It is now understood by bioprospectors that the tribal peoples of the rainforest represent the key to finding new and useful tropical forest plants.
- The degree to which these indigenous people understand and are able to use this diversity sustainably is astounding. A single Amazonian tribe of Indians may use more than 200 species of plants for medicinal purposes alone.

The Medicine Man?

- Dr. Robert Mendelsohn, an economist at Yale University, and Dr. Michael J. Balick, director of the Institute of Economic Botany at the New York Botanical Gardens, estimate the minimum number of pharmaceutical drugs potentially remaining to be extracted from the rainforests.
- They estimate that there are at least 328 new drugs that still await discovery in the rainforest, with a potential value of $3 billion to $4 billion to a private pharmaceutical company and as much as $147 billion to society as a whole.



Desertification

Desertification

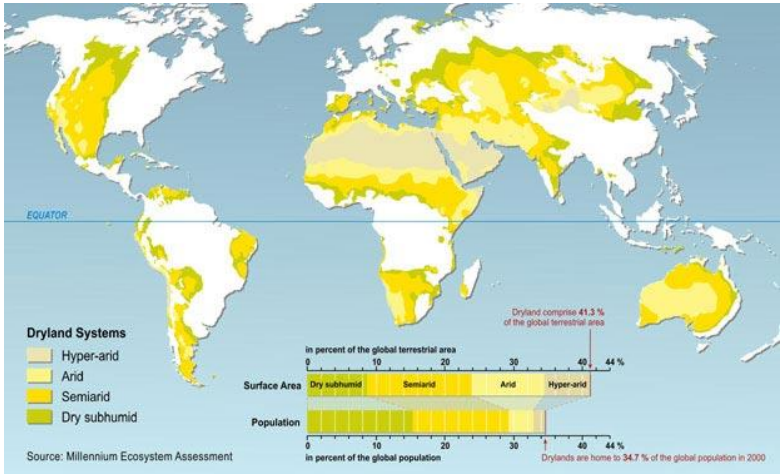
http://www.greenfacts.org/en/desertification/

- Desertification is the persistent degradation of dryland ecosystems (arid, semi-arid and dry sub-humid areas) by variations in climate and human activities.
- Home to a third of the human population in 2000, drylands occupy nearly half of Earth's land area.
- Across the world, desertification affects the livelihoods of millions of people who rely on the benefits that dryland ecosystems can provide.
- In drylands, water scarcity limits the production of crops, forage, wood, and other services, ecosystems provide to humans.
- Drylands are therefore highly vulnerable to increases in human pressures and climatic variability, especially sub-Saharan and Central Asian drylands.
- Some 10 to 20% of drylands are already degraded, and ongoing desertification threatens the world's poorest populations and the prospects of poverty reduction. Therefore, desertification is one of the greatest environmental challenges today and a major barrier to meeting basic human needs in drylands.
- Current desertification is taking place much faster worldwide than historically and usually arises from the demands of increased populations that settle on the land in order to grow crops and graze animals.

Desertification

- In drylands, more people depend on ecosystem services for their basic needs than in any other ecosystem. Indeed, many of their resources, such as crops, livestock, fuelwood, and construction materials, depend on the growth of plants, which in turn depends on water availability and climate conditions.
- Fluctuations in the services supplied by ecosystems are normal, especially in drylands, where water supply is irregular and scarce.
- However, when a dryland ecosystem is no longer capable to recover from previous pressures, a downward spiral of desertification may follow, though it is not inevitable.

Present-day Drylands



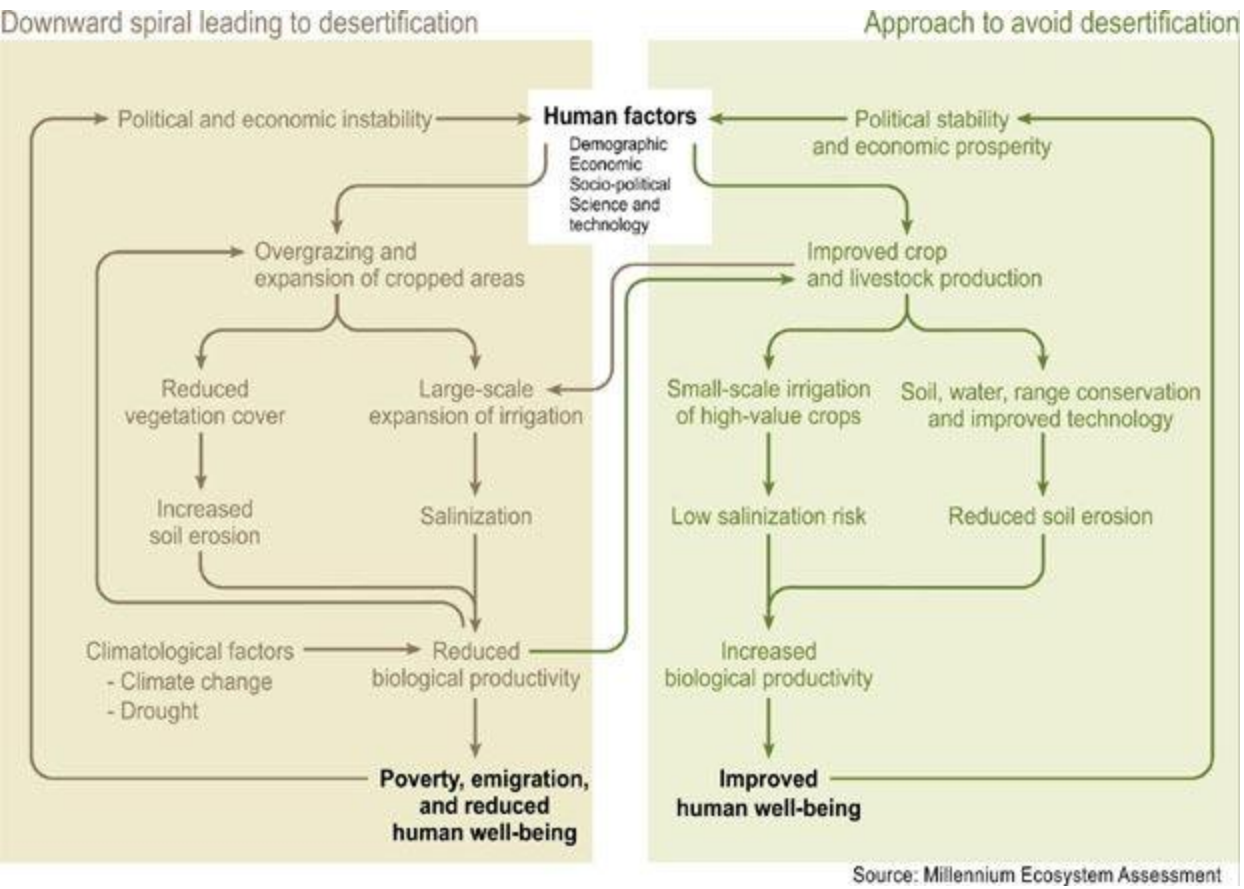
Impact of Desertification

- A major impact of desertification is biodiversity loss and loss of productive capacity, for example, by transition from grassland dominated by perennial grasses to one dominated by perennial shrubs.
- Desertification has environmental impacts that go beyond the areas directly affected. For instance, loss of vegetation can increase the formation of large dust clouds that can cause health problems in more densely populated areas, thousands of kilometers away.
- Moreover, the social and political impacts of desertification also reach non-dryland areas. For example, human migrations from drylands to cities and other countries can harm political and economic stability.

1 Number of children less than one year old dying in a year, per 1000 live births during that year

Source: Millennium Ecosystem Assessment

- A large majority of dryland populations live in developing countries. Compared to the rest of the world, these populations lag far behind in terms of human well-being, per capita income, and infant mortality.
- The situation is worst in the drylands of Asia and Africa.
- Dryland populations are often marginalized and unable to play a role in decision making processes that affect their well-being, making them even more vulnerable.



- This is a schematic graphic showing how drylands can be developed in response to changes in key human factors. The left side of the figure shows developments that lead to a downward spiral of desertification. The right side shows developments that can help avoid or reduce desertification. In the latter case, land users respond to stresses by improving their agricultural practices on currently used land. This leads to increased livestock and crop productivity, improved human well-being, and political and economic stability.

Source: MA _Desertification Synthesis Report (2005), p.4

Causes of Desertification

- Deserts may be separated from surrounding, less arid areas by mountains and other contrasting landforms that reflect basic structural differences in the terrain.
- In other areas, desert fringes form a gradual transition from a dry to a more humid environment, making it more difficult to determine the desert border.
- These transition zones have very fragile, delicately balanced ecosystems.
- In these marginal areas human activity may stress the ecosystem beyond its tolerance limit, resulting in degradation of the land.
- By pounding the soil with their hooves, livestock compact the substrate, increase the proportion of fine material, and reduce the percolation rate of the soil, thus encouraging erosion by wind and water.
- Grazing and collection of firewood reduce or eliminate plants that help to bind the soil.

Sand Storms

Sand Storms

- In large desert areas, sand dunes can encroach on human habitats. Sand dunes move through a few different means, all of them helped by wind.
- One way that dunes can move is through saltation, where sand particles skip along the ground like a rock thrown across a pond might skip across the water's surface.
- When these skipping particles land, they may knock into other particles and cause them to skip as well.
- With slightly stronger winds, particles collide in mid-air, causing sheet flows. In a major dust storm, dunes may move tens of meters through such sheet flows.
- Like snow, sand avalanches, falling down the steep slopes of the dunes that face away from the winds, also moving the dunes forward.

Linear dunes of the Sahara Desert encroach on Nouakchott,
the capital of Mauritania.
The dunes border a mosque at left
(photograph by Georg Gerster).

Land Desertification in China

- China is a developing country with a large population and scarce arable land, which feeds 22 percent of the world's population on seven percent of the world's tillable land.
- China is one of the countries most severely impacted by desertification which encompasses over 30 percent of the total land territory (approximately 3 327 million km^2) and adversely affects 400 million people.
- China’s deserts, already occupying 28% of the country, are growing at a rate of 10,400 km^2 a year.
- The Gobi desert grew by 52,000 km^2 between 1994 and 1999.
- The annual cost of desertification is estimated to be between 16-25 billion RMB.

- Land desertification occurs mainly in the arid, semi-arid and dry sub-humid areas in the western part of northeast China, the north part of northern China and most parts of northwest China.
- Desertification caused by wind erosion totals 1 533 million km^2 and is distributed in barren and dry grasslands east of the Helan Mountains and Wushiaoling Ridges.
- It is most serious in the transitional and marginal agriculture and animal husbandry zones of 11 provinces and autonomous regions: Xinjiang, Inner Mongolia, Gansu, Qinghai, Ningxia, Shaanxi, Shanxi, Liaoning, Jilin, Heilongjiang and Hebei.
- Land desertification caused by water erosion totals 1 794 million km^2 and is concentrated on the Loess Plateau (which is the most severely eroded area in China and even the world) and middle and upper reaches of the Yangtze River.

- Physical, chemical and biological processes of soil degradation and related economic activities are responsible for desertification near oases or other sandy areas with poor drainage.
- This is most pronounced in arid regions of the northwest and areas surrounding irrigated oases in Xinjiang and Inner Mongolia.

- Climate change, human activities and other factors are accelerating the desertification process along this vast 5 000 km-long arid stretch in northern China. The annual expansion of land desertification increased from 1 600 km^2 in the 1970s to 2 100 km^2 during the 1980s.
- On the Loess Plateau the average erosion model records between 5 000 to 8 000 $t/km^2/yr$ with 20 000 $t/km^2/yr$ as maximum.
- The annual quantity of silt flowing into the Yellow River now totals 1.6 billion tons (t) which raises the river bed in the lower reaches by ten centimeters (cm) each year.
- Desertification threatens two million hectare (ha) of farmland and 4.93 million ha of pasture land.
- Estimated direct economic losses from low and unstable productivity in agriculture, forestry and animal husbandry total 4.5 billion RMB yuan. China's most underdeveloped counties are located in desertified areas.

- The major causes of land desertification in China are climate change and human economic activities.
- Climate variation and desertification are contributing factors to the phenomena of global climate change.
- Since the 1970s China's semi-arid and dry sub-humid zones simultaneously experienced increases in temperature and decreases in precipitation.
- Given current industrial energy usage, China is projected to lose 959 000 km^2 in the humid areas and gain 843 000 km^2 in arid and semi-arid areas by 2030.
- Human activities are a direct cause of land desertification in modern times. Rapid population increases have led to over utilization of land resources. These include intensification of agriculture and animal husbandry, agricultural reclamation on pasture land, deforestation, overgrazing, destruction of vegetation, misuse of water resources and the lack of environmental protection and scientific management in traffic, mining, energy development, tourism and city building.

The Loess Plateau
黄土高原

- The **Loess Plateau** also known as the Huangtu Plateau 黄土高原, is a plateau that covers an area of some 640,000 km^2 in the upper and middle parts of China's Yellow River.
- Loess is the name for the silty soil that has been deposited by wind storms on the plateau over the ages. Loess is a highly erosion-prone soil that is susceptible to the forces of wind and water.
- The Loess Plateau and its dusty soil cover almost all of Shanxi, Shaanxi, and Gansu provinces, the Ningxia Hui Autonomous Region, and parts of others.
- The Loess Plateau provides simple yet insulated shelter from the cold winter and hot summer in the region, as homes called *yaodong* 窑洞 were often carved into the loess soil.

http://en.wikipedia.org/wiki/Loess_Plateau

- The Loess Plateau was highly fertile and easy to farm in ancient times, which contributed to the development of early Chinese civilization around the Loess Plateau.
- Hundreds of years of deforestration and over-grazing, exacerbated by China's population increase, have resulted in degenerated ecosystems, desertification, and poor local economies.
- In 1994 a project known as the Loess Plateau Rehabilitation Project was launched to help try and reverse this desertification and this goal has been achieved for a sizeable area of the Loess Plateau, where now trees and grass have turned green, lambs are bleating and farmers are busy in their croplands.
- A major focus of the Project was to try and guide the people living in the Plateau to use more sustainable ways of living such as keeping goats in pens not being allowed to roam free and erode the soft silty soil found in the plateau.
- Many trees were planted and nature has now vastly taken over the expanse in which the project is taking place.

The Disappearing Great Wall of China

- Western sections of the Great Wall of China are being reduced to "mounds of dirt" by sandstorms and may disappear entirely in 20 years, according to a Xinhua News Agency Report in 2007.
- The reasons for the deterioration are entirely manmade, due to destructive farming methods in the 1950s that desertified areas of northern China, causing sandstorms.
- One of the most threatened sections of the wall runs through Minqin county in Gansu province along the ancient Silk Road trade route. Unlike the better-known stone and brick sections around Beijing, the wall in Gansu is made of less-resilient packed earth that easily erodes.
- Lookout towers have vanished and the wall's height has been worn down from 16 feet to less than 7 feet.
- Minqin conservationists hoped to protect the remaining sections in their county from wind and sandstorms by covering them with dirt. Eventually, they hope to replant enough vegetation to prevent future sandstorms

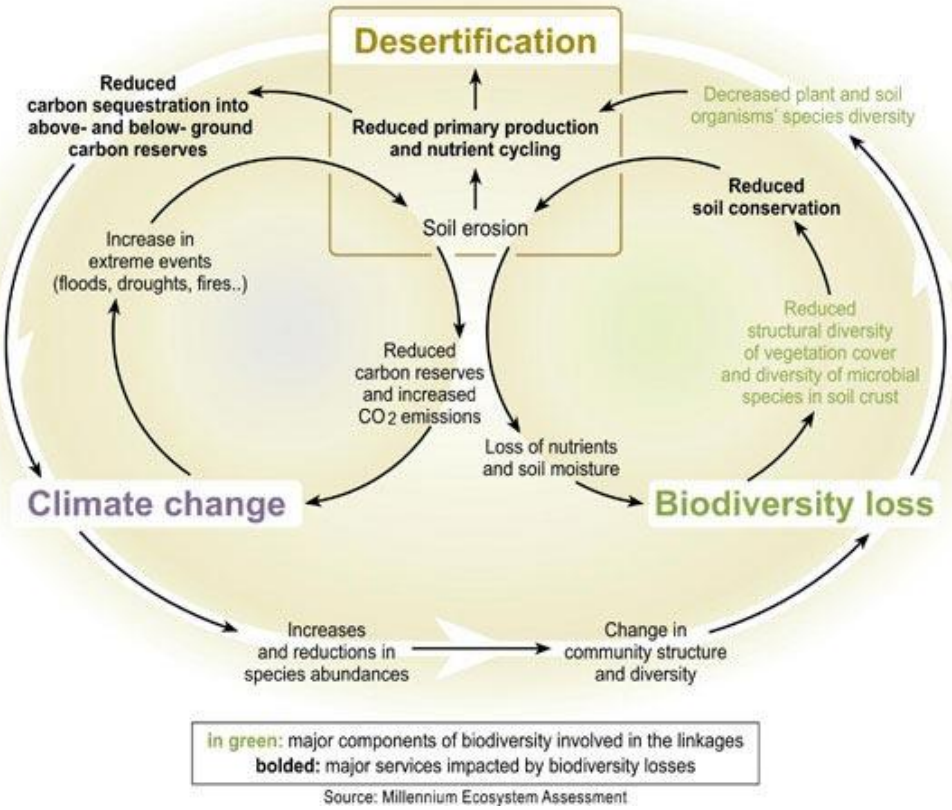
The Disappearing Capital?

- The Chinese capital has been battered by several sandstorms over the past two months, prompting the communist government to step up efforts to combat desertification. China is losing thousands of square kilometers of arable land to the deserts each year - the fastest rate in the world.
- Springtime in Beijing means sandstorms — a reminder that the desert is advancing.
- Scientists say the deserts of northern and western China are expanding by several hundred thousand square kilometers a year.
- They estimate that in just a few years, the Chinese capital could be covered with silt.

- **Sandstorms choked Beijing on Wednesday, 20 March, 2002, 12:44 GMT.**
- Visibility was very poor for motorists.
- Beijing was hit by choking sandstorms whipped up by high winds.
- Pedestrians donned masks and fled for shelter and there were traffic delays as thick dust reduced visibility.
- Pedestrians tried to protect themselves.
- Meteorologists have blamed a winter drought and advised people to stay indoors to protect their lungs.
- Sand storms are common in northern China at this time of year but this storm was one of the strongest to hit Beijing.

- The Chinese capital is now less than 250-kilometres from the encroaching desert, prompting alarm from officials and from the public.
- Weather experts advised people to stay indoors.
- Experts have warned that sandstorms could be a major problem for Beijing when it hosts the 2008 Olympics, despite costly efforts to halt the desert's advance.
- The government has pledged $6.8bn (56.8bn yuan) on an environmental program, which includes planting a green belt of trees around the capital.

Linkages between Desertification, Global Climate Change, and Biodiversity Loss



The major components of biodiversity loss (in green) directly affect major dryland services (in bold).

The inner loops connect desertification to biodiversity loss and climate change through soil erosion.

The outer loop interrelates biodiversity loss and climate change.

On the top section of the outer loop, reduced primary production and microbial activity reduce carbon sequestration and contribute to global warming.

On the bottom section of the outer loop, global warming increases evapotranspiration, thus adversely affecting biodiversity; changes in community structure and diversity are also expected because different species will react differently to the elevated CO2 concentrations.

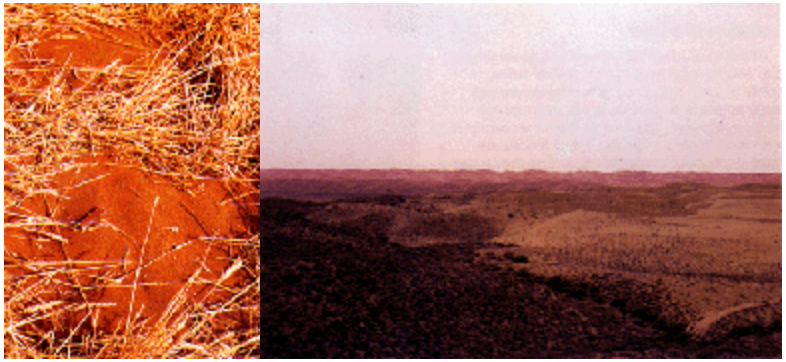
Source: MA Desertification Synthesis Report (2005)

- Desertification diminishes biological diversity, a diversity which contributes to many of the services provided to humans by dryland ecosystems.
- Vegetation and its diversity are key for soil conservation and for the regulation of surface water and local climate.
- Desertification also contributes to global climate change by releasing to the atmosphere carbon stored in dryland vegetation and soils.
- The effect of global climate change on desertification is complex and not yet sufficiently understood.
- On the one hand, higher temperatures resulting from increased carbon dioxide (CO2) levels can have a negative impact through increased loss of water from soil and reduced rainfall in drylands.
- On the other hand, for certain species, an increase in carbon dioxide in the atmosphere can boost plant growth.

Prevention and Reversal of Desertification

- Major policy interventions and changes in management approaches, both at local and global levels, are needed in order to prevent, stop or reverse desertification. Prevention is a lot more cost-effective than rehabilitation, and this should be taken into account in policy decisions.
- The creation of a “culture of prevention” that promotes alternative livelihoods and conservation strategies can go a long way toward protecting drylands both when desertification is just beginning and when it is ongoing.
- It requires a change in governments’ and peoples’ attitudes. Building on long-term experience and active innovation, dryland populations can prevent desertification by improving agricultural and grazing practices in a sustainable way.
- Even once land has been degraded, rehabilitation and restoration measures can help restore lost ecosystem services.
- The success of rehabilitation practices depends on the availability of human resources, funds, and infrastructures. It requires a combination of policies and technologies and the close involvement of local communities.

Straw grids and vegetation irrigated by water from the Yellow River stabilize dunes in this part of China's Tengger Desert (shown at right) and protect a nearby railroad from windblown sand



From wasteland to vineyard. Ground water and underground channels help this vineyard flourish on land reclaimed from desert pavement in China's Turpan Depression

Is There Really Spare Land?

ANTHONY YOUNG

Environment, Development and Sustainability **1:** 3–18, 1999.

- Current UN population projections predict that the population of developing countries will rise to about 8 billion by 2025 and 9 billion by 2050, an increase of some 50% and 80%, respectively, over the present number.
- It is widely recognized that massive agricultural development will be needed to feed this added population.
- Contributions to meeting these food needs are expected to come from three sources:
- an increase of cultivable land, higher crop yields, and reduction in post-harvest losses.
- all the estimates of land, food, the potential to feed future populations. assume the existence of substantial areas of land available for future cultivation,

Is There Really Spare Land?

- Five assessments covering less-developed countries have identified a ‘land balance’, available for future cultivation, using the approach of inventory and difference: assessment of the area cultivable, and subtraction of the area presently cultivated.
- All arrive at a balance of 1600–1900 Mha, about twice the present cultivated area.
- The supposed existence of this spare land is widely quoted in forecasts of capacity to meet the food requirements for future population increase.
- Young argued that these estimates greatly exaggerate the land available, by over-estimating cultivable land, under-estimating present cultivation, and failing to take sufficient account of other essential uses for land.

Is There Really Spare Land?

- He concluded that the major assessments by international bodies and research organizations, although conducted with integrity, without presuppositions, and with the greatest thoroughness, greatly over-estimate the extent of spare land: that is, land available for cultivation but presently uncultivated.

- Reasons are:
  - an over-estimation of the extent of cultivable land, through 'loss' of hills and other uncultivable areas, individually small but of substantial total extent, when detailed surveys are reduced to small scales;
  - an under-estimation of land already cultivated, statistics for which are demonstrably of great unreliability;
  - failure to take sufficient notice of the considerable, and necessary, requirements of other land uses, notably water supply, nature conservation, human settlements, and forest.

Is There Really Spare Land?

- Making speculative adjustments to allow for the above causes, a supposed land balance of 50% is reduced to one of between 3% and 25% of the present cultivable land.
- If this is correct, as an order of magnitude, then estimates of the total spare land in the developing world, and those for individual countries, should be reduced to *half or less* the values given by current estimates.

Learning Outcomes

- Know the shore environments – wetland, mangroves, sandy shore, rocky shore
- Know the volcanoes
- Appreciate the rainforests
- Realize the problem of deforestation
- Realize the problem of desertification
- Know the stress on the land environment
- Relate the land environment with sustainability