

## ENVIRONMENTAL SCIENCE

### ECOLOGY: A Study of Relationships

Ecology is the study of organisms in their natural environment.

- Ecosystem- A group of plants, animals, and other organisms which live together and interact with the surrounding physical environment.
  - Includes biotic (living) and abiotic (non-living) components
- Ecosystems can be natural or human made.
- A natural ecosystem contains all resources needed to support its organisms.
- Human made ecosystems are farms, cities, flower gardens, terrariums and aquariums.
- Human made ecosystems are seldom self sustaining systems.
- Ecosystems require a huge input of resources and energy.

### WORLD BIOMES

Biome- A large geographic region determined by the climate and soil type

Climate: The average weather pattern over a long period of time.

#### The Major Land biomes

##### Arctic Tundra

- Temp- Very low temperatures, cold winds, only surface soil thaws, growing seasons 60 days or less.
- Precipitation- Often less than 10 in/yr, falls mostly during the summer months.
- Soil Type- This, Acidic, few nutrients, permafrost- layer of permanently frozen soil.

##### Northern Coniferous Forest or Taiga

- Temp- Short summer, long cold winters, above freezing for only 2-4 months
- Precipitation- 14-39 in/yr, falls mostly during summer months.
- Soil Type- Thin, acidic soils, little humus (decayed matter) lacks nutrients no permafrost.

##### Temperate Deciduous Forests

- Temp- -30C to +30C, distinct seasons, growing seasons 5 months in North.
- Precipitation- 29-59 in/yr, snow in north, evenly spaced throughout year.
- Soil Type- Rich in humus, medium nutrient level, more decomposed than tundra.

##### Temperate Grasslands or Prairie

- Temp- Distinct seasons, moderate seasonal temperatures, hot summer & cold winters, continuous winds.
- Precipitation- 10-39 in/yr mostly in spring and early summer, growing season limited by rainfall, periodic drought.
- Soil Type- Ten times more humus than deciduous forest, very rich in nutrients, deep topsoil.

##### Desert

- Temp- cold, temperate, or tropical daily temperature variation, may be greater than seasonal variation.
- Usually less than 10 in/yr., years of drought, dry winds, high evaporation rate, flash floods.
- Soil Type- Sandy, little ability to hold water, some rich in nutrients, others nutrient-poor.

##### Tropical Savanna

- Temp- Cool and hot dry seasons, separated by warm and rainy seasons, no cold season.
- Precipitation- 39-59 in/yr, wet spring and fall, long dry spells during hot months, heavy thunderstorms.
- Soil Type- Fertile soils, deep layer of topsoil, grasses prevent erosion.

##### Tropical Rainforest

- Temp- Tropical daily variation 9F is greater than seasonal continuous growing season
- Precipitation- More than 78 in/yr, seasons determined by amount of rainfall.
- Soil Type- Thin soils, few nutrients, if exposed to sun, forms cement like layer, rapid leaching

#### Habitats

- Habitat- The part in an ecosystem where an organism prefers to live.
- A good habitat provides enough food, and water, suitable living space, and cover that an organism needs.
- Cover- Describes the places where animals can hide to escape predators or where the young can be protected from harm, provides the animals with shelter from harsh weather.

#### Populations

- Species- Similar organisms that breed to produce fertile offspring in their natural environment.

- Population- The total number of individuals of a species living in a defined region.
- Community- All of the different species living together in a defined area

#### Habitat Fragmentation

- Habitat fragmentation- the breaking of habitats into smaller isolated pieces.
- Fragmentation in large tracts of forests is partly responsible for the large declining populations
- To survive animals need a suitable habitat.
- The greatest threat to most species of wildlife is the destruction of their habitat.

#### Limits to Population Growth

- Carrying capacity the maximum population existing in the ecosystem at any given time without damage to the ecosystem.
- Limiting factor- anything limiting the growth of a species.
- When the population of one place becomes too crowded many species emigrate (move to other areas)
- Population density- number of a species per unit area of living space.
- Organisms spread disease more quickly in crowded areas
- As human population increases the population of species that cannot tolerate human activity decline.

#### Food chains, Food Webs, Trophic Levels

- Producer- An organism that can use the sun's energy to make its own food through photosynthesis
  - Photosynthesis- the process a plant uses to make its food.
  - Producers are vital to the ecosystem because they make food for other species.
  - Plants on land and algae in oceans and freshwater.
- Consumers- organisms that cannot make their own food.
- Herbivores- consumers that eat plants.
- Carnivores- consumers that eat meat.
- Omnivores- consumers that eat plants and meat.
- Decomposers- feed on waste products or bodies of other dead organisms.
  - Decomposers recycle nutrients
- Niche- an organism's role in the ecosystem.
  - Describes the position of the organism in the food chain.
- Predator- an organism that feeds on other animals must hunt/kill the animal first.
- Prey- the hunted and killed animal.
- Scavengers- animals that eat organisms that died naturally or were killed by other organisms.
- Parasites- consumer that feeds on living organisms.
- Host- the organism that is eaten.

#### Energy Maps

- Food chain- a diagram that shows the flow of energy from green plant or algae to consumer organisms.
 

Producer → herbivore → Carnivore (omnivores are both herbivore and carnivore)
- Arrows in the food chain flow from the organism being eaten to the organism that is eating it
- Food web- shows the many possible food chains in the ecosystem.
- More complex webs mean the ecosystem is more stable.

#### Predators

- Predators control the size of a population
- Game species- species that humans can legally hunt.
- Bounty- Money people pay to control predators.
- Predators balance the reproductive power of most animals.

#### The Flow of Energy through an Ecosystem

- About 30% of solar energy reaching the earth's surface is reflected from the surface of warm water, land, clouds, air, plants and human-made structures.
- About 70% is absorbed by water, land, clouds, air, human made structures and plants.

- Most absorbed energy is changed to heat energy.
- Once it is trapped by chlorophyll in plants, solar energy is changed to chemical energy (photosynthesis).
- In the process of photosynthesis low energy molecules are combined to make high energy molecules.
  - carbon dioxide and water are combined to make sugar.
- Photosynthesis provides the foundation for the flow of energy through the ecosystem.

#### Pyramids

- Biomass- the total amount of all organic matter at any level in a food chain.
- To determine the biomass of the producers in an ecosystem you have to collect all plants in one unit area dry them and weigh them.
- Biomass of producers is always greater than the biomass of herbivores.
- The biomass of herbivores is always greater than the biomass of carnivores.
- The biomass decreases with each step in the food chain.
- Only about 10% of the biomass on one level is passed on to the next.
- 90% of the energy is lost from one trophic level to the next as heat, waste and unused material.

#### Number Pyramids -Population Dimensions

- Usually large numbers of organisms at the base are required to support smaller numbers at the top; this makes a pyramid of numbers.
- The numbers of organisms at each level do not always make a pyramid.
- The biomass always makes a pyramid, but the number of organisms doesn't.
- If the producer is very large there may be a smaller number of organisms at the base.
  - Ex: if the producer is an oak tree rather than a small bush
- Productivity- the amount of biomass created in an ecosystem over a period of time.
- The most productive ecosystem is the aquatic ecosystem.
- Coral reefs produce 70,000 pounds of algae per acre per year.
- The biomass that an ecosystem can grow per unit area depends on the solar energy that reaches the ecosystem, the nutrients and water available, and the length of the growing season.
- Energy is lost at each step in the food chain which means there will be smaller population of the organisms at the higher levels.

#### MATTER AND ENERGY CYCLES

##### Cycles in the Ecosystem

- Matter- anything that takes up space and has mass.
- Matter can be recycled within an ecosystem, unlike energy.
- In a closed ecosystem matter is never gained or lost.
- With controlled light and temperature sealed ecosystems can continue to function without loss or gain of matter.
- Light provides the energy and microorganisms recycle the chemicals.
- In a natural ecosystem some matter is gained or lost, but most matter is recycled.
- Wind and water are the most likely source of matter entering from one ecosystem into another.
- Biogeochemical cycles- the flow of chemicals between the environment and organisms in it.
- Biogeochemical cycles are essential to the survival of all ecosystems.

### The Carbon-Oxygen Cycle

- Plants combine carbon dioxide and water to make sugar.
- The sugar is used for energy and in other compounds like proteins, oils and starches.
- Organic compounds- The compounds produced by plants that contain carbon.
- Plants give off oxygen as a waste product.
- Plants animals and microorganisms use oxygen in the process of respiration and release carbon dioxide.
- Respiration-The process in which organisms break down compounds containing carbon and release energy.
- Combustion- carbon dioxide is produced during the process of burning.
- When things containing carbon are burned the carbon gets chemically combined with oxygen and carbon dioxide is released.
- Plants release carbon dioxide into the atmosphere in the process of photosynthesis but at a much slower rate.
- When organisms die decomposers break down the carbon compounds in their body and carbon dioxide is released into the atmosphere.
- During decomposition other chemicals are returned to the soil and into the air.

### The Nitrogen Cycle

- The air is about 78% nitrogen
- Plants and animals cannot use nitrogen directly from the atmosphere.
- Nitrogen Fixing- Bacteria in the soil and water have to change nitrogen gas into nitrogen fertilizers that plants can use.
  - Nitrogen fixers- the bacteria .
- Nodules- the houses on the roots of plants where most nitrogen-fixing bacteria live.
- Legumes- The plants that the nitrogen-fixing bacteria live on.
- Lightning combines nitrogen and oxygen in the atmosphere and creates usable nitrogen.
- Dissolved in the rain the fixed nitrogen goes into the soil where the bacteria convert it into nitrate fertilizer.
- Burning fossil fuels is another major source of nitrogen.
- The high temperature during combustion cause the nitrogen and oxygen to combine creating nitrogen oxides (NO<sub>x</sub>)

### The Mineral Cycle

- Most minerals in an ecosystem are stored in rocks.
- They are released from the rocks by wind water and changes in temperature.
- Weathering- the process of physical and chemical forces releasing minerals from rocks.
- Chemical weathering occurs when acidic rain dissolves minerals in the rocks.
- Roots also produce chemicals that dissolve minerals in rocks.
- Trees absorb some of the minerals and others are carried away by water moving through the soil, that process is called leaching.

### The Water (hydrologic) Cycle

- The hydrologic (or water) cycle describes the movement and storage of water on earth.
- The total amount of water doesn't change.
- The sun provides the energy for the water cycle.
- Most water enters the atmosphere through evaporation.
- Evaporation occurs when the sun's energy heats the water changing it from a liquid to a gas called water vapor.
- Transpiration- the loss of water vapor from the leaves of the plant.
  - Stomata- openings in a leaf that water vapor diffuses from.
- Condensation- the process of water vapor changing into a liquid.
  - Condensation nuclei-small particles in the atmosphere that provide surfaces on which water vapor collects and condenses.
- Precipitation- all moisture falling from the atmosphere collectively.
- Runoff- the water that flows over the earth's surface.
- Infiltration- the process of precipitation entering the ground.
- Percolation- when water moves through the soil and rocks until it reaches the impermeable layer.
- Groundwater- the layer of water on top of the impermeable material.

- Aquifer- the layer of permeable rock where water is stored.
- The amount of precipitation is an important factor in determining the type of ecosystem and the population of the organisms it can support.

#### Succession: Changes in Ecosystems

- Ecological Succession- A series of changes in which the original species are replaced by new species that immigrate into an ecosystem due to a change in conditions.
- Ecological succession is the natural “aging” of an ecosystem.
- In cold, dry climates the rate of succession is very slow.
- Pond Ecosystem Succession
  - Pioneer stage- the muddy bottom of a pond when it is first being created.
  - Submerged plant stage- When the hummus (decayed organisms and aquatic plants) at the bottom of the pond allows plants to grow there, but the plants do not reach the surface.
  - Emerging Plant Stage- When larger plants begin to grow that break the surface of the water.
  - At this stage organisms found in the pioneer stage are all gone.
  - Organisms that require high oxygen levels cannot live in the pond because the stagnant water creates low oxygen levels.
  - As years past the pond is filled with plants waste products and bodies of dead organisms.
  - When there are no longer any large areas of open water the pond has becomes a marsh.
  - The marsh will become drier as the organic matter continues to build up.
  - The marsh is now a swamp.
  - As the area fills in the ecosystem will reach its final stage of succession, the climax community.

#### Old-Growth Forest Ecosystem

- Virgin Forest- A forest that has not been altered by human activity.
- When settlers first came to America much of it was covered with virgin forests
- Less then 10% of those forests are still remaining.
- Nature Conservancy- An organization whose goal is to preserve the best examples of wide variety of unique ecosystems.
- Colonists viewed the forest as an obstacle to agriculture and began clearing the land.
- Bark Rights- An agreement between the buyer and seller of land, that the seller could retain the right to log the land and sell the bark of the trees.
- Old growth forest- a forest that has trees that are at least 250 years old.
- Snags- The standing dead trees.
- Dead and dying trees have an important role in the ecosystem to create habitats for insects and small mammals.
- Nurse Logs- Fallen trees where young seedlings take root and grow.

#### Biodiversity- The variety of plant and animal species in an ecosystem.

- The biodiversity of an ecosystem determines the stability of the ecosystem.
- Indicator Species- A species whose presence indicates a healthy ecosystem.
- Truffle- A kinds of fungus that produces a massive network of filaments that grow through the soil and penetrate the outer cells of the tree roots.
  - The fungi help the trees to absorbed minerals, nutrients and water.
- Streams in old-growth forests are some of the cleanest in the world.
- The thick mat of decaying matter on the forest floor holds and filters the water entering the streams.

### Multiple Use Management

- Multiple uses- Timbering, Mining, watershed protection, grazing, recreation, and fish and wildlife habitats.
- Law now requires that the 156 national forests and other federal lands have to be managed for multiple use

### Conflict in the Northwest

- Reasons why the logging industry in the northwest is an endangered way of life...
- For many years trees were logged but not replanted.
- Advances in technology have reduced the number of workers needed.
- The export of logs to Japan and China has reduced the number of jobs in local mills.
- Some timber companies are moving south to take advantage of cheaper land, better soil and a longer growing season.
- Products must compete with cheaper imports.

National Forest Management Act- This law requires that management plans be made for all national forests.

- About 80% of the area inhabited by endangered species is now protected.
- Sustainability- The ability to keep in existence or maintain.
- Viable ecosystems- Able to survive with all of their functioning parts.
- Logging- The felling of trees for industry.
- Felling- The cutting of a tree.
- Clear-cut logging- Removing all of the trees in a specific area.

### Forest Management and Wildlife

- In a mature forest some trees begin to die leaving hollow sections in the trunk that make homes for cavity nesters.
- Mast- acorns and other nuts and seeds that lie on a forest floor.
- At least 40% of a forest should have trees that can produce mast.
- Forage- plants that are eaten by grazing or browsing animals.
- 20% of the forest must be capable of producing forage.
- A forest with all stages of growth ensures a diversity of wildlife.
- Clear cutting a forest creates edges, places where one ecosystem meets another.
- Edge effect- An increase in the populations of those species that depend upon the forest for cover and the clearing for food.
- Deep forest species- Species that live in the interior of the forest.
- Deep forest species decline as clear cutting creates more edges.

Habitat fragmentation- the carving of an ecosystem into small isolated tracts.

- The size of clear-cuts must be kept small, and the location must be carefully chosen to prevent fragmentation.
- Species unwilling to move across large open areas become genetically isolated populations.

### The Forest Cycle- Managing for Timber

- Monoculture- The planting of a single species.
- When a forest is managed to produce a "crop of trees" the biodiversity is reduced.

### The Harvest: Which Trees to Cut?

- Even-aged trees: All trees are matured and ready for harvesting at the same time.
- Clear-cutting is necessary for the regeneration of certain tree species.
- Selection logging- Harvest mature trees in a stand of uneven-aged trees.
- High-quality trees are removed for sale as saw logs.
- Smaller trees are removed to improve the growing conditions for the remaining trees.
- Seed-tree logging- Same as clear cutting- except that selected mature trees are left to provide seed for regeneration of the cut area.
- Seed-tree logging is used for sun-dependent species.
- Shelterwood logging- Mature trees are harvested in a series of cuts over several years.

### After the Harvest: Planting for the Next Crop

- Natural regeneration- germination of seeds from remaining trees after seed-tree, shelterwood or selection logging.
- Planting may be necessary to grow a selected species, preparation for planting often includes:
- Mechanical preparation- Debris on the forest floor makes replanting difficult and expensive.
- If the duff, blanket of twigs and needles, is too thick the roots of the seedlings may die before they reach the moisture and nutrients in the soil.
- Slash- limbs tree tops and other waste.

- Slash burning- Clears planting sites of brush and duff. Slash burning is cheap and suitable for steep slopes.
- Herbicides- Used to kill the undesirable plant species.
- Plantings- Forests are restored by planting genetically improved seedlings, or plantings.
  - Plantings are produced by tissue culture from a few selected parent plants.
- Thinning- Forests with great commercial value contain trees that are tall and straight. After trees grow to pole size, 6-10 inches in diameter they are examined to see which trees should be removed.
- Fertilization- Many soils do not provide enough nutrients for trees, applying fertilizers increase the growth rate.
- Protection- Forests need protection from fire and pests.

#### Forest Forever

- Intensively managed forests can produce almost twice as much timber as unmanaged forests.
- High-quality seedlings are planted, competition from “weed” species is controlled, growth is enhanced by thinning and adding fertilizers, and trees are protected from fire and insects.

#### Spare that Snag!

- Snag- a standing dead tree.
- The dead branches at the top of an aging tree provide an ideal nesting site for some birds.
- Other birds prefer to nest in cavities.
- Many woodpeckers make cavities in dead or dying trees.
- The pileated woodpecker used snags for “drumming boards” to announce their presence to other birds intruding on their territory.

#### Life in the Old Hemlock

- Boring insects attack aging trees creating tunnels that allow water fungi and other insects to enter.
- As the wood begins to soften other bird’s species are attracted to the tree.
- As branches die and lose their needles they provide places for birds to sit and watch for flying insects.
- As the bark becomes loose and the wood becomes softer other species of birds can find food more easily.
- Eventually the tree falls becoming a log where small animals find food and a place to hide.
- The rotting log continues to break down into humus- partly decayed plant material.
- Nurse log- a nursery for new trees.
- The nutrients in the humus provide the ideal conditions needed for a seed to sprout.

#### U.S.F.S Policy

- It is the policy of the United States forest services (U.S.F.S) to save some trees for the insect eating woodpeckers and other cavity nesters.
- Cull trees- trees that will not yield high quality lumber.
- Cull trees are left to become future snags.

#### Introduced Species

- Bioinvasion- Describes the introduction of species by direct or indirect human actions to areas where they did not previously exist.
- Non-native species- Species introduced to areas beyond their historic natural range.
- Some introduced species are invasive species because they are aggressive and spread over large areas disturbing natural ecosystems and interfering with human activity.
- Hundreds of plants were brought to North America intentionally for food, medicine or ornaments uses, others were brought accidentally in grain straw or soil.
  - Ex: Purple Loosestrife was introduced to North America in the 1800’s and has been growing rapidly eliminating many native plants ever since.
  - The zebra mussel entered the great lakes by ships dumping ballast- water taken from other ports.
  - There has been a population explosion of zebra mussels since they were released in Lake St. Clair. The fast multiplying mussels have spread to all the great lakes and are expected to spread to all bodies of water connecting to them.

#### Dreaded Diseases of Invasives

- Chestnut blight- a fungus that grows beneath the bark and cuts off the flow of nutrients and water.
- The disease has attacked two of the most valuable native trees in the US, the American chestnut and the American elm.
- Scientists have designed a non-lethal hypovirulent form of the fungus; trees infected with this form of the disease seem to be recovering.

- Dutch elm disease- Produces a poison that clogs the sap-carrying tubes of the American elm.
- The disease is carried from tree to tree by the European elm bark beetle.

#### The Hitchhiker Invasive

- The gypsy moth is the most devastating insect pest in the forests of the northeastern United States.
- The larvae are carried long distances by strong winds.
- It continues to spread south and west at a rate of about 13 miles per year.
- As the population increases the larvae feed on as many as 500 species of plants.
- As food becomes a limiting factor many larvae die of starvation, cold and wet weather also reduces gypsy moth survival.
- When insects immigrate to this country they usually leave their natural enemies behind, without this limiting factor and with plenty of food they population quickly reached epidemic numbers.

#### USDA Animal and Plant Health Inspection Services (APHIS)

- The APHIS is responsible for guarding against the introduction of foreign plants and animals into this country.
- Anyone entering into this country has to declare any meat, fruits, vegetables, plants, and animal products they are bringing into the country.
- The APHIS inspectors search luggage for undeclared items at airports.
- Potted plants and soil from overseas cannot be imported because the soil might carry pests and diseases.
- Many plant and animal species can be imported safely if the correct procedures are followed.
- Most fruit and lumber trees must go through inspection and testing procedures in quarantine.
- The only way to get new genes that might improve the varieties we grow here is to import plants from the mother country.

#### Will Endangered Species Become Extinct?

- Endangered Species Act of 1973- Requires the US Department of the Interior to identify and protect species that are in danger of extinction.
- Endangered Species- A plants or animals chances of survival and reproduction are in immediate jeopardy.
- Threatened- If a species is likely to become endangered.
- Extinct- When a species disappears from planet earth.
- The act prohibits killing or harming of endangered species.
- The law requires the US fish and wildlife service to maintain the official list of endangered and threatened species.

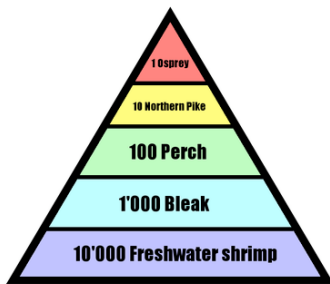
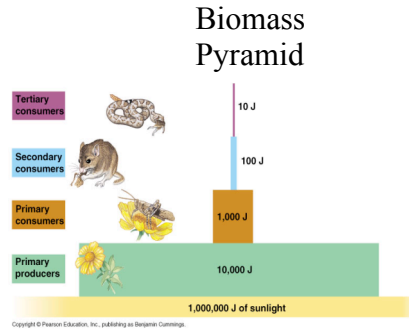
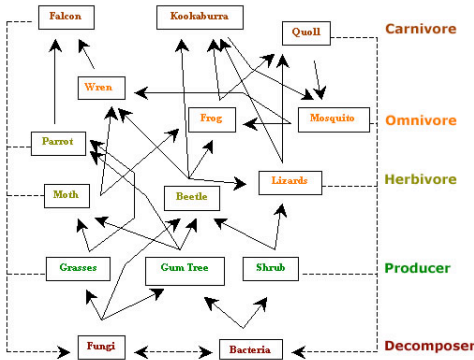
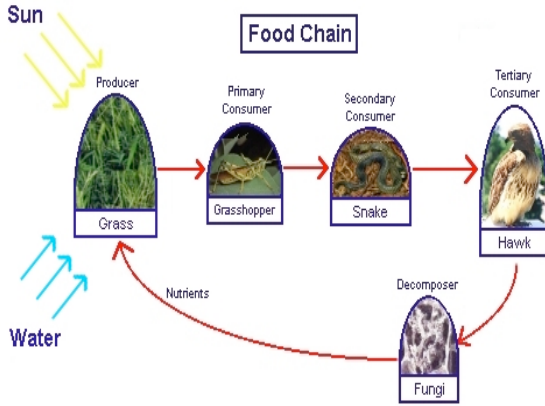
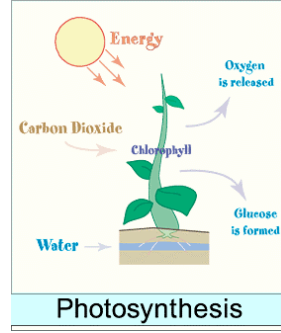
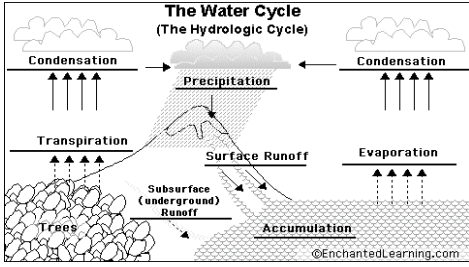
#### Extinction

- Human activities are causing species to disappear at a much faster rate than in the past.
- Many species are declining in numbers due to human population growth.
- Poaching- illegal hunting is another threat.
- Another threat is isolation caused by habitat fragmentation.

#### Game Management

- Under the Endangered Species act no federal projects are permitted that could destroy the habitat of an endangered species.
- Game species- Species that can be legally hunted.
- Regulated hunting is the primary method of wildlife management.
- Poaching- Taking wildlife by any method that is illegal

#### Diagrams:



Pyramid of Numbers