Unit 4. Vegetation Development

Ecological Succession

➢ Gradual change in living communities that follows a disturbance.

There are two main types of Ecological Succession

- **Primary Succession:** The process of creating life in an area where no life previously existed.
- After severe disturbance that remove or bury products of the ecosystem

✓ takes place in an area that is devoid of life - e.g., a lava flow, rocky mountaintop, or an area of land scraped clean by a glacier.

- **Secondary Succession:** The process of re-stabilization that follows a disturbance in an area where life has formed an ecosystem.
- After disturbance on a vegetated site.
- Most above ground live biomass may be disturbed but soil organic matter and plant propagules remain.

Mechanisms of succession

- Succession generally begins after disturbance creates a situation of great resource availability that can be exploited by organisms, but under conditions of little competition.
- The classical explanation of the ecological mechanism of community change during succession is the so-called **facilitation model.**
  - ✓ This theory suggests that the recently disturbed situation is first exploited by certain pioneer species that are most capable of reaching and establishing on the site.
  - ✓ These initial species modify the site, making it more suitable for invasion by other species, for example, by carrying out the earliest stages of soil development.
  - ✓ Once established, the later-successional species eliminate the pioneers through competition.
  - ✓ This ecological dynamic proceeds through a progression of stages in which earlier species are eliminated by later species, until the climax stage is reached, and there is no longer any net change in the community.

- Another proposed mechanism of succession is the tolerance model.
- This concept suggests that all species in the succession are capable of establishing on a newly disturbed site, although with varying successes in terms of the rapid attainment of a large population size and biomass.
- In contrast with predictions of the facilitation model, the early occupants of the site do not change environmental conditions in ways that favor the subsequent invasion of later-successional species.
- Rather, with increasing time, the various species sort themselves out through their differing tolerances of the successionally increasing intensity of biological stresses associated with competition.
- In the tolerance model, competition-intolerant species are relatively successful early in succession when site conditions are characterized by a free availability of resources.
- However, these species are eliminated later on because they are not as competitive as later species, which eventually develop a climax community.

- A third suggested mechanism of succession is the **inhibition model**.
- As with the tolerance model, both early and later-successional species can establish populations soon after disturbance.
- However, some early species make the site less suitable for the development of other species.
  - ✓ For example, some plants are known to secrete toxic biochemicals into soil (these are called allelochemicals), which inhibit the establishment and growth of other species.
- Eventually, however, the inhibitory species die, and this creates opportunities that later-successional species can exploit.
- These gradual changes eventually culminate in development of the climax community.

- All three of these models, facilitation, tolerance, and inhibition, can be supported by selected evidence from the many ecological studies that have been made of succession (especially plant succession).
- Although these models differ significantly in their predictions about the organizing principles of successional dynamics,
    - ✓ it appears that none of them are correct all of the time.
- Facilitation seems to be most appropriate in explaining changes in many primary successions, but less so for secondary successions, when early post-disturbance site conditions are suitable for the vigorous growth of most species.

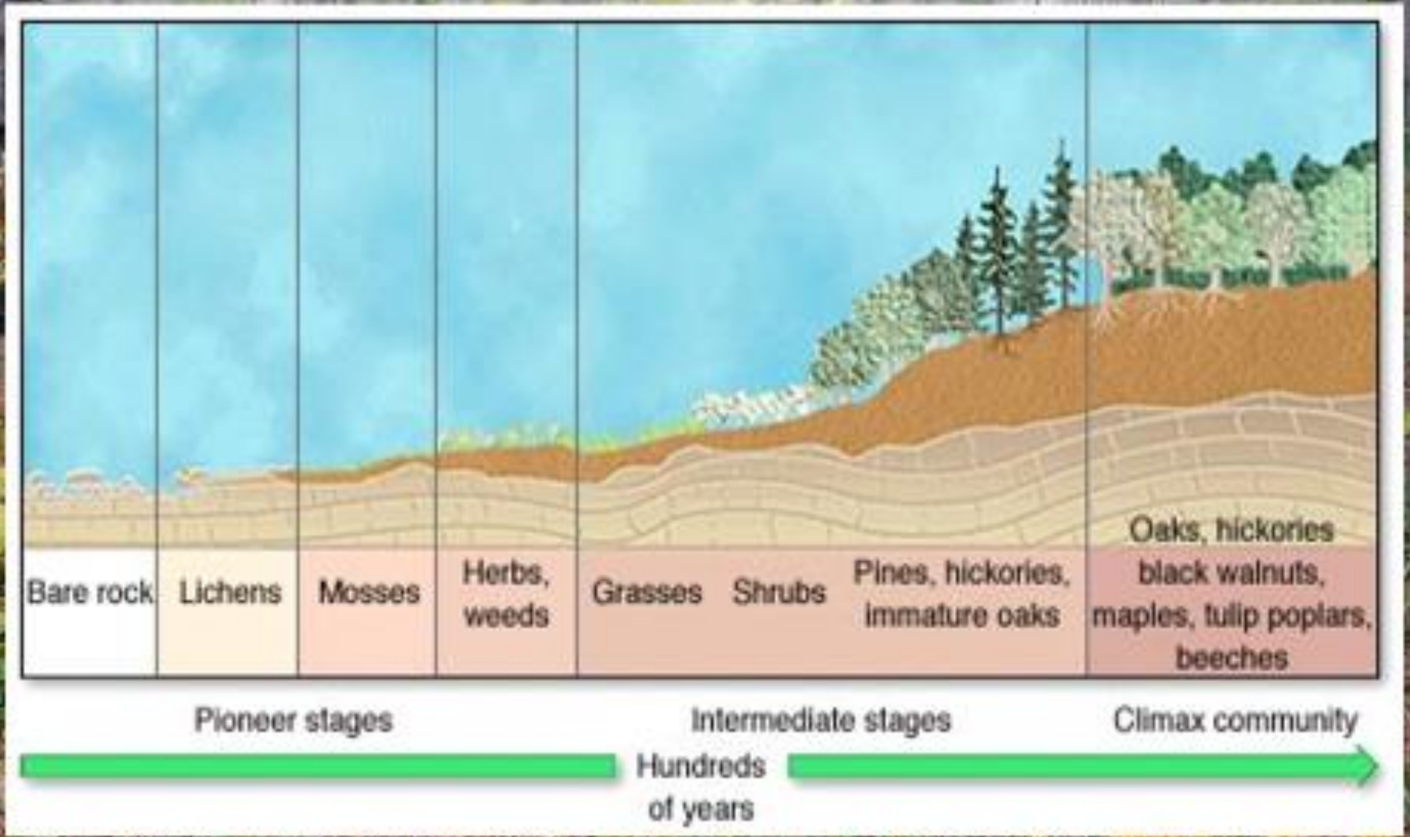
Primary Succession

- The development of an ecosystem in an area that has never had a community living within it occurs by a process called **Primary Succession**.
- An example of an area in which a community has never lived before, would be a new lava or rock from a volcano that makes a new island.
- Begins in a place ***<u>without any soil</u>***
  - In the beginning there is only rock, sand, volcanic ash.
  - Since there is no soil, there is no community.

Features of Primary Succession

- Dispersal – getting to the site
  - ✓ Small seeds arrive first, wind blown
- Colonization and Recruitment
  - ✓ N Fixers dominate and facilitate the environment
  - ✓ Recruitment Success, f(soil moisture, temperature, competition (light/soil moisture), herbivory/predation)
- Establishment, Facilitation and Inhibition
  - ✓ making due with the resources you can find or make

Primary Succession



- **Primary Succession Characteristics**

- Pioneer organisms that require little or no soil (lichens and mosses) invade first.
- As they grow and die, soil builds up and larger plants such as grasses can now grow.
- The growing grasses shade out the lichen and moss communities, which die out.
- The process continues with each community being replaced - bushes, small trees, and then larger trees.

- Lichens begin growing on the rocks.
- Over many years lichens break down rock into sand.
- Weathering and erosion break down rock into sand.
- Lichens that do not need soil to survive Called **PIONEER SPECIES** (Why?)
- Seeds are blown in by the wind or carried in by animals.
- Simple plants like mosses can grow in the new soil.
- The plants grow and the soil gets enriched as plants die.




- **Pioneer species** - the first species to populate an area.
- Example: After a volcanic eruption lichens grow on the rock helping to break it up.
- When they die, their remains add organic matter to the soil.

- The simple plants die, adding more organic material
- The soil layer thickens, and grasses, wildflowers, and other plants begin to take over.
- Medium sized animals and birds make this their habitat.
- The vegetation grows closer together, reducing the amount of space available for growing.
- Competition between lichen and shrubs for the same space.
- Eventually one species (lichen) will die out (or move) and the other species will survive (shrubs).
- These plants die, and they add more nutrients to the soil
- Shrubs and tress can survive now

- Insects, small birds, and mammals have begun to move in

- What was once bare rock now supports a variety of life

- These plants die, and they add more nutrients to the soil

- Now larger trees can grow: Beech, Oak, Walnut, Maple…

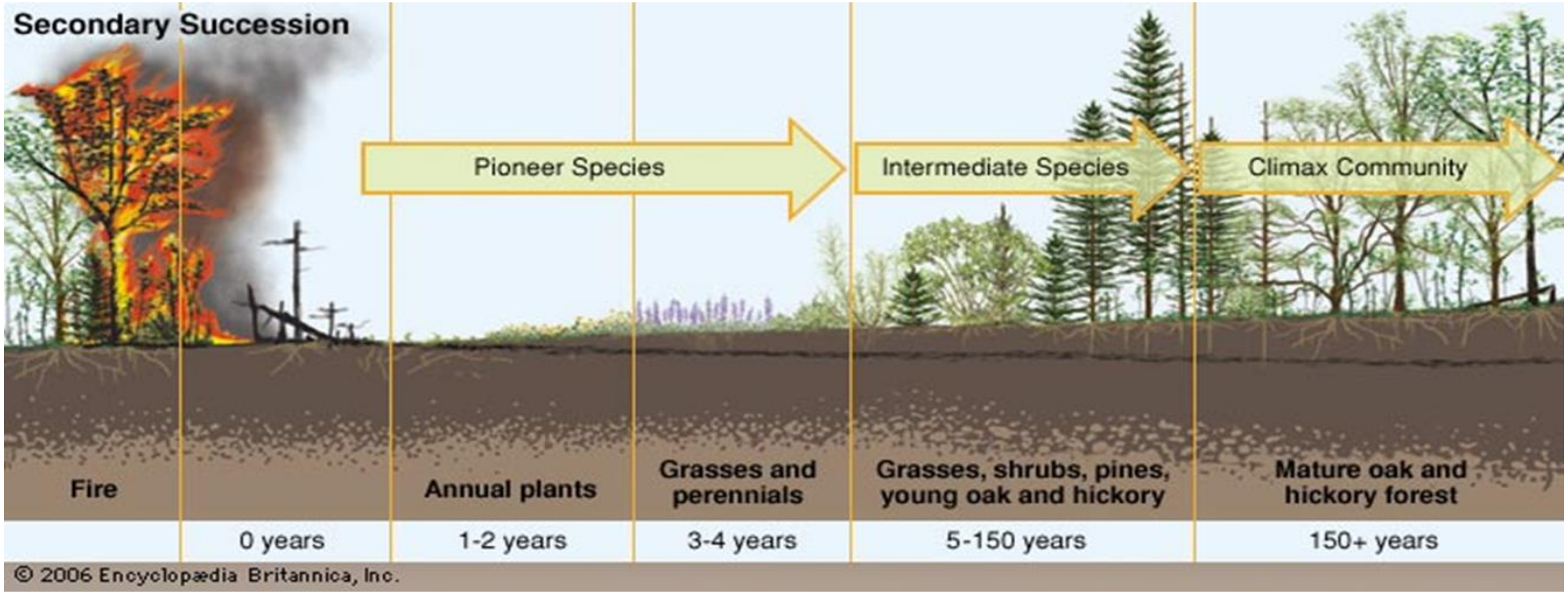
Secondary Succession

- Occurs following a disturbance that destroys a community without destroying the soil.





- Certain plants have adapted to regular cycles of fire and re-growth.
- Their seeds won’t sprout unless exposed to fire.



1. Some seeds in the soil begin to grow.

2. Larger shrubs move in.

3. Fast growing trees (such as pines) move in

4. These are followed by slower-growing hardwood trees.

Climax Community

- A mature stable community that does not undergo further succession.

Features of Secondary Succession

- Colonization
  - ✓ Sprouting from root and stems
  - ✓ Germination from soil seed bank
  - ✓ Advanced regeneration by long-lived, shade tolerant seedlings
  - ✓ Dispersal and In-fill from adjacent gaps
    - ➢ Wind blown seeds, Birds, Animals
- Facilitation
  - ✓ Hydraulic Lift
  - ✓ Shade and protection of seedlings from desiccation
- Competition
- Herbivory and Pathogens

Disturbance and Succession-Type

- Primary
  - Volcano
  - Landslide
  - Flooding
  - Dune Formation
  - Lake Drainage
  - Tsunami
- Secondary
  - Fire
  - Hurricane
  - Logging

Unit 5. Ecosystem Organization

- Ecosystem is the structural and functional unit of ecology where living organisms interact with each other and also with the surrounding physical environment.
- In other words, it is the whole community in which plants and animals live together.
    - ✓ For example, Tropical rain forest with its trees, animals etc.

Types of Ecosystem

- Mainly there are two types of ecosystems - Namely terrestrial ecosystem and aquatic ecosystem

1. Terrestrial ecosystem: This is the ecosystem which exists on land. It can be further divided into the following types,

- Forest ecosystem
- Grassland ecosystem
- Desert ecosystem

2. Aquatic ecosystem: This is the ecosystem which exists in water. It can be further divided into,

- Fresh water ecosystem (Pong or lake or river ecosystem)
- Marine ecosystem (Ocean ecosystem)

Structure and function of Ecosystem

- Organisms interact with each other and also with the physical conditions that are present in their habitats.
- 'The organisms and the physical features of the habitat form an ecosystem' - **Clarke** (1954).
- The concept of ecosystem was first put forth by **A.G.Tansley**(1935).
- Ecosystem is the major ecological unit. It has both structure and function.
- The structure is related to species diversity.

❖ According to **E.P. Odum**, the ecosystem is the basic functional unit of organism and their environment interacting with each other.

- The function of ecosystem is related to the energy flow, decomposition, nutrient cycling and major biomes.

Structure

Generally ecosystems consist of two basic components.

1. Abiotic component
2. Biotic component

1. Abiotic components

- It includes basic in-organic (soil, water, oxygen, calcium carbonates, phosphates etc.) and organic compounds.
- It also includes physical factors such as moisture, wind currents and solar radiation. Radiant energy of sun is the only significant energy source for any ecosystem.

2. Biotic components

- Include producers, consumers and decomposers.

Producer : These are the autotrophic, chlorophyll-bearing organisms, which produce their own food.

Consumers : A consumer which gets nutrition by eating plants is called **Primary consumers** (herbivore) (eg) Rabbit, deer and cow.

The Secondary Consumer: (carnivores) is an animal that eats the flesh of herbivores (eg) cats and dogs.

Tertiary Consumers: are the type of carnivores, which prey upon other carnivores. (eg) Lion, tiger and vulture.

Decomposers

- Decomposers attack the dead remains of producers and consumers and degrade the complex organic substances into simpler compounds to derive their nutrients.
- The decomposers play very important role in maintaining the dynamic nature of ecosystem.

Functions of Ecosystem

- An ecosystem is a functional and life sustaining environmental system.
- The environmental system consists of biotic and abiotic components.
- Biotic components include living organisms and abiotic components includes in organic matter and energy.

❖ In an ecosystem there are three functional components.

1. Inorganic constituents (air, water and mineral salts)
2. Organisms (plants, animals and microbes), and
3. Energy input which enters from outside (the sun).

Productivity in an Ecosystem

- Productivity refers to the amount of organic matter accumulated in any unit time. It is of following types.

1. Primary productivity

- Green plants absorb solar energy and store it in organic form as chemical energy.
- This forms the first and basic form of energy storage and is known as primary productivity.
- It is the rate at which the organic material is formed by photosynthesis per unit area of surface per unit time.

2. Secondary productivity

- It refers to consumers or heterotrophs.
- The consumers utilize the food materials during the process of respiration.
- The rate at which the food energy is assimilated is called secondary productivity.

3. Net productivity

- This refers to the rate of storage of organic matter which is not used by heterotrophs.
- These may be equivalent to the net primary production minus consumption by the heterotrophs.

Ecosystem Productivity

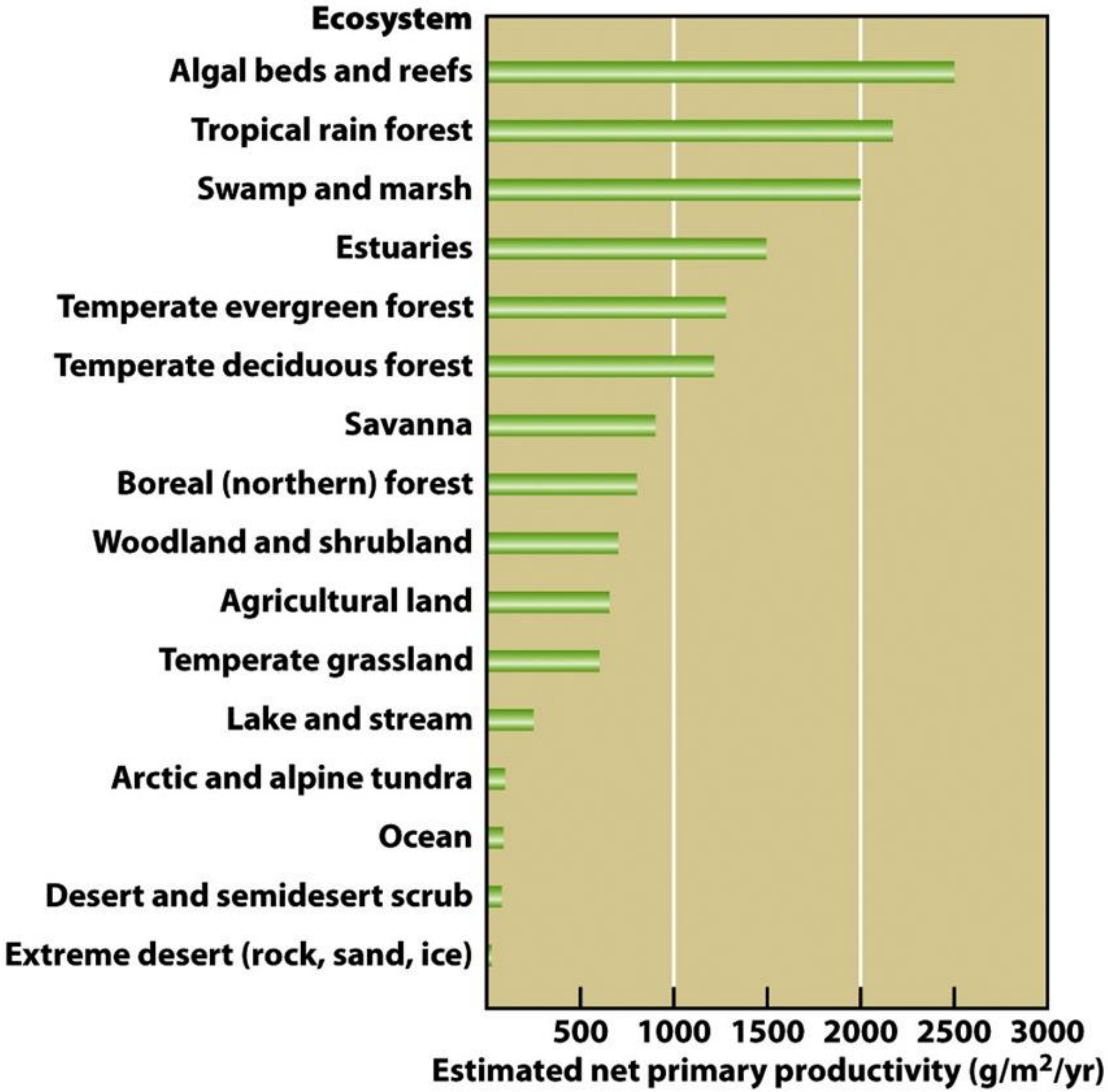
- **Gross Primary Productivity (GPP)**
  - Total amount of energy that plants capture and assimilate in a given period of time
- **Net Primary Productivity (NPP)**
  - Plant growth per unit area per time
  - Represents the rate at which organic material is actually incorporated into the plant tissue for growth
- **GPP – cellular respiration = NPP**
  - Only NPP is available as food to organisms

Primary production and plant biomass for the Earth

Ecosystem type	Area (10^6 km²)	Mean NPP (g/m²/yr)	World NPP (10^9 tons/yr)	Mean biomass (kg/m²)	World biomass (10^9 tons)
Tropical rainforest	17.0	2,200	37.4	45	763
Tropical seasonal forest	7.5	1,600	12.0	35	260
Temperate evergreen forest	5.0	1,300	6.5	35	175
Temperate deciduous forest	7.0	1,200	8.4	30	210
Boreal forest	12.0	800	9.6	20	240
Woodlands and shrublands	8.5	700	6.0	6	50
Savanna	15.0	900	13.6	4	60
Temperate grasslands	9.0	600	5.4	1.6	14
Tundra and alpine	8.0	140	1.1	0.6	5
Desert and semi-desert	18.0	90	1.6	0.7	13
Extreme desert and ice	24.0	3	0.07	0.02	0.5
Cultivated land	14.0	650	9.1	1.0	14
Swamp and wetland	2.0	2,000	4.0	12.3	30
Lakes and streams	2.0	250	0.5	0.02	0.05
Total Continental	149	773	115	12.3	1837
Open ocean	332.0	125	41.5	0.003	1.0
Upwelling zones	0.4	500	0.2	0.02	0.008
Continental shelf	26.6	360	9.6	0.01	0.27
Algal bed and reef	0.6	2,500	1.6	2.0	1.2
Estuaries	1.4	1,500	2.1	1.0	1.4
Total marine	361	152	55.0	0.01	3.9
Grand total	510	333	170	3.6	1841

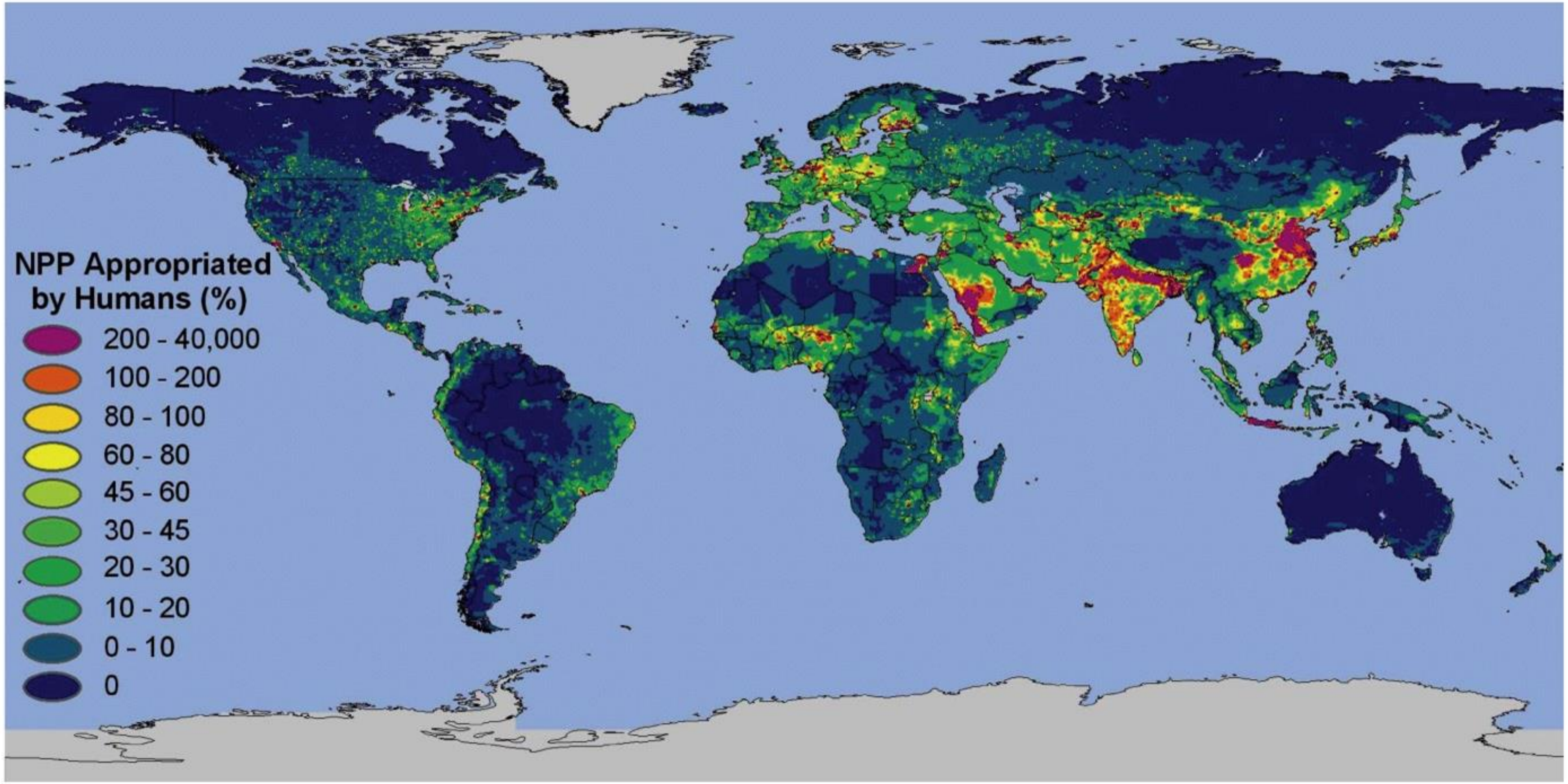
From R.H. Whittaker, quoted in Peter Stiling (1996), "Ecology: Theories and Applications" (Prentice Hall).

Variation in NPP by Ecosystem



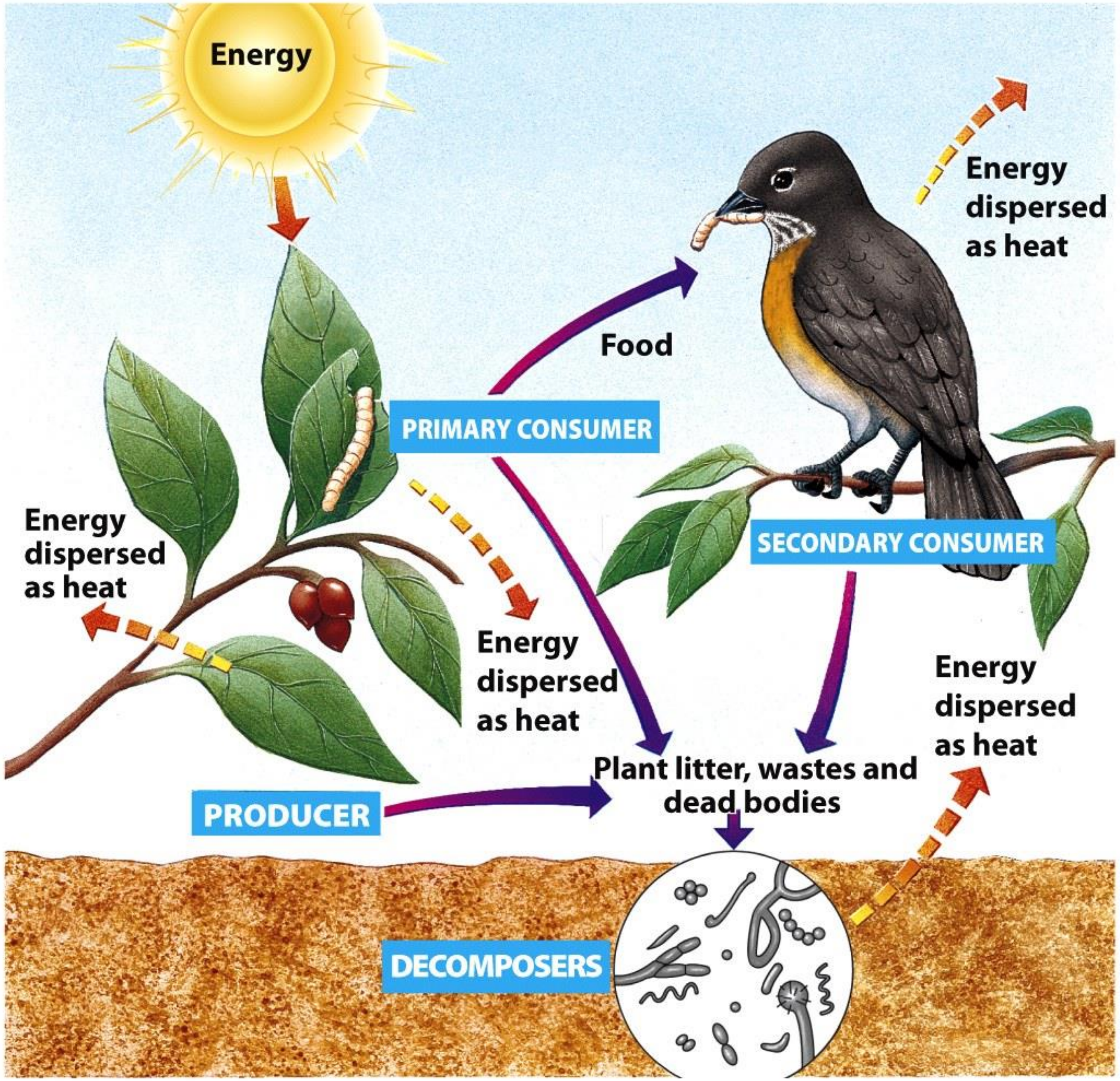
Human Impact on NPP

- ❖ Humans consume more of earth's resources than any other animal
  - Humans represent 0.5% of land-based biomass
  - Humans use 32 - 40% of land-based NPP!
- ❖ This may contribute to loss of species (extinction)
- ❖ Humans' high consumption represents a threat to planet's ability to support both human and non-human inhabitants (structural and functional integrity).


NPP Appropriated by Humans (%)
200 - 40,000
100 - 200
80 - 100
60 - 80
45 - 60
30 - 45
20 - 30
10 - 20
0 - 10
0

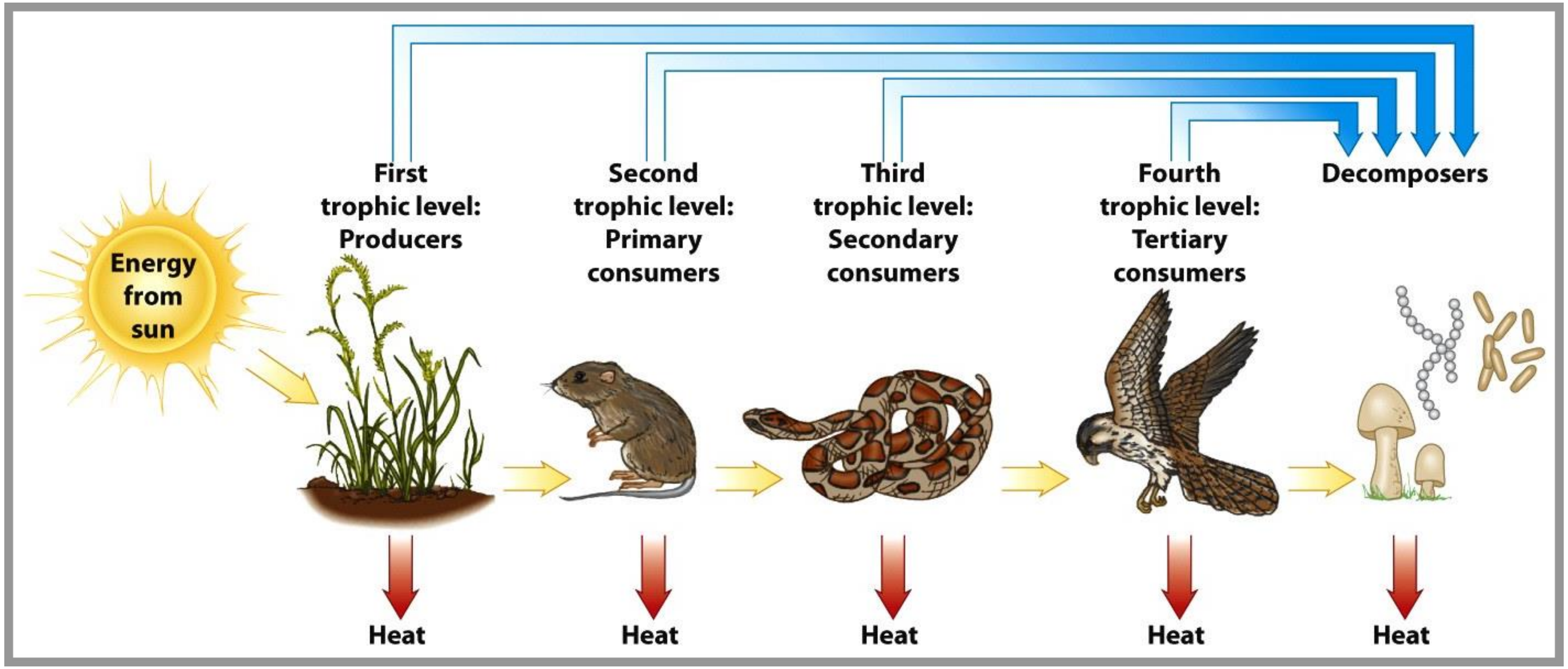
Energy flow

- Passage of energy in a one-way direction through an ecosystem
  - ✓ Producers
  - ✓ Primary consumers
  - ✓ Secondary consumers
  - ✓ Decomposers
- Energy in an ecosystem originally comes from the sun
- Energy flows through Ecosystems from producers to consumers.
- Producers (make food)
- Consumers (use food by eating producers or other consumers)



Food Chains- The Linear Path of Energy Flow

- Energy from food passes from one organisms to another.
  - ✓ Each "***link***" is called a trophic level



Producers

- Sunlight is the main source of energy for most life on earth.
- Producers contain chlorophyll & can use energy directly from the sun

Autotrophs

- An Autotroph is any organism that can produce its own food supply!
- Autotrophs are also called Producers
- Plants, algae, some protists, & some bacteria are examples

Photoautotroph

Producer That Captures Energy from the sun by:

- Photosynthesis
  - Adds Oxygen to the atmosphere
  - Removes Carbon Dioxide from the Atmosphere

Chemoautotrophs

- Capture energy from the bonds of inorganic molecules such as Hydrogen Sulfide
- Process is called Chemosynthesis
- Often occurs in deep sea vents or gut of animals

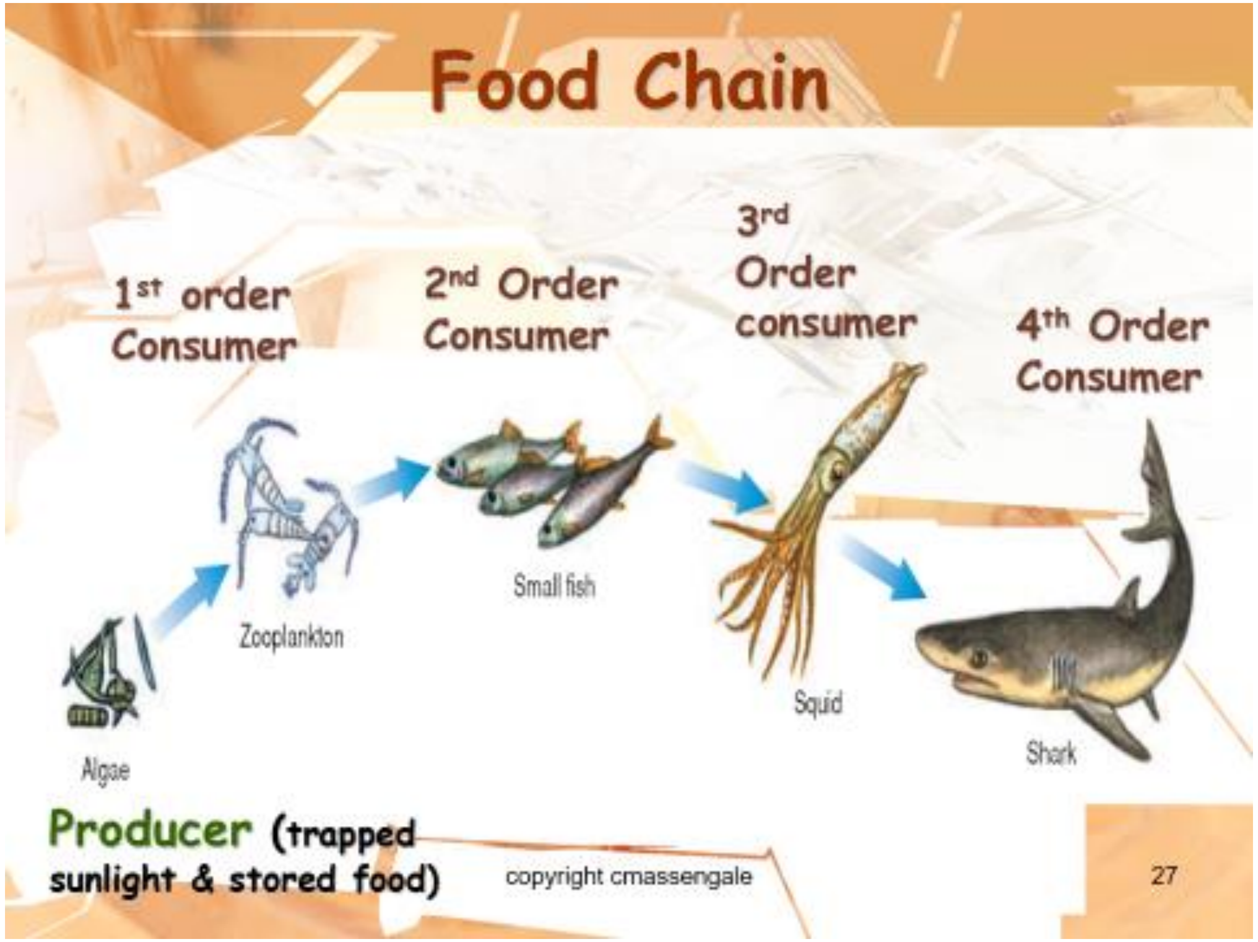
Consumers

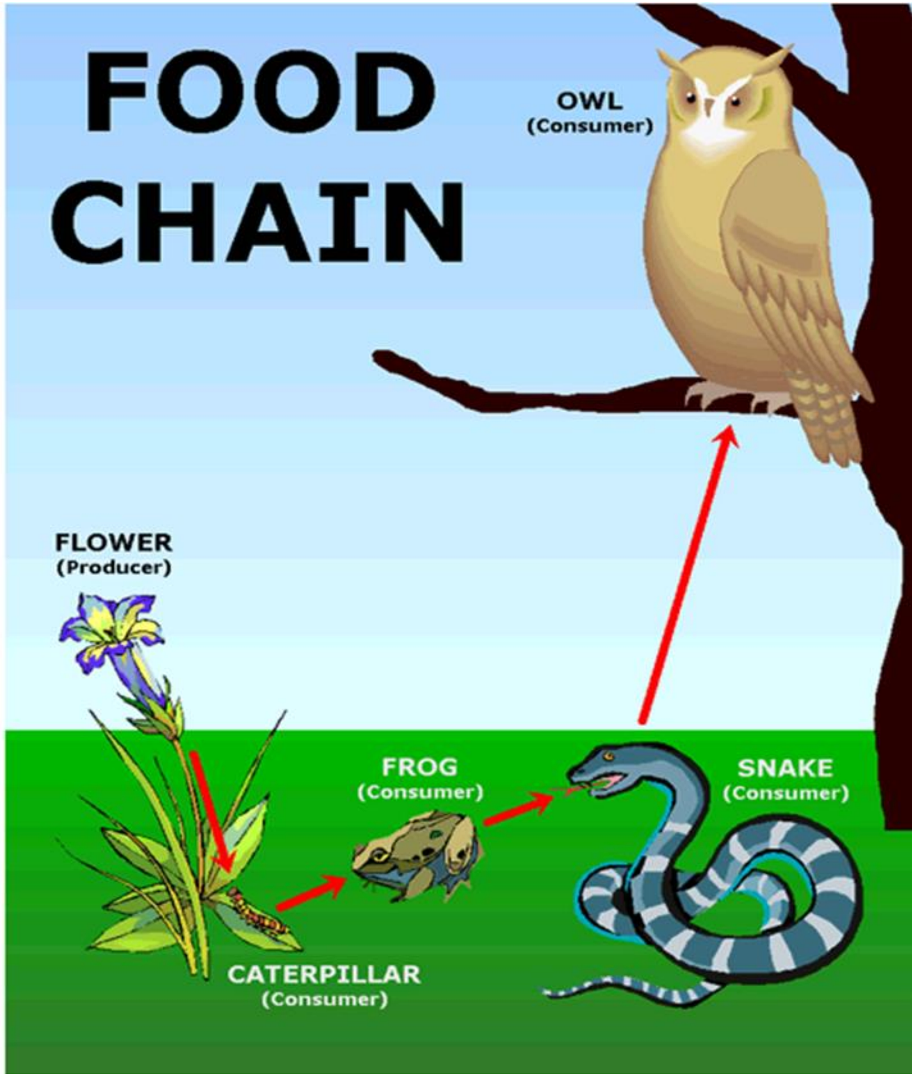
- Heterotrophs eat other organisms to obtain energy. (e.g. *animals*)
- **Herbivores**
  - Eat Only Plants
- **Carnivores**
  - Eat Only Other animals
- **Omnivores** (Humans)
  - Eat Plants & Animals
- **Detritivores (Scavengers)**
  - Feed On Dead Plant & Animal Remains (buzzards)
- **Decomposers**
  - Fungi & Bacteria

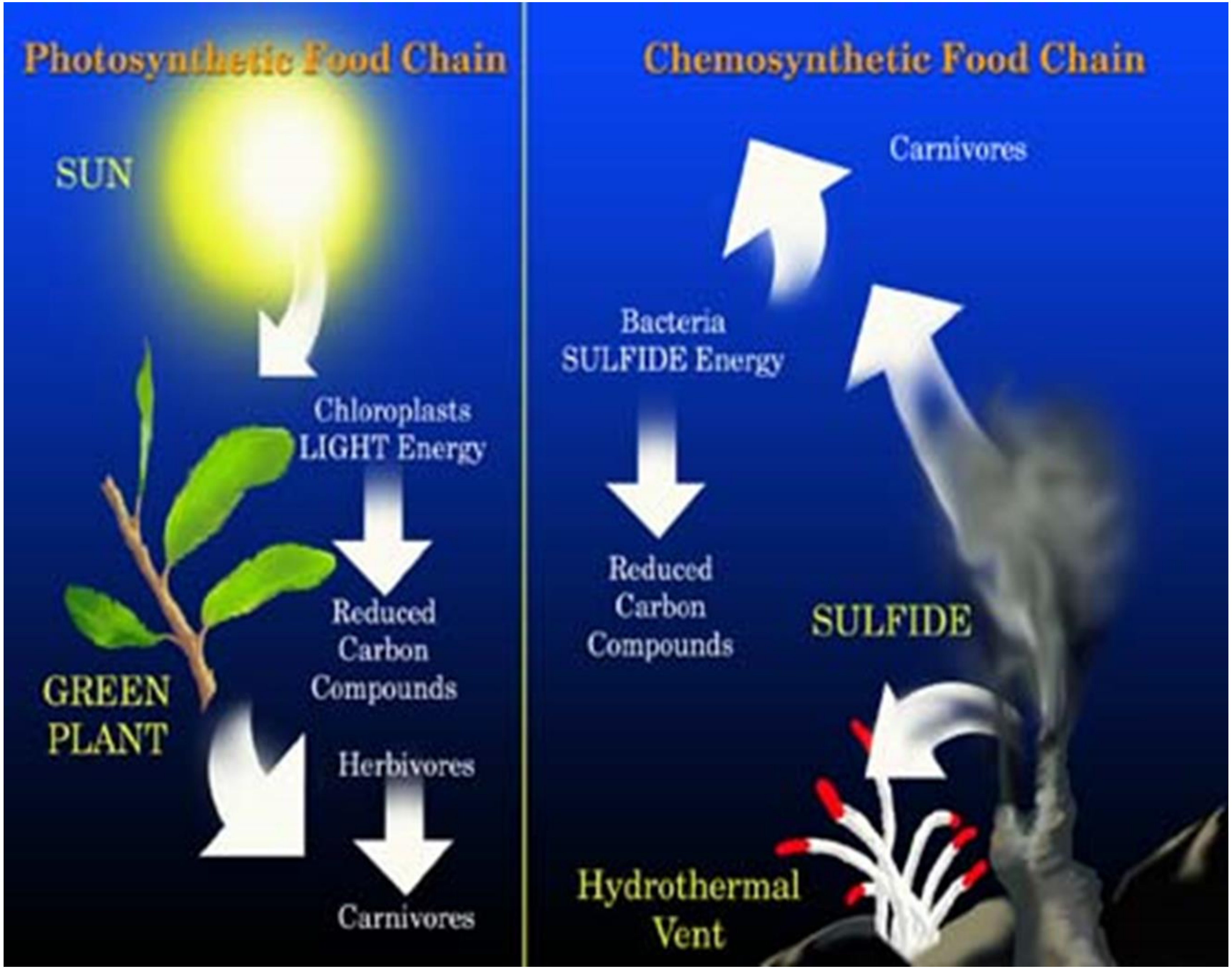
Feeding Relationships

- Energy flows through an ecosystem in one direction from producers to various levels of consumers

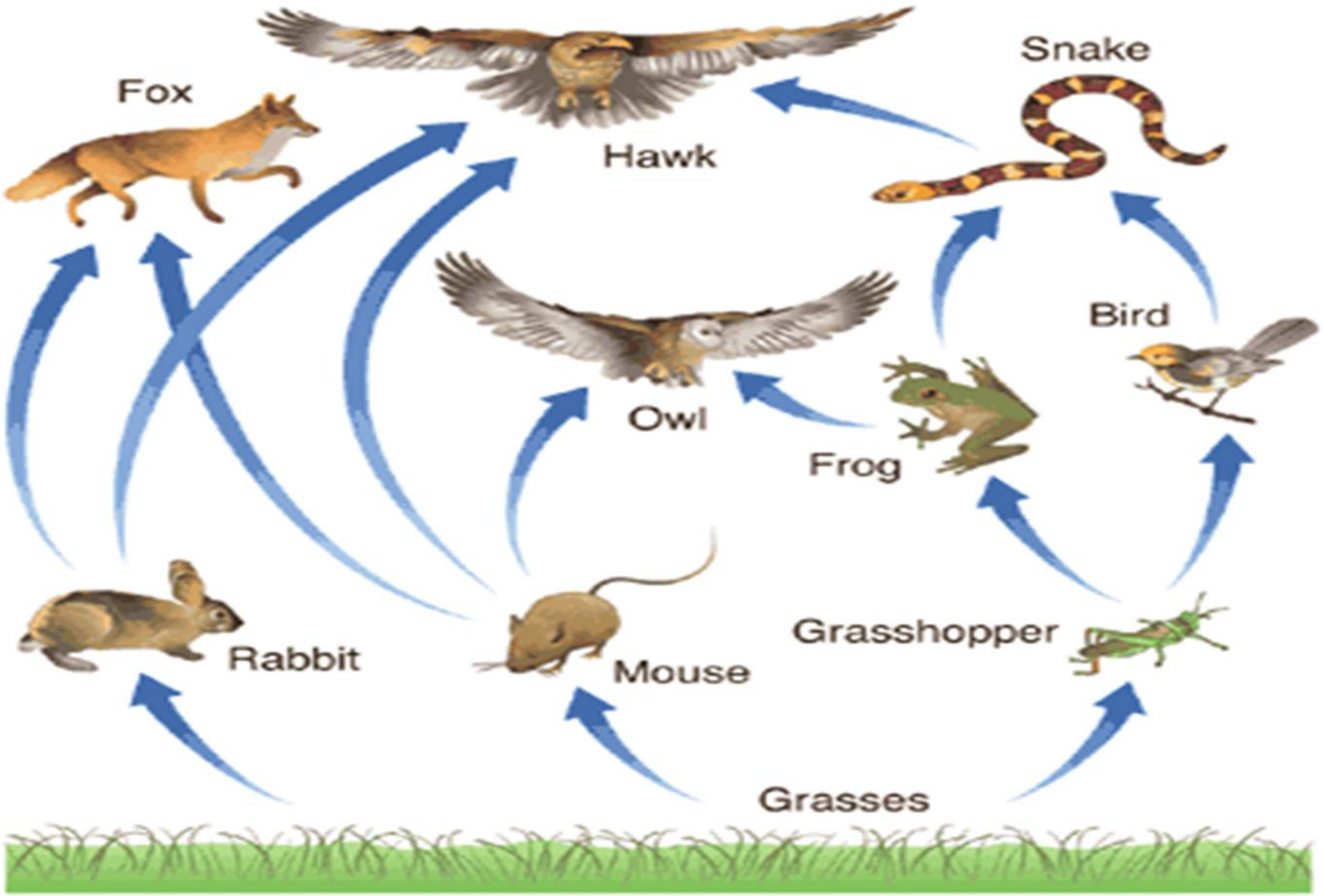
- **Food Chain**
  - Simple Energy path through an ecosystem
- **Food Web**
  - More realistic path through an ecosystem made of many food chains

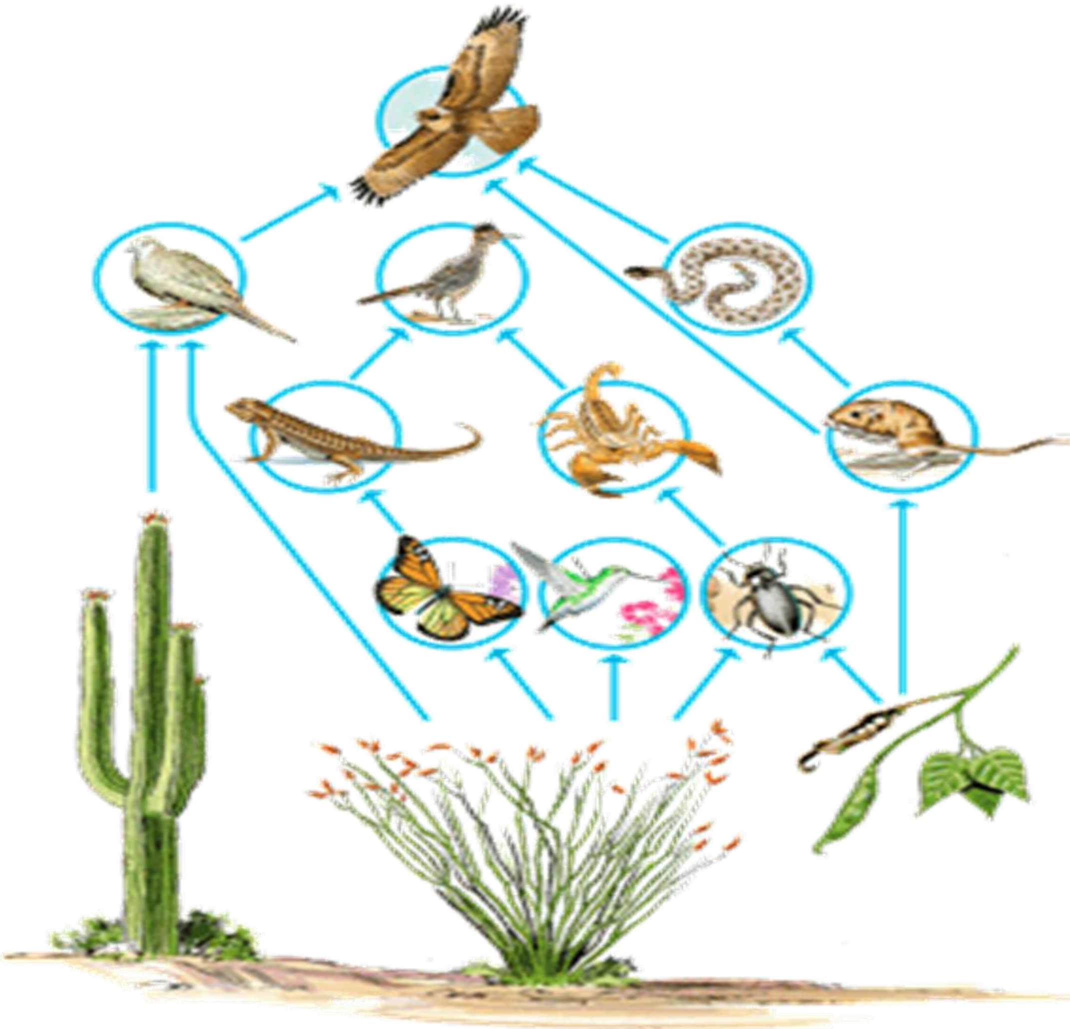





Photosynthetic Food Chain
SUN
Chloroplasts
LIGHT Energy
Reduced
Carbon
Compounds
GREEN
PLANT
Herbivores
Carnivores
Chemosynthetic Food Chain
Carnivores
Bacteria
SULFIDE Energy
Reduced
Carbon
Compounds
SULFIDE
Hydrothermal
Vent

Food web


Snake
Fox
Hawk
Bird
Owl
Frog
Grasshopper
Rabbit
Mouse
Grasses



Trophic Levels

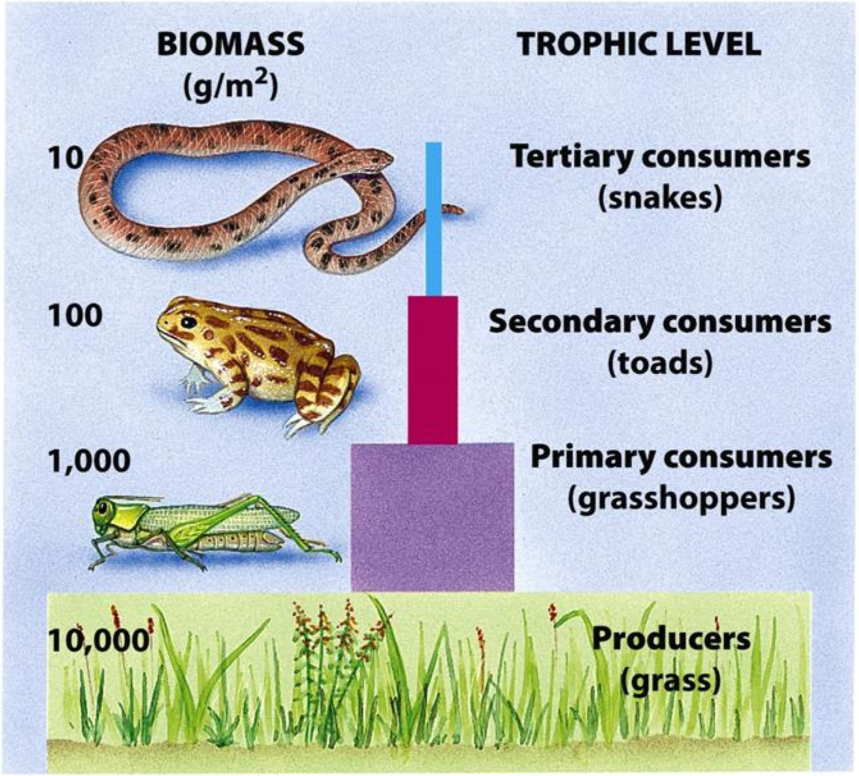
- Each level in a food chain or food web is a Trophic Level.
- **Producers**
  - Always The First Trophic Level
  - How Energy Enters The System
- **Herbivores**
  - Second Trophic Level
- **Carnivores/Omnivores**
  - Make Up The Remaining Trophic Levels
- Each level depends on the one below it for energy.

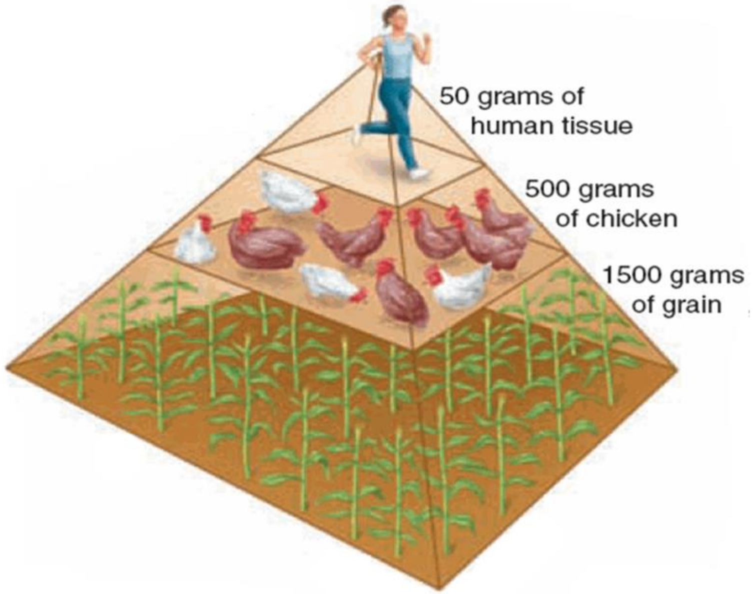
Ecological Pyramids

- Graphically represent the relative energy value of each trophic level.
    - Important feature is that large amount of energy are lost between trophic levels to heat.
- Three main types:
    - Pyramid of Biomass
    - Pyramid of Energy
    - Pyramid of Numbers

Pyramid of Biomass

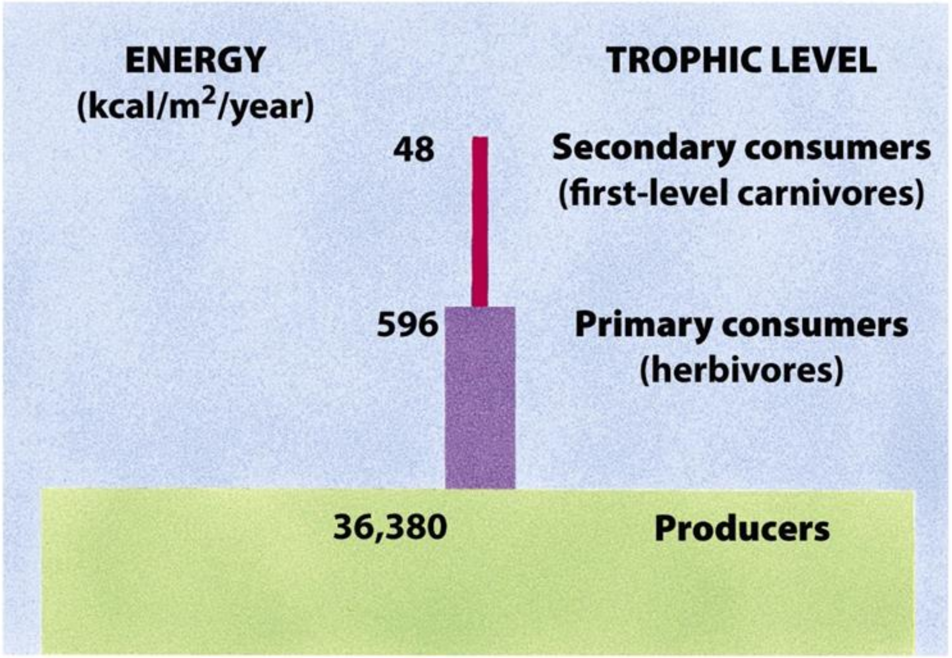
- Illustrates the total biomass at each successive trophic level.
    - Biomass: measure of the total amount of living material.
    - Biomass indicates the amount of fixed energy at a given time.
- Illustrates a progressive reduction in biomass through trophic levels.

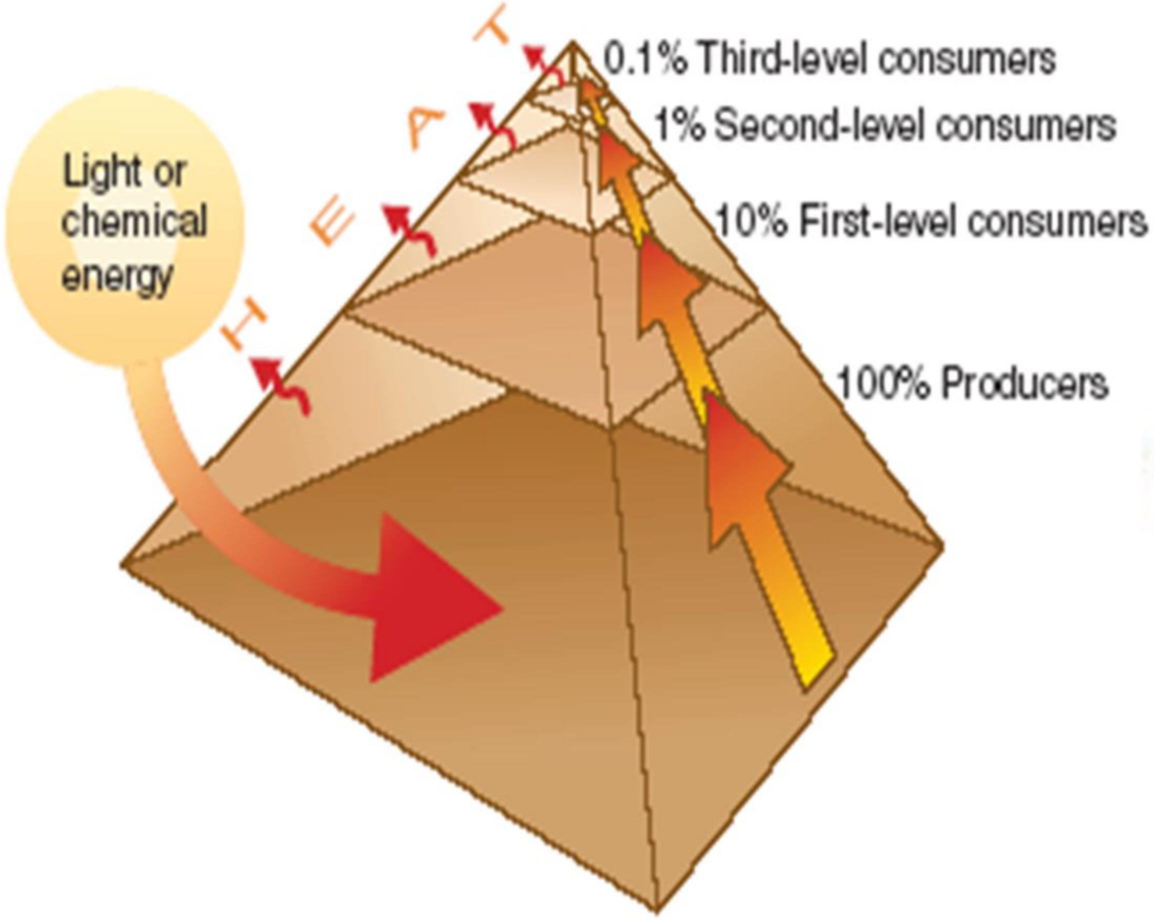




Pyramid of Energy

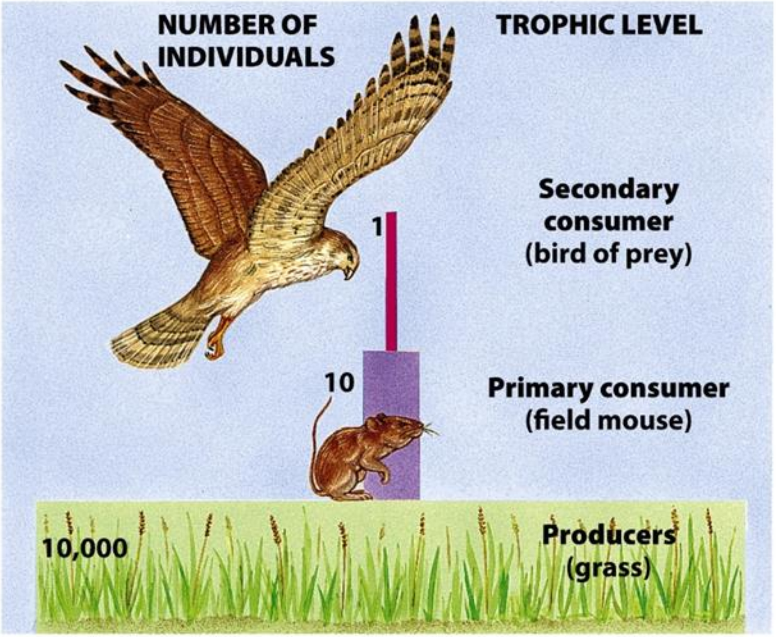
- Illustrates how much energy is present at each trophic level and how much is transferred to the next level.
  - Most energy dissipates between trophic levels.
- Explains why there are so few trophic levels.
  - Energy levels get too low to support life.





Pyramid of Numbers

- Illustrates the number of organisms at each trophic level.
  - Usually, organisms at the base of the pyramid are more numerous.
  - Fewer organisms occupy each successive level.
- Do not indicate the biomass of the organisms at each level or the amount of energy transferred between levels.



ECOLOGICAL EFFICIENCY

- It is clear from the trophic structure of an ecosystem that the amount of energy decreases at each subsequent trophic level.
- This is due to two reasons:

1. At each trophic a part of the available energy is lost in respiration or used up in metabolism.
2. A part of energy is lost at each transformation, i.e. when it moves from lower to higher trophic level as heat.

- It is the ratio between the amount of energy acquired from the lower trophic level and the amount of energy transferred from higher trophic level is called **ecological efficiency**.
- Lindman in 1942 defined these ecological efficiencies for the 1st time and proposed 10% rule e.g. if autotrophs produce 100 cal, herbivores will be able to store 10 cal. and carnivores 1cal.
- However, there may be slight variations in different ecosystems and ecological efficiencies may range from 5 to 35%.
- Ecological efficiency (also called Lindman's efficiency) can be represented as

$$\frac{I_t \times 100}{I_t - 1} = \frac{\text{Ingestion at trophic level}_t \times 100}{\text{Ingestion at previous trophic level} - 1}$$

Litter and Soil Organic Matter Decomposition

Decomposition

- Physical and chemical breakdown of dead organic matter (plant, animals, and microbial material)

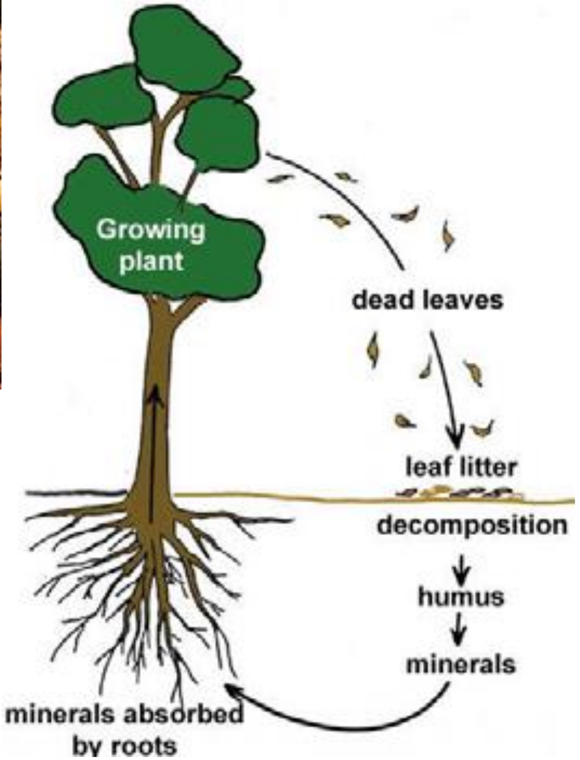
- Provides energy for microbial growth

- Controls over decomposition:

    ✓ Quantity of substrate/litter input

    ✓ Quality of substrate/litter input

    ✓ Environmental conditions

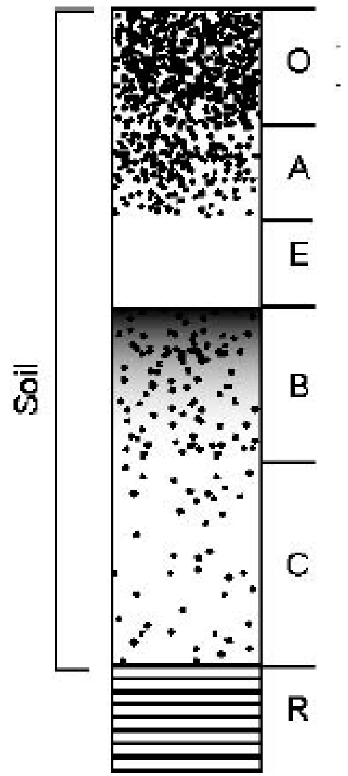


- Breaks down organic matter, releasing carbon to the atmosphere and nutrients in forms that can be used for plant and microbial production.

- Occurs in the litter layer and in the organic and mineral horizons of the soil.

- **Decomposition results from three types of processes:**

1. **Leaching** (most important in the early stages)



- This is the process by which simple and water soluble compounds percolate down to lower layers of soil with moving water.

2. Fragmentation (by soil animals)

- Fragmentation of detritus takes place with the help of invertebrates like snails and earthworms.

- As they feed on detritus they are called as detritivores.

- When detritus passes through their alimentary canal it gets fragmented or pulverized.

3. Chemical Alteration (fungi, bacteria, soil animals)

- During this process certain bacteria and fungi release extracellular enzymes.
- These enzymes help in converting decomposing detritus to inorganic forms.
- The enzymes are specific and work on a specific detritus, for example Pseudomonas bacteria decomposes proteins into ammonia and simple nitrogen compounds.
- The result of the process is humification and mineralization.
- Humification means formation of humus which is dark colored amorphous substance formed from dead and decomposing material.
- It is highly resistant to microbes because of which it undergoes slow decomposition. Humus is a reservoir of nutrients.
- Mineralization refers to the addition of inorganic substances like CO_2, H_2O and minerals like NH_4^+, Ca^{++}, Mg^{++}, K^+, etc. to soil.

- There are times when these nutrients instead of getting mineralized, get bound to the biomass of decomposers.
- Due to this they become temporarily unavailable to other organisms.
- This is known as immobilization of nutrients.

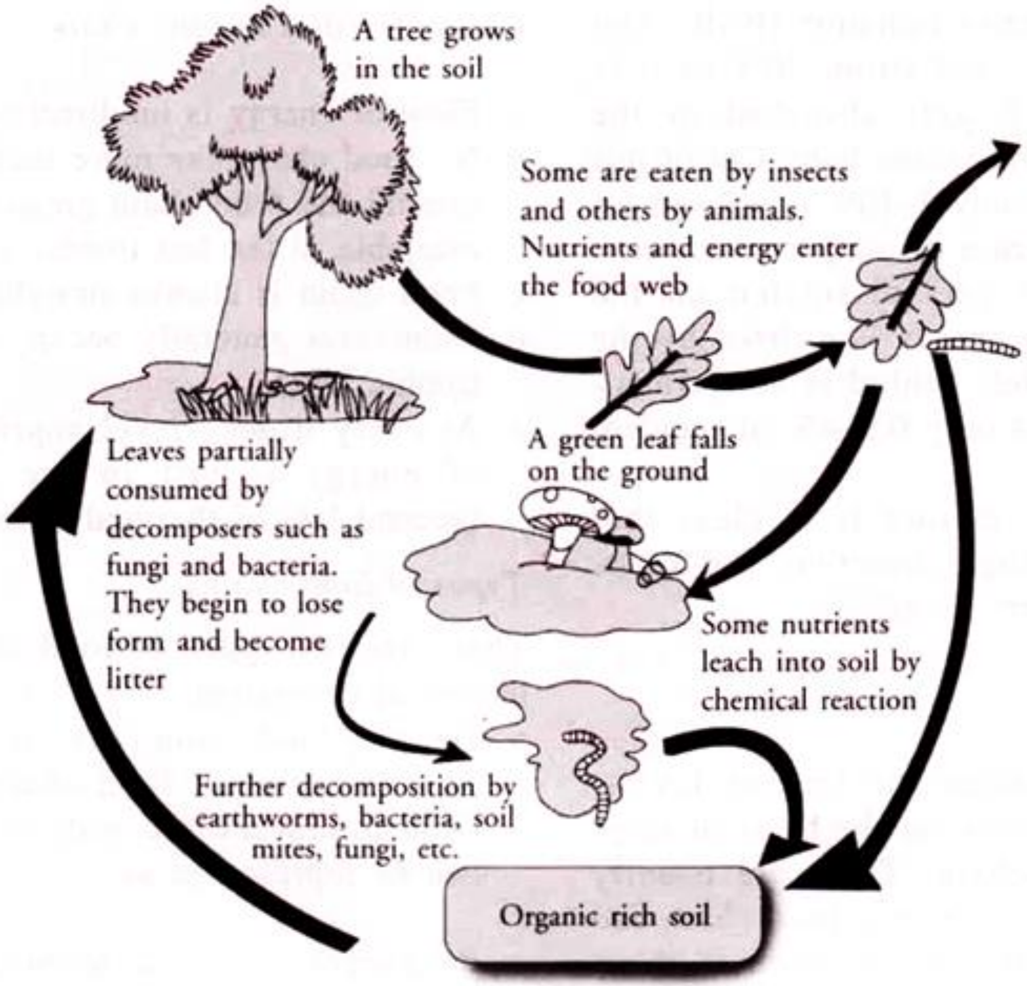


Fig. 4 Mechanism of decomposition of detritus.

Factors affecting litter decomposition

- The rate and patterns of litter decomposition are dependent on the interaction of climate, soil biota and quality and quantity of organic matter.
- One can predict gross estimates of decomposition based on the climate and the C:N:lignin rations organic matter (litter).
- The primary factors which affect litter decomposition:

a) climate,

b) vegetation,

c) substrate and its quality and

d) soil biota.

1. Climatic factors

- Climate markedly modifies the nature and rapidity of litter decomposition.
- Moisture and temperature are among the most crucial variables because they affect both the development of plant cover and the activities of microorganisms which are highly critical factors in soil formation.
- Effects of soil moisture on litter decomposition are little complicated.
- Decomposition is inhibited in very dry soils because **bacteria and fungi dry out**.
- Decomposition is also slow in very wet soils because anaerobic conditions develop in saturated soils.
- Decomposition **proceeds at faster rate at intermediate water contents.**
- Temperature is often the primary factor determining rates of litter decomposition and decomposition rate are generally more sensitive to temperature than are rates of net primary production.
- Thus, the balance between ecosystem C fixation and decomposition **may be altered under a warmer climate**, potentially causing a dramatic increase in the flux of CO_2 from soils to the atmosphere.

- For each 10 °C increase in temperature between 20 and 40 °C the rate of CO_2 production doubled.
- No CO_2 production at all was detected at 10 °C and 50 °C or above it declined markedly.
- The highest intensity of organic matter decomposition is observed under conditions of moderate temperature (about 30 °C).
- Increase or decrease of temperature beyond the optimal levels brought about a decline in the rate of organic matter decomposition.

- The rate of decomposition in **rainfall** rich forests is faster than in those where the rainfall is comparatively less.
- The percolating water from rainfall may leach the excrements and remains of organisms down to the lower horizons, where other specialized microbes will attack the remaining organic matter.
- The litter breakdown rate varies with **season**.
- Decomposition is rapid in summer, whereas the leaf litter decay to 3.75 g/m2/day during the autumn months and 0.80 g/m2/day during the remainder of the year.
- The highest decomposition of **hill evergreen forest** litter occurred in the late rainy season and early winter (0.36 t /ha/month) and
- The lowest rate in summer (0.14 t/ha/month).

2. Growing Vegetation

- In general, the decay rate in tropical plantations is lesser than those in natural forests.
- One of the reasons for slow rate of decomposition is the lack of ground cover.
- The ground cover can provide favorable microclimate and promote the abundance and activities of soil fauna and microorganisms.
- However, there are reports to indicate that the presence of growing plant significantly alters decomposition dynamics and decreases the rates of decomposition.
- Living plants can decrease decomposition rate because:

a) Microbes preferentially use labile material provided by living roots rather than more recalcitrant litter,

b) Roots release compounds that inhibit microbial activity,

c) Plants compete with microbes for uptake of nutrients and organic compounds and/ or

d) Exudates stimulate predation on microbes and thus decrease microbial populations.

- In contrast, growing plants can stimulate decomposition through inputs of labile carbon that increases the activity and turnover of microbes.
- Plants can also influence decomposition through their effects on soil temperature, moisture or oxygen concentration.

3. Vegetation type

- The decay rate in general is faster in the tropical region than in the temperate region.
- Even within the tropical region, leaf litter decomposition rates vary with the types of forests.
- Forest canopy gaps formed either by natural tree fall or branch fall or by human activities such as selective logging can also alter the process and the rate of litter decomposition.
- Canopy gap formation by natural means may lead to a situation where the microclimate is more favorable than that in closed canopy area for litter decomposition.
- Thus, litter decomposing rate increased with increase in gap size.
- However, the rate of litter decomposition declined as the canopy gaps are closed owing to reduction in the light and temperature.

4. Substrate and its quality

- The quality of the leaves as a food source for microbial decomposers is another important factor that determines the rate and pattern of litter decomposition.
- Substrate quality has been defined in many different ways-as the nitrogen concentration (N), as the lignin content, and as the C:N ratio.
- Basically, high quality leaves (nutrient rich-leaves) will decompose faster than low quality leaves (nutrient –poor leaves).
- Generally speaking, the rate of decomposition is highest in species with maximum ash and nitrogen contents and minimal C: N ratios and lignin contents

5. Soil biota

- Soil biota, playing a meditative role, in decomposition may affect the type and availability of nutrients and thus community interactions.
- Soil fauna are key to litter decomposition.
- It is also reported that the seasonal variation in rate of decomposition could be variation in abundance of soil fauna.
- Since more animals are there on the litter layer during the wet season than in dry season, rate of decomposition was faster in the former season.
- When animals were completely excluded for nine months, no visible breakdown of oak and beech leaf litter occurred.
- The same investigators reported that in earthworms removed litter the decomposition rate is three times faster than the litter from where smaller invertebrates such as springtails, enchytraeids and dipterous larvae were removed.
- Excluding micro invertebrates slowed decomposition rate of leaf liter in humid tropical forests.

BIOGEOCHEMICAL CYCLES

- Unlike the one-way flow of energy, matter is recycled within and between ecosystems.
- Elements, chemical compounds, and other forms of matter are passed from one organism to another and from one part of the biosphere to another through cycles that connect living things to the earth.
- Biogeochemical cycles connect living things to the earth.
- The four chemicals that make up 95% of living things are:
    - ✓ carbon,
    - ✓ hydrogen,
    - ✓ oxygen and
    - ✓ nitrogen.
- These elements are constantly being cycled through living and non-living organic matter.

NUTRIENT CYCLES WITHIN ECOSYSTEMS

1. Energy flows through an ecosystem and nutrients cycle within an ecosystem.

- Nutrients are substances such as water, carbon and nitrogen which are necessary for the survival of living things.

2. In an Ecosystem the Three Primary Nutrient Cycles:

A. The **Water Cycle**

B. The **Carbon Cycle**

C. The **Nitrogen Cycle**

THE WATER (Hydrologic) CYCLE: The movement of water between different reservoirs on the earth, under ground and in the atmosphere is known as the water cycle.

1. To a large degree, availability of water determines the diversity of organisms in an ecosystem.
   - ✓ **Water is crucial to Life**.
   - ✓ Cells contain 70 - 90 % water, and water provides the aqueous environment in which most of life's reactions occur.

2. The **availability of WATER** is one of the key factors that regulates the productivity of terrestrial (land) ecosystems.

3. Bodies of water such as lakes, rivers, streams, and the oceans contain a substantial percentage of the Earths water.
   - ✓ The atmosphere also contains water in the form of:
     - ➢ water vapor
     - ➢ some water found below ground known as ground water.

Processes of the Water Cycle:

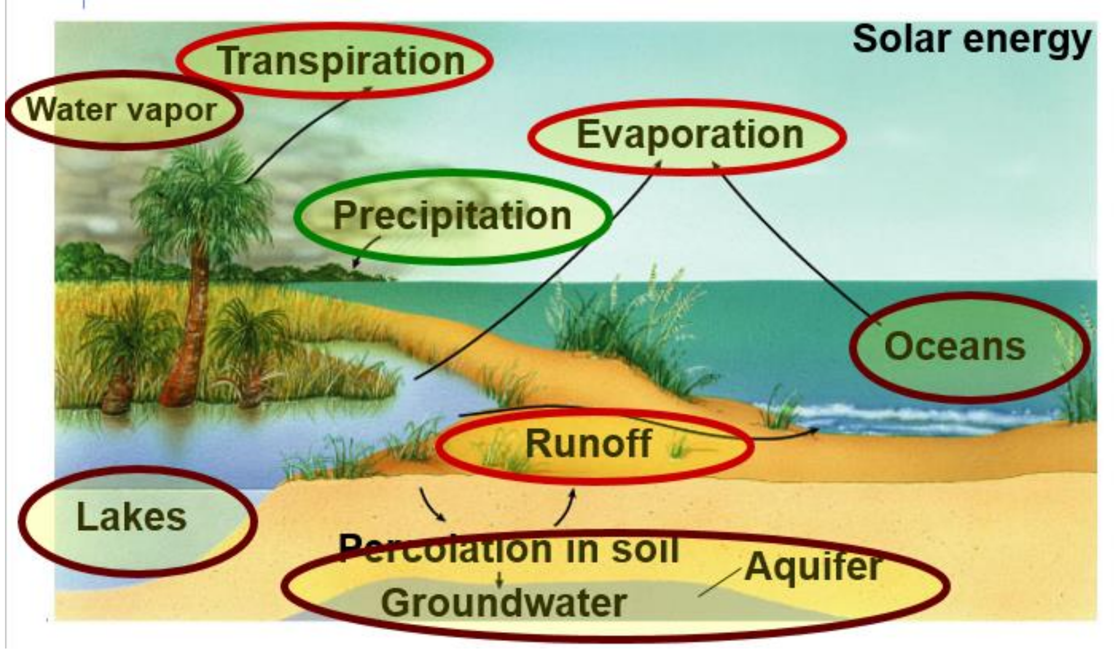
A. **EVAPORATION:** from lakes, rivers, and oceans.

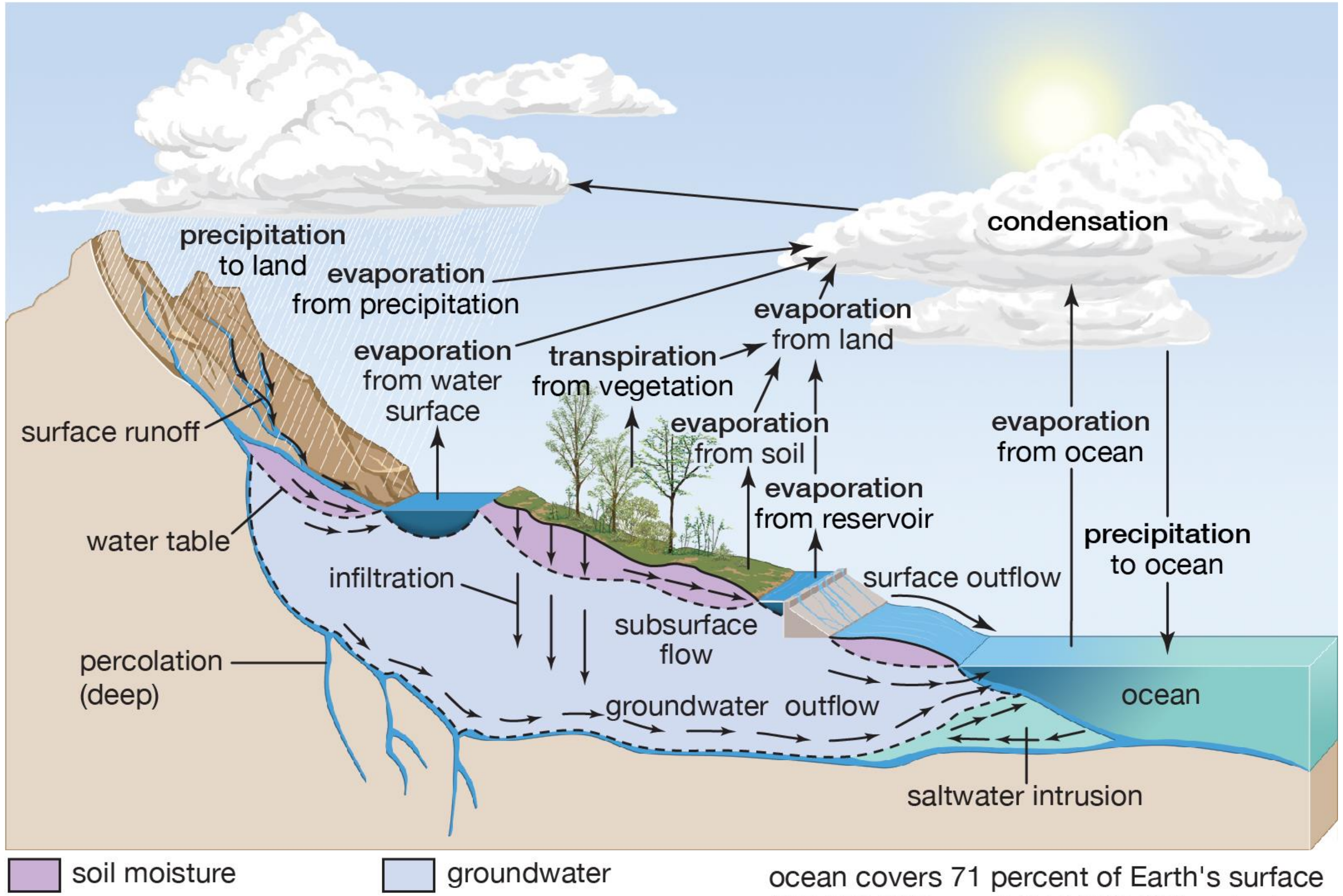
B. **TRANSPIRATION:** from plants and trees.

C. **CONDENSATION:** Cloud Formation

D. **PRECIPITATION**: Rain, Snow, Sleet, Hail.

E. **RUN OFF, or RETURNED** back into the Cycle.





THE CARBON CYCLE

1. Together, photosynthesis and cellular respiration form the basis of the carbon cycle.

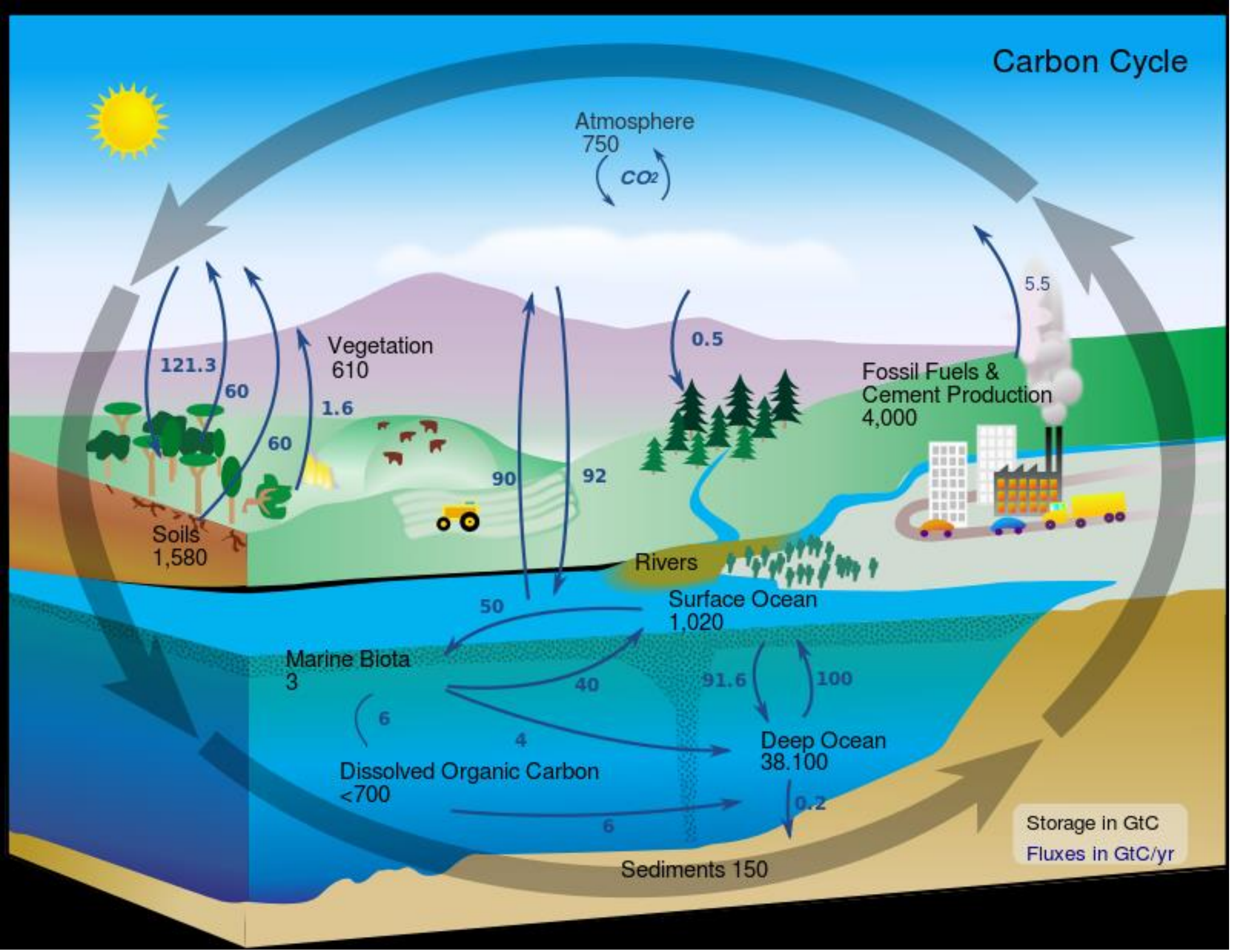
- Carbon is found in all of the major macromolecules (carbohydrates, nucleic acids, proteins and lipids) which are necessary for all living systems.

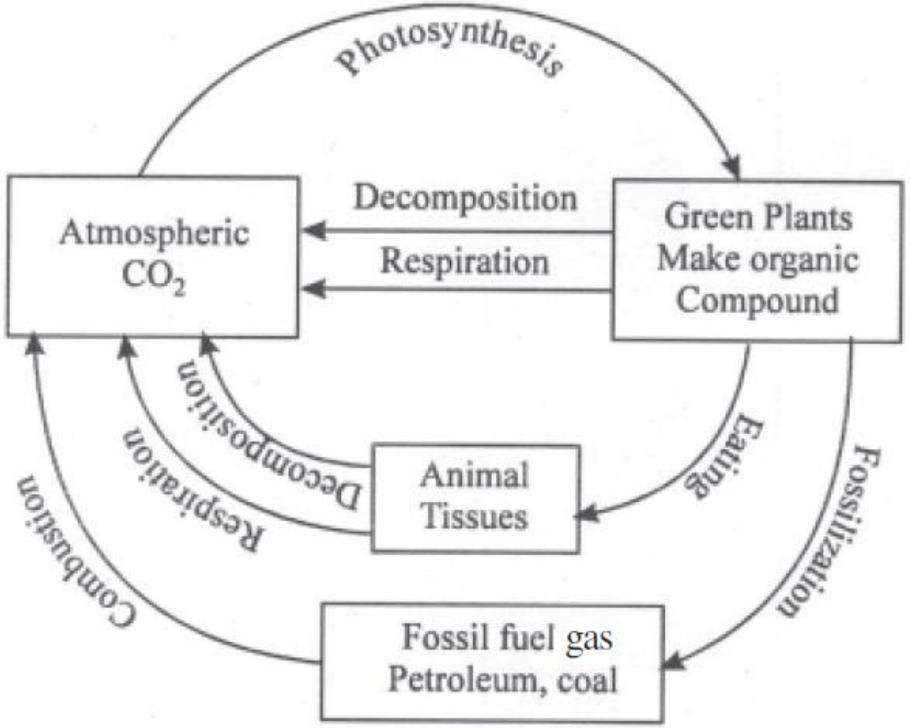
2. The Earth's atmosphere contains carbon in the form of carbon dioxide (CO^2). There are five major reservoirs of carbon:

- ✓ the atmosphere
- ✓ the terrestrial biosphere
- ✓ oceans
- ✓ ocean sediments and
- ✓ the earth's interior.

Processes of the Carbon Cycle:

- **Photosynthesis**: During photosynthesis, plants and other autotrophs use CO^2 along with water and solar energy, to build organic molecules (carbohydrates), thus storing the carbon for themselves and other organisms.
- **Cellular Respiration**: Both autotrophs and heterotrophs use oxygen to break down carbohydrates during cellular respiration.
- Consumers obtain energy-rich molecules that contain carbon by eating plants and animals.
- **Volcanic Eruptions and geothermal vents**: carbon from deep within the earth's interior is brought back to the surface during eruptions of steam, gasses and lava
- **Decomposition**: Carbon is returned to the environment through decomposers and cellular respiration (breathing releases CO_2 back to the atmosphere).
- **Combustion**: When wood or fossil fuels are burned, the chemical reaction releases carbon dioxide back into the atmosphere
- **Deposition**: Coal, petroleum, and calcium carbonate rock are deposited in sediment and underground.
- Calcium carbonate deposits are eroded by water to form carbon dioxide.
- Large amounts of carbon are tied up in wood, only returning to the atmosphere when wood is burned.





- The black numbers in the image above indicate how much carbon is stored in various reservoirs, in billions of tons ("GtC" stands for Giga Tons of Carbon).
- The dark blue numbers indicate how much carbon moves between reservoirs each year.

THE NITROGEN CYCLE

- ALL organisms need nitrogen, an important nutrient, to make proteins and nucleic acids.
- Most nitrogen is found in the atmosphere (80%) as N_2, and most living things cannot use it.
- ALL organisms rely on the actions of bacteria that are able to transform nitrogen gas into a usable form.
- Nitrogen-fixing bacteria (Cyanobacteria and Rhizobium) play a key role in the nitrogen cycle.
- They live in the soil and in the roots of some kinds of plants, such as beans, peas, clover, and alfalfa.
- These bacteria have enzymes that can break the atmospheric N_2 bonds.
- Nitrogen atoms are then free to bond with hydrogen atoms to form Ammonia (NH^3).

Processes of the Nitrogen Cycle:

NITROGEN FIXATION: is the conversion of nitrogen gas to ammonia; Ammonia can be absorbed by plants from the soil, and used to make proteins, and enter the food web for consumers.

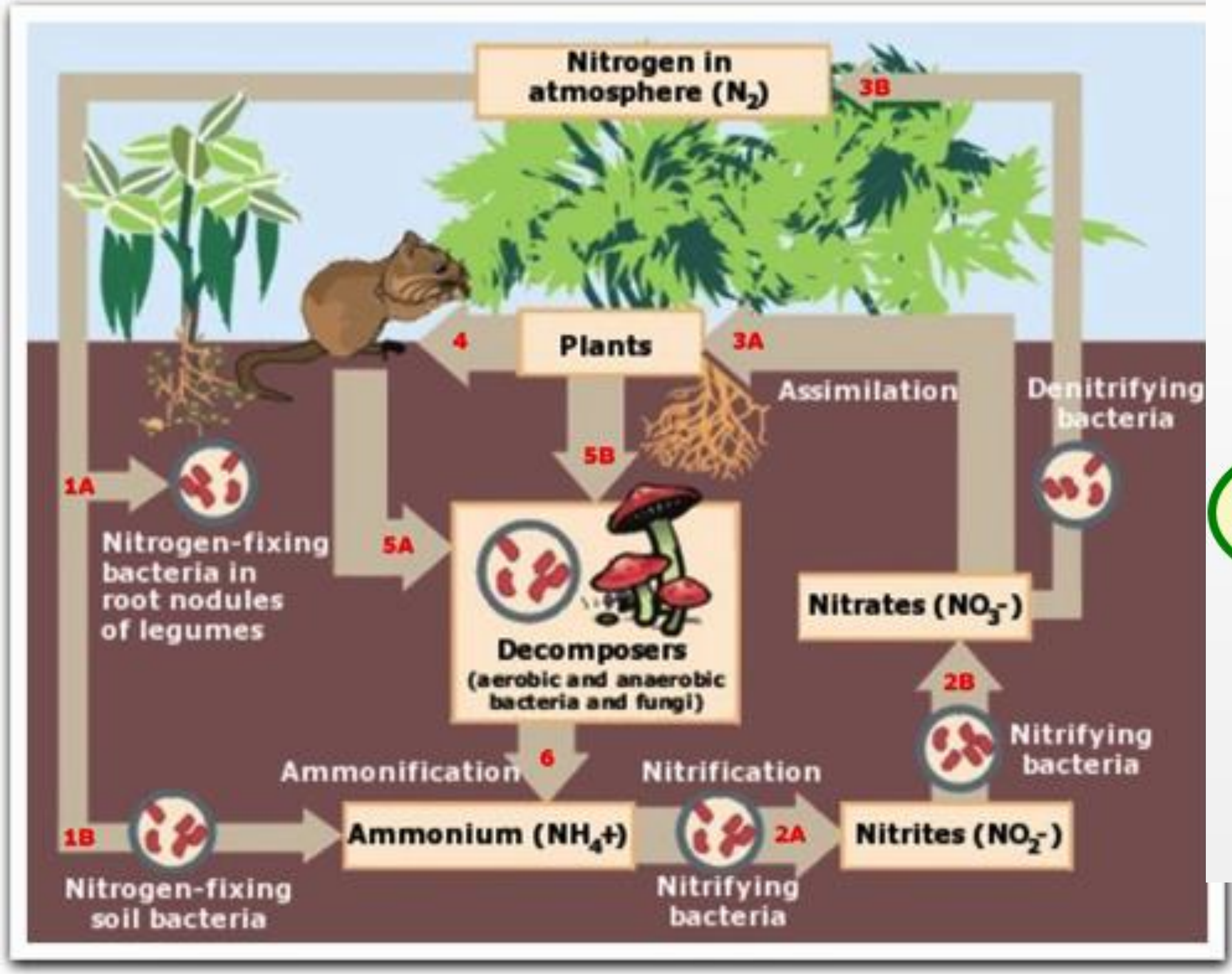
ASSIMILATION: Consumers obtain nitrogen from the plants and animals they eat by digesting the food's proteins and using it to make their own proteins.

AMMONIFICATION: Decomposers return the nitrogen from the remains of dead plants and animals back to the soil.

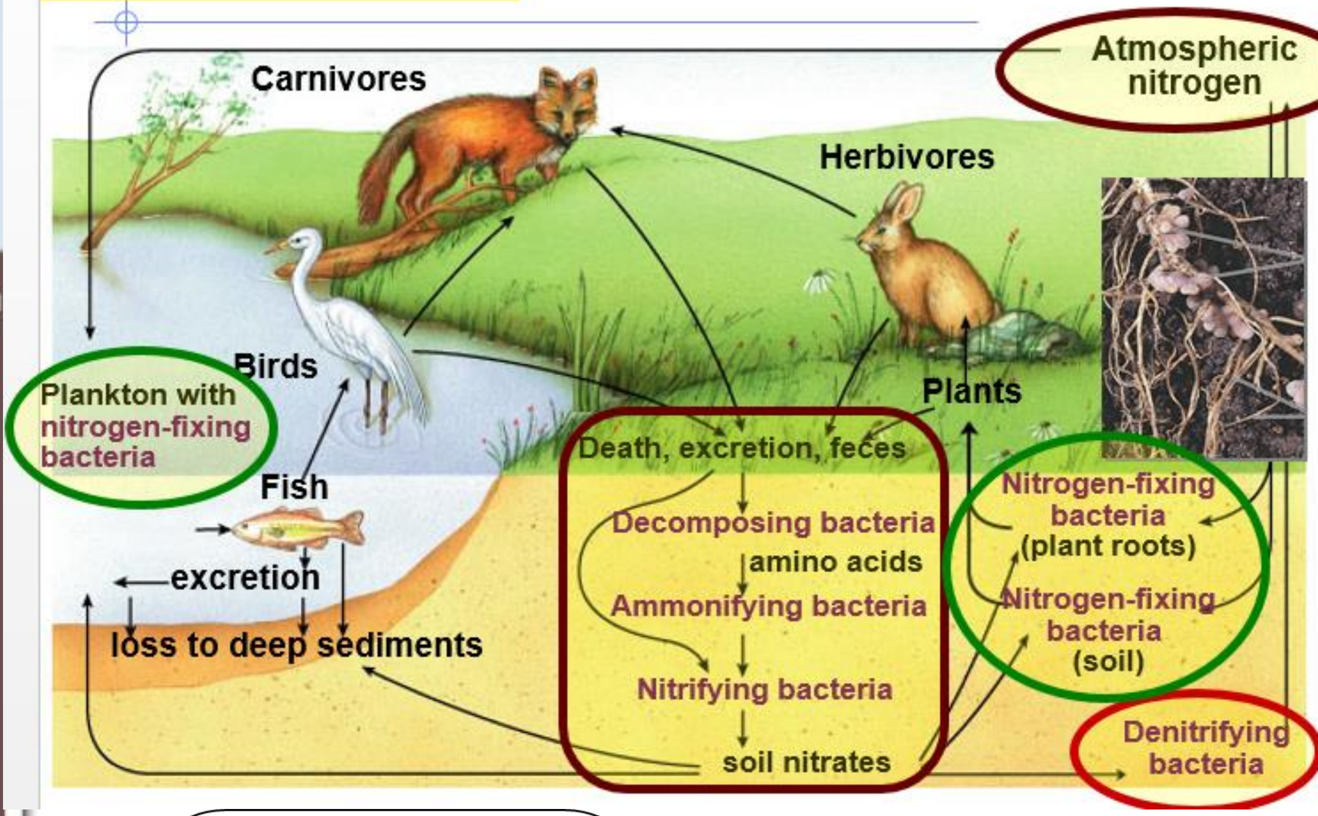
- Nitrogen is also returned from animal and plant waste by decomposers (dung, urine, leaves and bark).
- Through ammonification, nitrogen that would be lost, is recycled back into the ecosystem.
- **DENITRIFICATION**: occurs when anaerobic bacteria (chemoautotrophs) break down nitrates and release nitrogen gas back into the atmosphere.

NITRIFICATION

- Bacteria convert ammonia into nitrogen compounds that plants can utilize more easily
- Autotrophs (plants) are therefore DEPENDENT on nitrogen-fixing bacteria, and all other organisms are DEPENDENT on autotrophs!



Nitrogen cycle



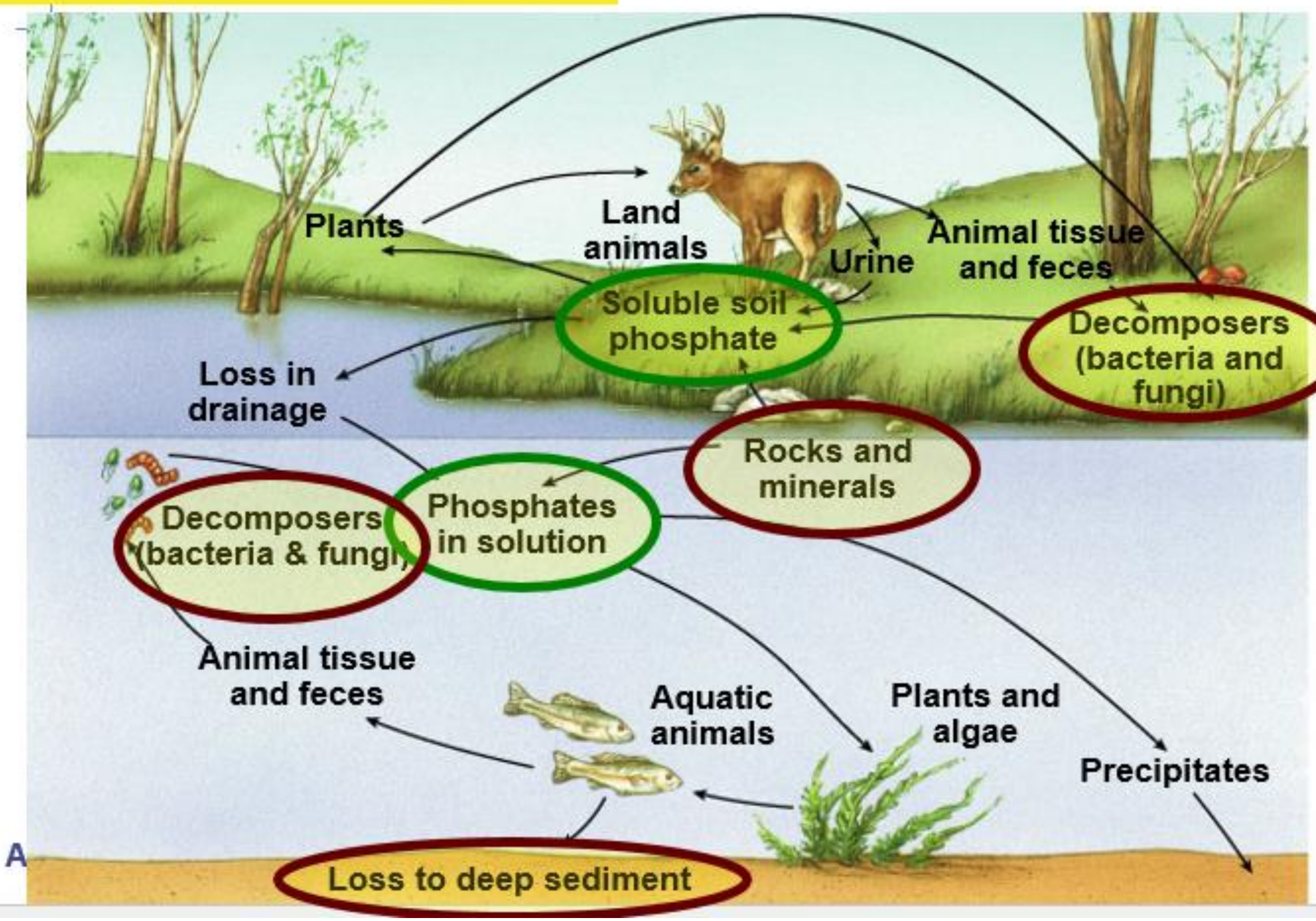
<u>abiotic reservoir</u>:
- N in atmosphere

<u>enter food chain</u>:
- nitrogen fixation by soil & aquatic bacteria

<u>recycle</u>:
- decomposing & nitrifying bacteria

<u>return to abiotic</u>:
- denitrifying bacteria

Phosphorus cycle



abiotic reservoir:
- **rocks, minerals, soil**

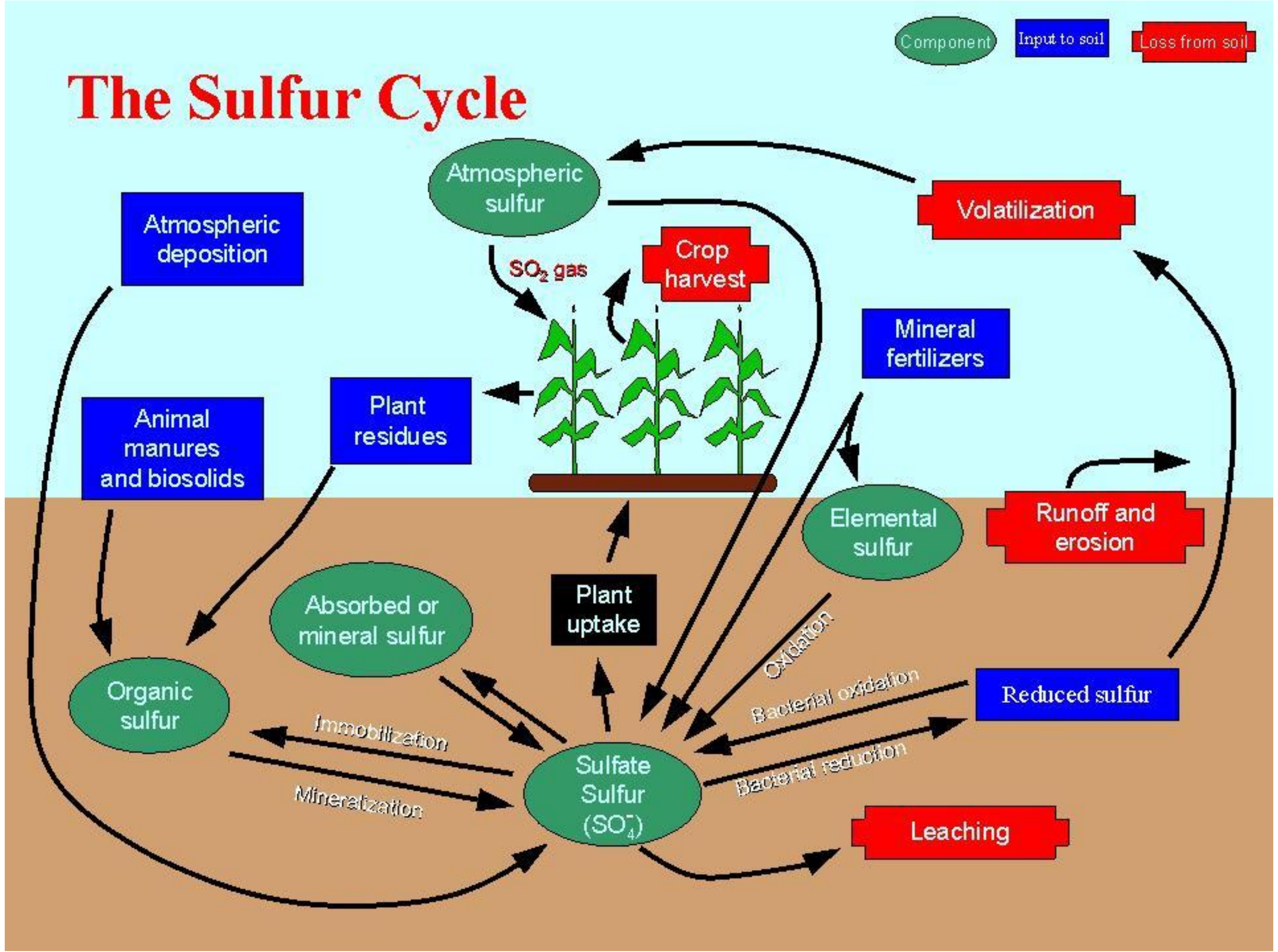
enter food chain:
- **erosion releases soluble phosphate**
- **uptake by plants**

recycle:
- **decomposing bacteria & fungi**

return to abiotic:
- **loss to ocean sediment**

Sulfur Cycle:

- Sulfur is an important nutrient for organisms, being a key constituent of certain amino acids, proteins, and other biochemical.
- Plants satisfy their nutritional needs for sulfur by assimilating simple mineral compounds from the environment.
- This mostly occurs as sulfate dissolved in soil water that is taken up by roots, or as gaseous sulfur dioxide that is absorbed by foliage in environments where the atmosphere is somewhat polluted with this gas.



Unit 6. Ecosystems

- **An ecosystem** is a group of organisms living together in a specific environment.
- Ecosystems are usually seen to be definite, discrete systems but they may be permeable to outside influences.
- **An ecosystem** is a community of plants, animals, birds and other organisms as well as the vitamins and minerals and energy sources that keep them alive.

Types of Ecosystem

- There are essentially two kinds of ecosystems;
  - ✓ Aquatic and Terrestrial - Any other sub-ecosystem falls under one of these two headings.

Terrestrial ecosystems

- ➢ Terrestrial ecosystems can be found anywhere apart from heavily saturated places.

- They are broadly classed into:

1. **The Forest Ecosystems**

- They are the ecosystems in which an abundance of flora, or plants, is seen so they have a big number of organisms which live in relatively small space.
- Therefore, in forest ecosystems the density of living organisms is quite high.
- A small change in this ecosystem could affect the whole balance, effectively bringing down the whole ecosystem.

They are further divided into:

A. Tropical evergreen forest: These are tropical forests that receive a mean rainfall of 80 for every 400 inches annually.

- The forests are characterized by dense vegetation which comprises tall trees at different heights.
- Each level is shelter to different types of animals.

B. Tropical deciduous forest: There, shrubs and dense bushes rule along with a broad selection of trees.

- The type of forest is found in quite a few parts of the world while a large variety of fauna and flora are found there.

C. Temperate evergreen forest: Those have quite a few number of trees as mosses and ferns make up for them.

- Trees have developed spiked leaves in order to minimize transpiration.

D. Temperate deciduous forest: The forest is located in the moist temperate places that have sufficient rainfall.

- Summers and winters are clearly defined and the trees shed the leaves during the winter months.

E. Taiga: Situated just before the arctic regions, the taiga is defined by evergreen conifers.

- As the temperature is below zero for almost half a year, the remainder of the months, it buzzes with migratory birds and insects.

2. The Desert Ecosystem

- Desert ecosystems are located in regions that receive an annual rainfall less than 25.
- They occupy about 17 percent of all the land on our planet.
- Due to the extremely high temperature, low water availability and intense sunlight, fauna and flora are scarce and poorly developed.
- The vegetation is mainly shrubs, bushes, few grasses and rare trees. The stems and leaves of the plants are modified in order to conserve water as much as possible.
- The best known desert ones are the succulents such as the spiny leaved cacti.
- The animal organisms include insects, birds, camels, reptiles all of which are adapted to the desert (xeric) conditions.

3. The Grassland Ecosystem

- Grasslands are located in both the tropical and temperate regions of the world though the ecosystems vary slightly.
- The area mainly comprises grasses with a little number of trees and shrubs.
- The main vegetation includes grasses, plants and legumes that belong to the composite family.
- A lot of grazing animals, insectivores and herbivores inhabit the grasslands.

- The two main kinds of grasslands ecosystems are:

A. Savanna: The tropical grasslands are dry seasonally and have few individual trees.

- They support a large number of predators and grazers.

B. Prairies: It is temperate grassland, completely devoid of large shrubs and trees.

- Prairies could be categorized as mixed grass, tall grass and short grass prairies.

4. The Mountain Ecosystem

- Mountain land provides a scattered and diverse array of habitats where a large number of animals and plants can be found.
- At the higher altitudes, the harsh environmental conditions normally prevail, and only the treeless alpine vegetation can survive.
- The animals that live there have thick fur coats for prevention from cold and hibernation in the winter months.
- Lower slopes are commonly covered with coniferous forests.

Aquatic Ecosystems

- The aquatic ecosystem is the ecosystem found in a body of water. It encompasses aquatic flora, fauna and water properties, as well.
- There are two main types of aquatic ecosystem - Marine and Freshwater.

A. The Marine Ecosystem

- Marine ecosystems are the biggest ecosystems, which cover around 71% of Earth's surface and contain 97% of out planet's water.
- Water in Marine ecosystems features in high amounts minerals and salts dissolved in them.
- The different divisions of the marine ecosystem are:

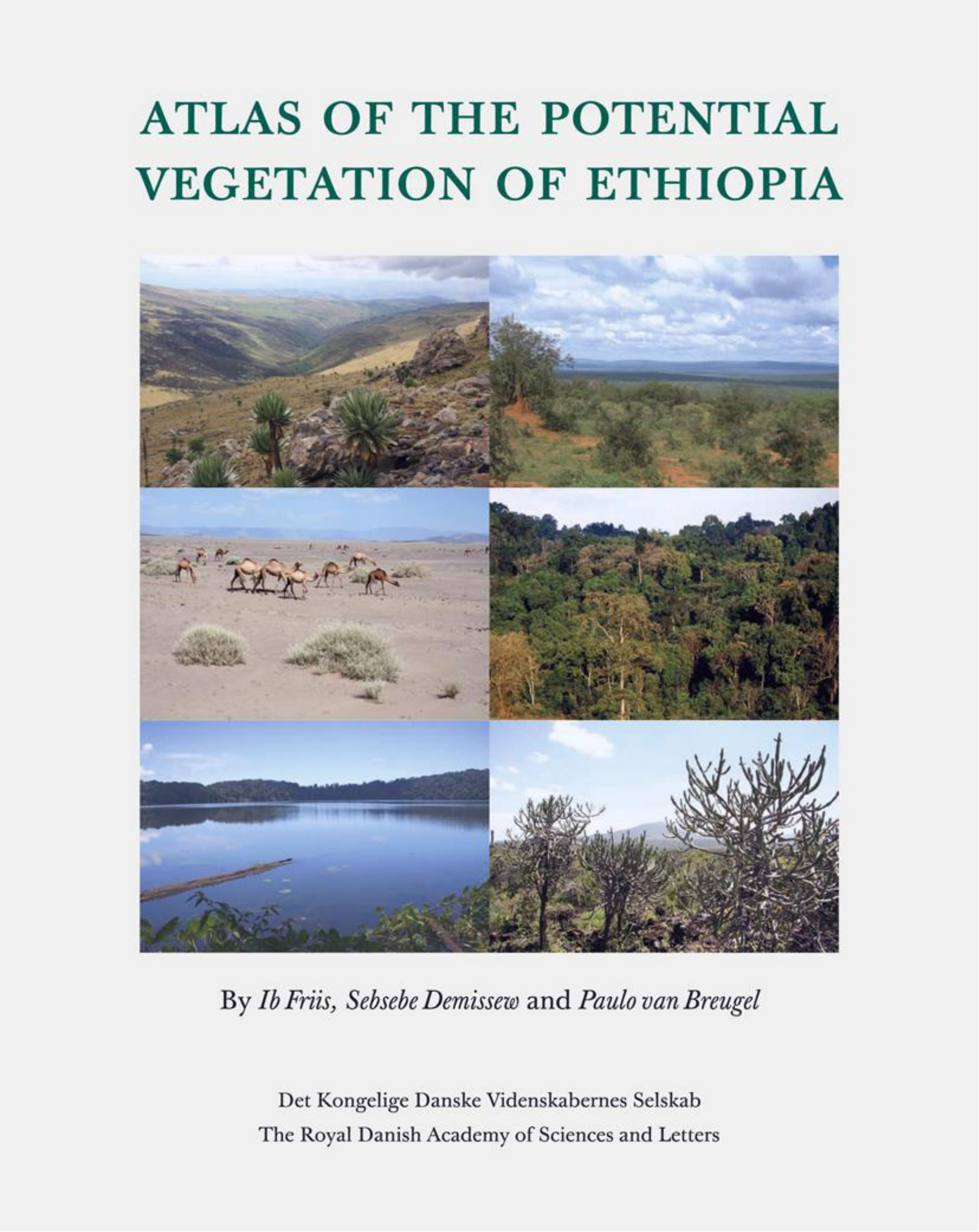
    - ✓Oceanic: A relatively shallow part of oceans which lies on the continental shelf.
    - ✓Profundal: deep or Bottom water.
    - ✓Benthic Bottom substrates.
    - ✓Inter-tidal: The place between low and high tides.
    - ✓Estuaries
    - ✓Coral reefs
    - ✓Salt marshes
    - ✓Hydrothermal vents where chemosynthetic bacteria make up the food base.

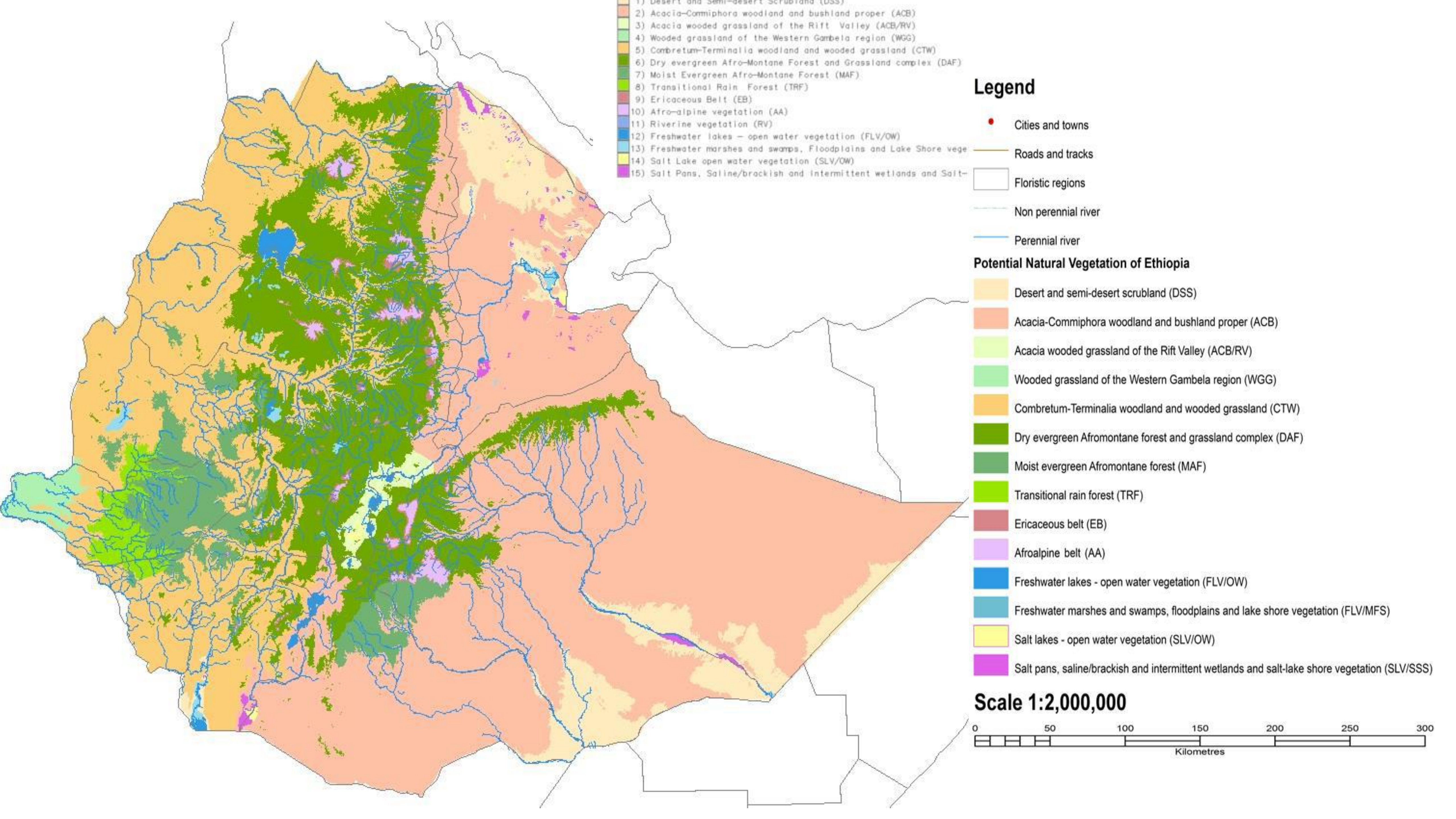
- Many kinds of organisms live in marine ecosystems: the brown algae, corals, cephalopods, echinoderms, dinoflagellates and sharks.

B. The Freshwater Ecosystem

- Contrary to the Marine ecosystems, the freshwater ecosystem covers only 0.8% of Earth's surface and contains 0.009% of the total water.
- Three basic kinds of freshwater ecosystems exist:
  - ✓ **Lentic:** Slow-moving or till water like pools, lakes or ponds.
  - ✓ **Lotic:** Fast-moving water such as streams and rivers.
  - ✓ **Wetlands:** Places in which the soil is inundated or saturated for some lenghty period of time.
- The ecosystems are habitats to reptiles, amphibians and around 41% of the world’s fish species.
- The faster moving turbulent waters typically contain a greater concentrations of dissolved oxygen, supporting greater biodiversity than slow moving waters in pools.

Potential natural vegetation map of Ethiopia




2) Acacia-Commiphora woodland and bushland proper (ACB)
3) Acacia wooded grassland of the Rift Valley (ACB/RV)
4) Wooded grassland of the Western Gambela region (WGG)
5) Combretum-Terminalia woodland and wooded grassland (CTW)
6) Dry evergreen Afro-Montane Forest and Grassland complex (DAF)
7) Moist Evergreen Afro-Montane Forest (MAF)
8) Transitional Rain Forest (TRF)
9) Ericaceous Belt (EB)
10) Afro-alpine vegetation (AA)
11) Riverine vegetation (RV)
12) Freshwater lakes - open water vegetation (FLV/OW)
13) Freshwater marshes and swamps, Floodplains and Lake Shore vege
14) Salt Lake open water vegetation (SLV/OW)
15) Salt Pans, Saline/brackish and intermittent wetlands and Salt-
Legend
Cities and towns
Roads and tracks
Floristic regions
Non perennial river
Perennial river
Potential Natural Vegetation of Ethiopia
Desert and semi-desert scrubland (DSS)
Acacia-Commiphora woodland and bushland proper (ACB)
Acacia wooded grassland of the Rift Valley (ACB/RV)
Wooded grassland of the Western Gambela region (WGG)
Combretum-Terminalia woodland and wooded grassland (CTW)
Dry evergreen Afromontane forest and grassland complex (DAF)
Moist evergreen Afromontane forest (MAF)
Transitional rain forest (TRF)
Ericaceous belt (EB)
Afroalpine belt (AA)
Freshwater lakes - open water vegetation (FLV/OW)
Freshwater marshes and swamps, floodplains and lake shore vegetation (FLV/MFS)
Salt lakes - open water vegetation (SLV/OW)
Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation (SLV/SSS)
Scale 1:2,000,000
0 50 100 150 200 250 300
Kilometres

Desert and Semi desert

DISTRIBUTION:

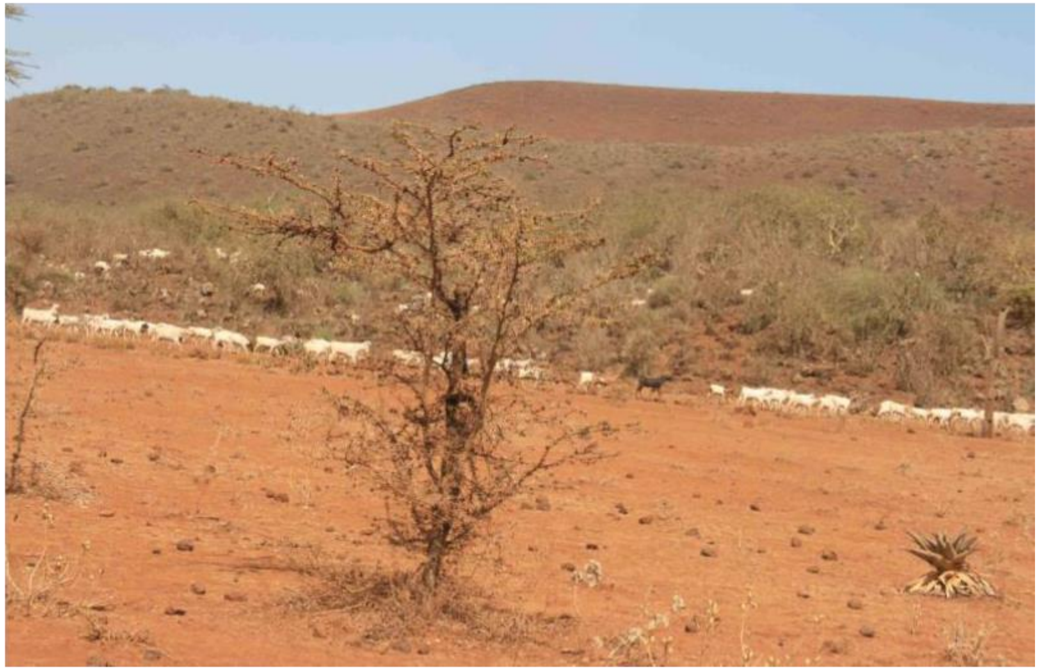
- This vegetation type occurs in large parts of the AF floristic region, the Ogaden, around Lake Chew Bahir and the delta of the Omo river in GG, and in the extreme lowlands of the BA, SD and HA floristic regions.
- The western part of the AF floristic region has an open type of *Acacia- Commiphora* bushland.

❖ This vegetation is found below 400 meters altitude in eastern Ethiopia.

❖ It is characterized by the presence of small trees, shrubs and herbs, which may be succulent, geophytic or annual.

CHARACTERISTIC SPECIES:

- The characteristic species of trees and shrubs include *Acacia ehrenbergiana* (Fabaceae subfam. Mimosoideae), *Boswellia ogadensis*, *Commiphora erosa*, *C. longipedicellata* (all Burseraceae), *Gyrocarpus hababensis* (Hernandiaceae), *Kissenia arabica* (Loasaceae), *Ochradenus baccatus* (Resedaceae), *Diceratella revoilii* (Brassicaceae); *Cadaba barbigera*, *C. divaricata*, (all Capparidaceae), and *Ziziphus hamur* (Rhamnaceae).



***Acacia-Commiphora* Woodland**

(Subtype 2a) Acacia-Commiphora woodland and bushland proper (ACB)

CHARACTERISTIC SPECIES of ACB:

- The trees and shrubs form an almost complete canopy and among the species are: *Acacia bussei*, *A. drepanolobium* (often dominant on black soils in places with impeded drainage), *A. hamulosa*, *A. ogadensis*, *A.prasinata* (**endemic**), *A. tortilis*, *A. zizyphispina* (all Fabaceae subfam. Mimosoideae), *Boswellia microphylla*, *B. neglecta*, *Commiphora alaticaulis*, *C. albiflora*, *C. ancistrophora*, *C. boiviniana*, *C. boranensis*, *C. campestris*, *C. ciliata*, *C. confusa*, *C. coronillijolia*, *C. corrugata*, *C. cyclophylla*, *C. ellenbeckii*, *C. gowello*, *C. hildebrandtii*, *C. mildbraedii*, *C. myrrha*, *C. obovata*, *C. quadricincta*, *C. rostrata*, *C. serrulata*, *C. sphaerophylla*, *C. truncata* (all Burseraceae), *Balanites aegyptiaca*, *B. rotundifolia* (both Balanitaceae), *Boscia minimifolia*, *Cadaba ruspolii*, *C. rotundifolia*, *Capparis tomentosa* (all Capparidaceae); *Combretum aculeatum and Terminalia orbicularis* (both Combretaceae).

DISTRIBUTION:

- This vegetation type occurs in the northern, eastern, central and southern parts of the country between 400-(900) and 1600 - 1800(-1900) meters altitude.

- It is particularly characteristic of extensive areas in the Southern and South-eastern lowlands and in the western part of the AF floristic region.

(Subtype 2 b) *Acacia wooded grassland of the Rift Valley* (ACB/RV)

CHARACTERISTIC SPECIES:

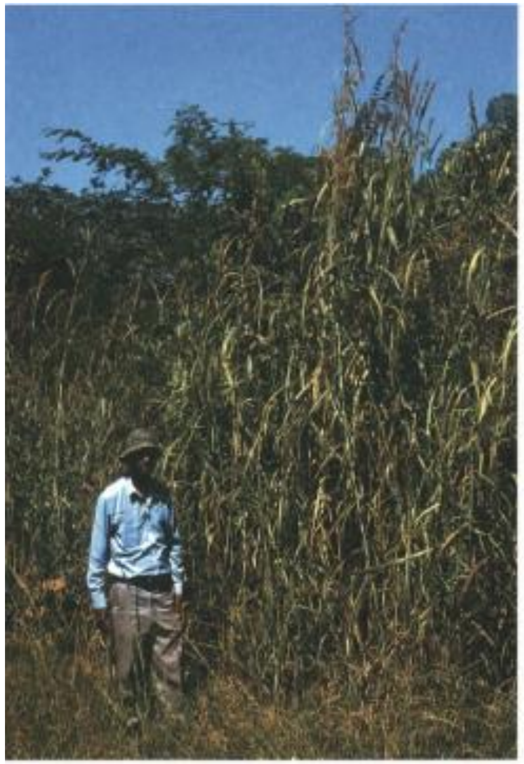
- The tree stratum consists mainly of *Acacia etbaica*, *A. seyal*,*A. albida*, *A. tortilis*, *A. Senegal*, etc. (all Fabaceae subfam. Mimosoideae).
- Other genera are *Croton* (especially *C. dichogamus*), and a candelabra-shaped *Euphorbia* (both Euphorbiaceae).
- The Grasses belong mainly to the genera *Hyparrhenia*, *Heteropogon*, *Setaria*, *Sporobolus* and *Panicum*.
- There are also some succulents, including the widespread *Aloe trichosantha* and the endemic *A. gilbertii* subsp. *gilbertii* (both Aloaceae).
- Other endemic species include the succulent *Euphorbia nigrispinioides* (Euphorbiaceae).

DISTRIBUTION:

- The wooded grasslands of the Rift Valley occur from the upper part of the Awash river in the north along the Rift Valley lakes to the town of Konso in the south.
- On the slopes of the Rift Valley above the wooded grassland there is a range of vegetation types, in the south-western part of the Rift Valley a narrow zone of Combretum-Terminalia woodland, on the eastern side mainly vegetation of the Dry Afromontane forest and grassland complex.

(3) *Wooded grassland o f the Western Gambela region* (WGG)

- This vegetation is characterized by a tall grass stratum that burns annually, and a canopy layer of trees that can both tolerate burning and temporary flooding.



CHARACTERISTIC SPECIES:

- The most dominant species in the tree stratum are species of *Acacia* (Fabaceae subfam. Mimosoideae), especially *A. seyal* and *A. nilotica*.
- The palms *Hyphaene thebaica* and *Borassus aethiopum* may also occur, either singly or together.
- In the grass stratum species of *Echinochloa*, *Setaria*, *Hyparrhenia*, *Cymbopogon* and *Sorghum* are common.
- In the most flooded areas there are nearly pure stands of *Oryza*, especially *O . longistaminata*.
- Moisture tolerant herbs are also common in the flooded areas, for example *Caperonia serrata* (Euphorbiaceae), and *Thalia geniculata* (Maranthaceae).

DISTRIBUTION:

- This vegetation occurs in Ethiopia only in the western part of the Gambela region.

- (4) *Combretum-Terminalia woodland and wooded grassland* (CTW)

CHARACTERISTIC SPECIES:

- The small to moderate sized trees with fairly large deciduous leaves characteristic of *Combretum-Terminalia woodland and wooded grassland* (CTW) include *Cussonia arborea* (Araliaceae), *Boswellia papyrifera* (Burseraceae); *Anogeissus leiocarpa*, *Combretum adenogonium*, *C. hartmannianum* (near endemic), *C. molle*, *C. rochetianum* (near endemic), *C. collinum*, and species of *Terminalia*, for example *Terminalia laxiflora*, *T macroptera*, and *T. schimperiana* (all Combretaceae); *Lonchocarpus laxiflorus*, *Pterocarpus lucens*, *Dalbergia melanoxylon*, *Piliostigma thonningii* (all Fabaceae subfam. Papilionoideae), *Balanites aegyptiaca* (Balanitaceae), *Stereospermum kunthianum* (Bignoniaceae), species of *Lannea*, for example *L. barteri*, *L.Jruticosa*, *L. schimperi* and *L. schweinfurthii*, *Ozoroa insignis*, *0 . pulcherrima*, *Sclerocaryabirrea* subsp. *birrea* (all Anacardiaceae), *Vitexdoniana* (Lamiaceae), *Acacia hockii* (Fabaceae subfam. Mimosoideae), and *Grewia mollis* (Tiliaceae). *Adansonia digitata* (Bombacaceae) is rather rare, but it does occur in the Tekeze valley and in the western parts in Benshangul- Gumuz [Benishangul-Gumuz] north to the village of Gelego, south of Metema, in the GD floristic region.

DISTRIBUTION:

- This vegetation type occurs along the western escarpment of the Ethiopian highlands, from the border region between Ethiopia and Eritrea to the western KF floristic region to Sudan and the Omo Zone.
- It is the dominant vegetation in large parts of what is now Gambela (Western lowlands of the IL floristic region), the Benshangul-Gumuz (western part of the GJ and WG floristic regions), the Didcsa valley [Dedesa valley] in WG in Oromya extending to the lower parts of Quara to Humera (in the GD floristic region), where it occurs at 500-1900 meters altitude.

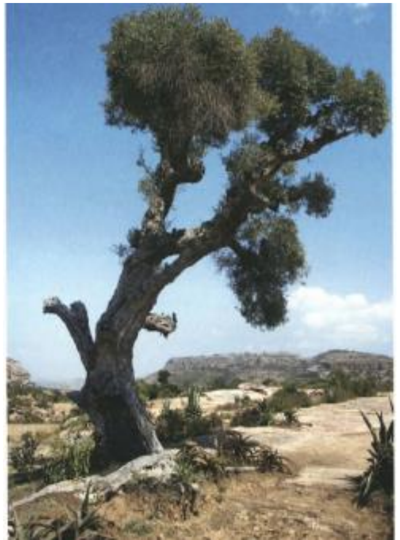
(5) *Dry evergreen Afromontane forest and grassland complex* (DAF)

DISTRIBUTION:

- Throughout the highlands above 1800 meters and below 3000 meters from the border with Eritrea to scattered areas with high ground in the south; avoiding higher rainfall areas in the western and south-eastern parts o f the highland, where it is replaced by vegetation type (6) *Moist evergreen Afromontane forest* (MAF).
- A broad outline of the distribution of (DAF) is indicated by the modelled distribution of *Juniperus procera* (Cupressaceae).
- In contrast, both the established and the modelled distribution of *Podocarpus falcatus* (Podocarpaceae)
- transgresses the western boundary of this vegetation type into the area of (MAF.

CHARACTERISTIC SPECIES:

- As mentioned above, the characteristic species of canopy tree of this forest type is *Juniperus procera*, with *Olea europaea* subsp. *cuspidata* in the lower storey.
- Smaller trees and shrubs recorded from the northern forests include *Acokanthera schimperi* (dominant species), *Carissa spinarum* (both Apocynaceae), *Calpurnia aurea* (Fabaceae subfam. Papilionoideae), *Clausena anisata* (Rutaceae), *Clutia abyssinica* (Euphorbiaceae), *Discopodium penninervium* (Solanaceae), *Euclea racemosa* subsp. *schimperi* (Ebenaceae), *Grewia ferruginea* (Tiliaceae), *Maesa lanceolata* (Myrsinaceae), *Morelia salicifolia* (Myricaceae), *Psydrax schimperianum* (Rubiaceae), *Teclea nobilis* (Rutaceae), and *Rhus natalensis* (Anacardiaceae).



Dry Evergreen Afromonatne Forest

(6) *Moist evergreen Afromontane forest* (MAF)

- In most cases this vegetation type is characterized by one or more closed strata of evergreen trees that may reach a height of 30 to 40 meters.

CHARACTERISTIC SPECIES:

- These forests predominantly contain broad-leaved evergreen species in the multilayered canopy. *Podocarpus falcatus* may occur in the eastern- and northernmost of these forests, but *Podocarpus* is never prominent (and it may occasionally only be present due to human introduction).
- while *Pouteria adolfifriederici* (Sapotaceae) seems to become more prominent in the same direction, although this statement is now difficult to verify due to the profound human influence on the forests.
- The 10-30 meters high main canopy consists of *Albizia gummifera*, *A. schimperiana*, *A. grandibracteata* (predominant at lower altitudes; all Fabaceae subfam. Mimosoideae), *Cassipoureamalosana* (Rhizophoraceae), *Celtis africana* (Ulmaceae), *Sapium ellipticum*, *Macaranga capensis* var. *kilimandscharica*, *Croton macrostachyus*, *Euphorbia ampliphylla* (most common in clearings at forest margins and in secondary forest, may form monospecific stands; all four Euphorbiaceae), *Ekebergia capensis* (Meliaceae), *Ficus sur, F. ovata, F. thonningii* (all Moraceae), *Hallea rubrostipulata* (predominant at lower altitudes, Rubiaceae), *Ilexmitis* (Aquifoliaceae), *Ocotea kenyensis* (Lauraceae), *Olea welwitschii (Oleaceae), Polysciasfulva, Schefflera abyssinica* (both Araliaceae), *Prunus africana* (Rosaceae), and *Syzygium guineense* subsp. *afromontanum* (Myrtaceae). e.t.c.

DISTRIBUTION:

- Two major blocks of this vegetation type exist in the highlands over 1800 meters.
- One south-western block has its main distribution in the KF, IL and WG floristic regions and relatively small outlying patches in the GJ and GG floristic regions.
- Another block exists in the southern part of the BA floristic region and in the northern part of the SD floristic region.

Fig_25A.tif

Fig_25B.tif

Moist Montane Forest

(7) *Transitional rain forest* (TRF)

CHARACTERISTIC SPECIES:

- The canopy of (TRF) includes *Manilkara butugi*, *Pouteria altissima* (Fig. 28H), *Pouteria alnifolia* (all Sapotaceae), *Anthocleista schweinfurthii* (Loganiaceae), *Antiaristoxicaria*, *Ficusmucuso*, *F. exasperata*, *Milicia excelsa*, *Morns mesozygia*, *Trilepisium madagascariense* (all Moraceae), *Alstonia boonei* (Apocynaceae), *Croton sylvaticus* (Euphorbiaceae), *Celtis toka*, *C. zenkeri*, *C. gomphophylla* (all Ulmaceae), *Diospyrosabyssinica* (Ebenaceae), *Zanhagolungensis*, *Albizia schimperiana*, *and A. grandibracteata* (Fabaceae subfam. Mimosoideae), all of which either form or emerge from the main canopy.

DISTRIBUTION:

- Scattered examples of these forests are known from the western escarpment of the Ethiopian highlands in the WG, IL and KF floristic regions, where the rainfall and hence humidity from the rain bearing south-westerly winds is highest.
- The forests occur at altitudes between 450 and 1500 meters.
- The rainfall is close to 2000 millimeters/year or higher (up to 2700 millimeters/year), with some rain all the year round.
- The transitional rain forests are most similar in physiognomy and composition to the humid broadleaved Afromontane rainforests of south-western Ethiopia (characterized as Moist Afromontane forests).

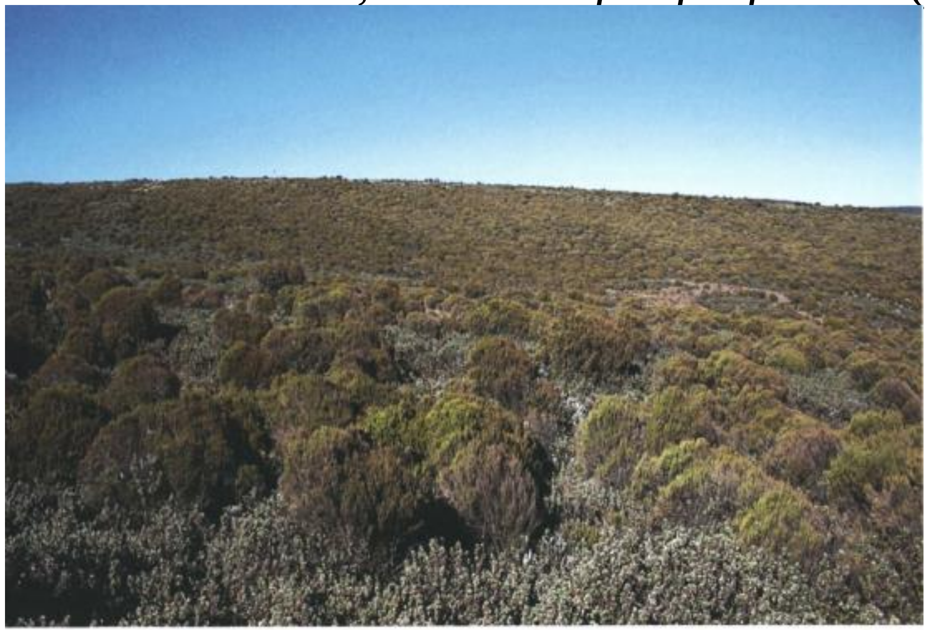
Transitional Forest

(8) *Ericaceous belt* (EB)

- CHARACTERISTIC SPECIES: is characterized by the dominance of shrubs and shrubby trees such as *Erica arborea*, *Erica trimera* (both Ericaceae), *Hypericum revolutum* (Guttiferae), *Myrsine melanophloeos* (Myrsinaceae) and perennial subshrubs or herbs, for example *Alchemilla haumannii* (Rosaceae), *Geranium arabicum* (Geraniaceae), *Anthemis tigreensis*, *Erigeron afroalpinum*, *Haplocarpha rueppellii*, *Helichrysum citrispinum*, *H. splendidum*, *H. gofense*, *H. formosissimum*, *Senecio schultzii* (all Asteraceae), *Romulea fscheri* (Iridaceae), *Satureja biflora*, *Thymus schimperi* (Lamiaceae), *Trifolium acaule*, and *T. burchellianum* (Fabaceae subfam. Papilionoideae).
- On dry rocky slopes in the Semien mountains *Aloe steudneri* is common, while *Kniphofia foliosa* (Asphodelaceae) dominates in moister places, also in the Bale mountains.
- A special flora is found on steep,

moist and shaded places, for example

Primula verticillata (Primulaceae).



(9) *Afroalpine belt* (AA)

- **CHARACTERISTIC SPECIES:** Th*e Afroalpine belt* (AA) is best characterized by a combination of giant Lobelias, cushion-forming species of *Helichrysum* (Asteraceae), shrubby species of *Alchemilla* (Rosaceae), and prominence of temperate grass genera *(Festuca*, *Poa*, *Deschampsia*, etc.).
- The presence of *Lobelia rhynchopetalum* can be taken as an indicator of the AA, but *Lobelia rhynchopetalum* has not been recorded from all areas of Ethiopia with altitudes above about 3200 meters.
- The evergreen shrubs or small trees include *Erica arborea* (Ericaceae) and *Hypericum revolutum* (Guttiferae).
- They mostly occur as shrubs, but when protected

against fire and cutting they can grow into trees.

DISTRIBUTION:

- As stated above, this vegetation type occurs in areas above an altitude of approximately 3200 meters.
- It occurs on the highest mountains in the country (all measurements must be taken with some reservation, as the indications often vary from source to source): Amba-Alage mountain (3440 meters) in the TU floristic region, the Choke mountains (4070 m) in the GJ floristic region, the Semien mountains in the GD floristic region (the tallest peak in the Semien mountains is Ras Dejen (4620 m), other notable peaks in the Semien include Bwahit mountain (4430 meters) and Abba Yared mountain (4460 meters)),
- other high mountains in GD include Guna mountain (4231 meters), high mountains in the WU floristic region are for example Abune Yosef mountain (4260 meters) and Amba Farit mountain (3975 meters), in the SU floristic region high mountains are for example Abuye Meda mountain (4305 meters) and the Gurage mountains (3720 meters), in the GG floristic region the Guge highlands (4200 meters), in the AR floristic region Chilalo mountain (4139 meters), Kaka mountain (4190 meters) and Badda mountain (4133 meters), in the BA floristic region the extensive Bale mountains (in which the highest peaks are Tulu Dimtu mountain (4377 meters) and Batu mountain (4307 meters), but the entire Sanetti plateau, an area of more then 20 x 18 kilometers, is above 4000 meters altitude.

- As mentioned above, there are many small peaks in Ethiopia that reach just above an altitude of 3200 meters.
- These include, in the TU floristic region, Mt. Amba Simba (Mt. Asimba, north-east of Adigrat, 3204 meters), and Mugulat mountain (Alekeye mountain, south-west of Adigrat, 3245 meters), Tulu Welel mountain [Tulu Walel mountain] (3273 meters) in the WG floristic region, Wuchacha mountain (3320 meters) and Entoto mountains (c. 3200 meters) in the SU floristic region, Delo mountain (ca. 3600 meters), the highest point in the Amaro mountains in the SD floristic region, and Gara Muleta mountain (3380 meters) in the HA floristic region.

(10) *Riverine vegetation* (RV)

CHARACTERISTIC SPECIES:

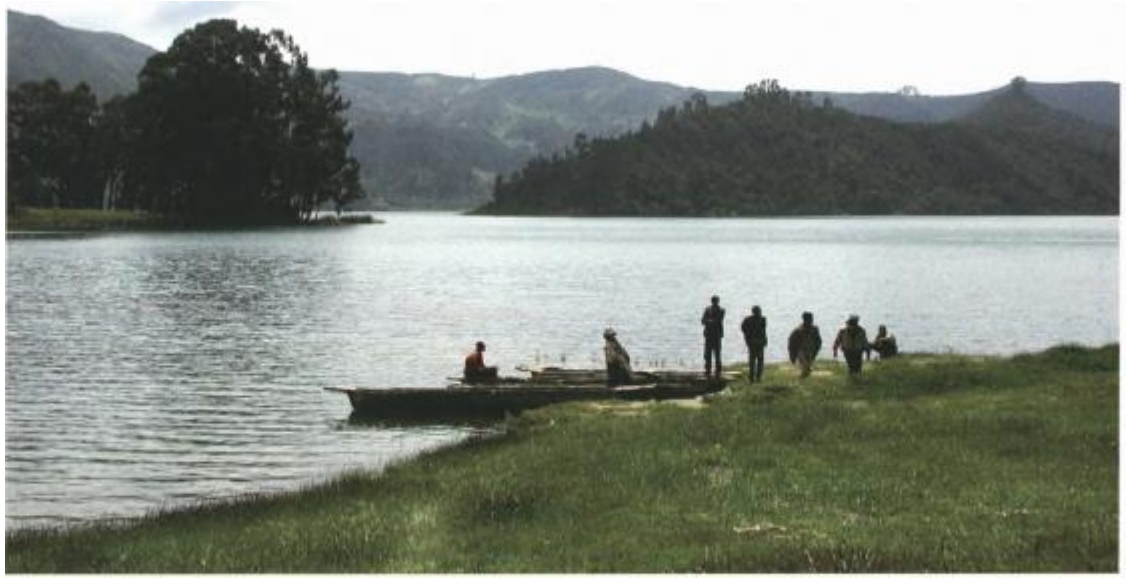
- Riverine species may also be associated with high ground water table for other reasons than the presence of a river. In a place approximately 30 kilometres north-west of Gonder on thenroad to Humera at 1600 metres altitude a small depression contained riverine tree species.
- There is a considerable number of species of woody plants that are only recorded from riverine forest in Ethiopia.
- Typical trees in riverine forest include *Acacia polyacantha* subsp. *campylacantha* (Fabaceae subfam. Mimosoideae), *Celtis ajricana* (Ulmaceae), *Ficus*
- *sycomorus* (Moraceae), *Mimusops kummel* (common in the forest), *Mimusops laurifolia* (both Sapotaceae; the latter only associated with rivers and temporary streams running to the Afar lowlands), and *Breonadia salicina* (Rubiaceae).
- Additional trees found in these forests are: *Salix subserrata* (Salicaceae), *Syzygium guineense* subsp. *guineense* (Myrtaceae), **T***amarindus indica* (Fabaceae subfam. Caesalpinioideae) e.t.c.

DISTRIBUTION:

- *Riverine vegetation* (RV) as defined here can be found in almost all parts of the country with permanent or temporary rivers and other streams below an altitude of 1800 metres
- However, *Riverine vegetation* (RV) is relatively rare in the driest parts of the AF, HA and SD floristic regions; GD & GJ.

(11) *Freshwater lakes, lake shores, marsh and floodplain vegetation* (FLV)

(Subtype 11a) *Freshwater lakes - Open water vegetation* (FLV/OW)



CHARACTERISTIC SPECIES:

- The characteristic species include floating aquatics such as native *Lemna aequinoctalis*, L. gibba, L. minor, Wolf a arrhiza (Lemnaceae), Pistia stratiotes (Araceae), the invasive Eichhomia crassipes, E. natans (both Pontederiaceae).
- In addition there are a number of phytoplankton species.

Examples include: Anabaena spp., Aphanothece microspora, Chroococus disperses, Closterium spp., Meliorosa granulata, Microcystis aeruginosa, etc.

DISTRIBUTION:

- The major freshwater lakes in Ethiopia include Lake Tana (in the GJ and GD floristic regions), Lake Ashange [Ashenge] (in the TU floristic region), Lakes Hayk and Ardibo (in the WU floristic region), Lake Langano and Lake Ziway (both in the SU floristic region), Lake Awasa (in the SD floristic region), Lakes Abaya, Chamo andTurkana (spanning the border between the SD and GG floristic regions).
- There are also smaller sized crater lakes such as Bishoftu Crater Lakes (Bishoftu, Hora, Arenguade, Pawlo and Kilotes) [Lake Chilotes; Lake Hora-Kilole] in the vicinity of Bishoftu (Debre Zeit) town, Lake Ziquala, Lake Hareshetan (west of Butajira town) (all in the SU floristic region) and Lake Zengena (in the GJ floristic region).
- The Koka reservoir, damming the Awash river (in the SU floristic region), and the Fincha and Chomen reservoirs, damming the Fincha river (and surrounded by the Chomen swamp, in the WG floristic region), are the two oldest; they are shown on the map.
- The remaining reservoirs, such as Melka Wakena reservoir, damming the Melka-Wakena river (in the BA floristic region), and the Gilgel Gibe reservoir I, damming the Gilgel Gibe river (in the KF floristic region).

(Subtype 11b) *Freshwater marshes and swamps, floodplains and lake shore vegetation* (FLV/MFS)

CHARACTERISTIC SPECIES:

- The characteristic species in Freshwater marsh/swamp, floodplain and lake shore vegetation along the shores of fresh water lakes include the sedges such as *Cyperus digitatus*, *C. denudatus*, *C. dichroostachys*, *C. elegantulus*, *C. latifolius*, *Ascolepis capensis* (Cyperaceae), but also a number of other herbs, including *Juncus dregeanus* (Juncaceae), *Floscopa glomerata* (Commelinaceae), *Eriocaulon* spp. *Syngonanthus wahlbergii* (both Eriocaulaceae), *Xyris capensis* (Xyridaceae), *Persicaria decipiens* and other *Persicaria* spp. (Polygonaceae), *Ludwigia abyssinica(Onagraceae), Chenopodium album* (Chenopodiaceae), *Ranunculus multibus* (Ranunculaceae), *Sphaeranthus* sp. (Asteraceae), *Plectranthus punctatus* (Lamiaceae), *Leersia hexandra*, and *Panicum hygro chans* (both in Poaceae), and *Nymphaea lotus* (Nymphaeaceae).
- There are relatively few woody species that are clearly associated with lake shores, etc.
- Among the woody species characteristic of these habitats are *Phoenix reclinata (*Arecaceae) and species of the genera *Aeschynomene* and *Sesbania* (Fabaceae subfam. Papilionoideae), particularly: *Aeschynomene cristata* var. *pubescens, Aeschynomene elaphroxylum, Aeschynomene pfundii* and *Aeschynomene schimperi.*

DISTRIBUTION:

- Freshwater lakes are mainly found in the Western highlands (in GD, GJ, WU and SU floristic regions), and in the central and southern part of the Rift Valley in the GG, SD, SU and AF floristic regions.
- Only few and small freshwater lakes are found east of the Rift Valley.
- Freshwater swamps and lake shore vegetation occur often in association with the above mentioned lakes, but swamps are also scattered in the Western lowlands and in areas of the highlands mentioned above.

(12) ***Salt lakes, salt-lake shores, marsh and pan vegetation*** **(SLV)**

(Subtype 12a) ***Salt lakes - open water vegetation*** **(SLV/OW)**

CHARACTERISTIC SPECIES:

- The vegetation along these lakes depends on the measure of salinity.
- At high salinity species of the family Chenopodiaceae tends to dominate.
- There are also a number of characteristic species of phytoplankton in this vegetation type, mainly consisting of cyanobacteria (Cyanophyta). Examples include: *Anabaenopsis* spp., *Anomoeoneis sphaerocarpa*, *Oscillatoria* spp., *Spirulina platensisis*, etc.

DISTRIBUTION:

- The salts in the salty lakes in the central rift valley including Lakes Abijata, Shala and Chitu (all in the SU floristic region) mainly consist of sodium bicarbonate (soda lakes), while the salts in the salt lakes in the in the more arid parts of the country, where both temperatures and evaporation are high, mainly consist of sodium chloride (the common salt of the ocean).
- There are three groups of salt lakes in the AF floristic region.
- The first consists of Lake Abe, Afambo and Bario that are all fed by Awash river.

(Subtype 12b) *Saltpans, saline/brackish and intermittent wetlands and salt-lake shore vegetation* (SLV/SSS)

CHARACTERISTIC SPECIES:

- The vegetation type is characterized by *Suaeda monoica*, and herbaceous species of *Atriplex* spp. and *Salicomia* spp. (all Chenopodiaceae).

DISTRIBUTION:

- This subtype is restricted to the Danakil depression in the AF floristic region, the lakes in the central and southern part of the Rift Valley in SU, SD and GG floristic regions, and along the Wabi Shebele river in the southern part of the HA floristic region.

Afroalpine Forest

Riverine Vegetation

Marshes and Floodplains, Swamp Forests

Salt-water lakes, Lake shores, salt marshes, and pan vegetation

DSD< 400 m

ACB: 400-1800 m

WGG:

CTW: 400-1800 m

DAF: 1800-3200 m

MAF: 1800-3200 m

EB: > 3200 m

AA: > 3500 m

Unit 7. Applications of Plant Ecology

1. Agriculture

- Ecology has great applications in agriculture.
- Agriculture provides us food and fibers.
- Agriculture depends on ecological principles.
- These principles are limiting factors, irrigation requirement, pest control and productivity.
- Ecology helps to conserve the land.
- It helps to reclaim the alkaline and water logging soil.

2. Forestry

- The developing countries are facing problem of population explosion.
- This rapid increase in population growth increase requirements for food and shelter.
- Therefore man is cutting trees for agriculture and for wood used in houses.
- Ecology helps in reforestation and afforestation.
- Ecologists are devising ways to stop deforestation, desertification and over grazing.

3. Wild life management

- **All non-cultivated plants and non-domesticated animals are included in wild life.**
- All living organisms are interdependent, A balance is present between living organisms and environment.
- Man is disturbing this balance since very long.
- **A species that is near to extinction is called endangered species.**
- Today there are thousands of endangered plants and animals.
- Wild life is a non-renewable resource.
- Ecologists are trying to save the endangered species.

4. Fishery and Aquaculture

- There is almost over fishing in rivers, lakes and seas.
- Therefore, population of fishes is decreasing in these water bodies.
- Ecological principles help to maintain population of fishes in rivers, ponds and lakes.

5. Range land management

- **The grass land used by the animals for grazing is called rangeland.**
- Rangeland has great importance -for livestock development.
- Unfortunately, man has changed most of the rangeland into agricultural land.
- maintenance of rangeland is one of the applications of ecology.
- Ecological studies tell us how much population of grazer a rangeland can sustain.
- It also tells us about the impact of destruction of rangeland on ecological cycle.

6. Water shed management

- Many dams are constructed all over the world.
- They have a lot of ecological impacts.
- Most the dams are facing the problem of silting that rapidly filling the dam.
- Ecology helps to stop the silting process.
- Plantation of tree in water shed area can reduce silting.

7. Conservation of soil

- Soil provides all essential contents to the plants.
- It provides water, mineral and oxygen to plant.
- All these contents are required in balance state.
- Soil erosion, alkalinity and water logging have badly affected the soil.
- Ecology provides us the solution of all these problems.
- Soil erosion can be controlled by planting trees and keeping thick vegetation cover.
- Ecology has devised many methods to control water logging.

8. Control of pollution

- **The contamination of environment with harmful and unwanted chemicals is called pollution.**
- Industrialization has destroyed our environment.
- These industries are producing a huge amount of industrial wastes.
- Those wastes pollute our environment.
- The industrial waste contains a large amount of toxic and **carcinogenic** (cancer causing) materials.
- Ecology helps us to control pollution.
- The ecologists are using the technique of bioremediation.

THE END

THANK YOU!!!

WE ALL ARE RESPONSIBLE TO KEEP THE HEALTH OF OUR ECOSYSTEM!!!