Chapter 3- Ecosystems: What Are They and How Do They Work?

- THE NATURE OF ECOLOGY
  - Ecology is a study of connections in nature- how organisms interact with one another and with their nonliving environment.
- Organisms→ Species→Populations→Communities→Ecosystems→Biosphere
- Genetic diversity
  - In most natural populations individuals vary slightly in their genetic makeup.
- The biosphere consists of several physical layers that contain:
  - Biosphere- contains all life
  - Atmosphere- membrane of air around planet
    - Stratosphere- contains "good" ozone (bad ozone is in troposphere)
  - Hydrosphere- All the earth's water: liquid, ice, water vapor
  - Lithosphere- The earth's crust and upper mantle.
- What Sustains Life on Earth?
  - Solar energy, the cycling of matter, and gravity sustain the earth's life.
  - Solar energy flowing through the biosphere warms the atmosphere, evaporates and recycles water, generates winds and supports plant growth.
- Nutrient Cycles: Global Recycling
  - Global Cycles recycle nutrients through the earth's air, land, water, and living organisms.
    - The Water Cycle
    - The Sulfur Cycle
    - The Phosphorous Cycle
    - The Nitrogen Cycle: Bacteria in Action
- ECOSYSTEM COMPONENTS
  - Ecosystems consist of nonliving (abiotic) and living (biotic) components.
- Factors That Limit Population Growth
  - r and K strategists
- Producers: Basic Source of All Food
  - Most producers capture sunlight to produce carbohydrates by photosynthesis:
  - Photosynthesis: $CO_2 + H_2O$ + sunlight → $C_6H_{12}O_6 + O_2$
    - Chlorophyll molecules in the chloroplasts of plant cells absorb solar energy.
- Consumers: Eating and Recycling to Survive
- Consumers (heterotrophs) get their food by eating or breaking down all or parts of other organisms or their remains.
  - Herbivores- Primary consumers that eat producers
  - Carnivores- Primary consumers eat primary consumers. Third and higher level consumers: carnivores that eat carnivores.
  - Omnivores- Feed on both plant and animals.
- Decomposers and Detrivores
  - Decomposers: Recycle nutrients in ecosystems.
  - Detrivores: Insects or other scavengers that feed on wastes or dead bodies.
- Organisms break down carbohydrates and other organic compounds in their cells to obtain the energy they need.
  - This is usually done through ***aerobic respiration***. (The opposite of photosynthesis)
  - Anaerobic respiration or fermentation: Some decomposers get energy by breaking down glucose (or other organic compounds) in the absence of oxygen.
- Biodiversity Loss and Species Extinction: Remember HIPPO
  - **H** for ***habitat destruction*** and ***degradation***
  - **I** for ***invasive species***
  - **P** for ***pollution***
  - **P** for ***human population growth***
  - **O** for ***overexploitation***
- Why Should We Care About Biodiversity?
- Trophic levels are interconnected within a complicated food web.
  - Energy Flow in an Ecosystem: Losing Energy in Food Chains and Webs
- In accordance with the 2nd law of thermodynamics, there is a decrease in the amount of energy available to each succeeding organism in a food chain or web. (when energy is transferred, some is always lost)
- ***Ecological efficiency***: percentage of useable energy transferred as biomass from one trophic level to the next. (1/10 energy is available to next level)
- Gross primary production (GPP) - Rate at which an ecosystem's producers convert solar energy into chemical energy as biomass.
- Net Primary Production (NPP)- Rate at which producers use photosynthesis to store energy minus the rate at which they use some of this energy through respiration (R).

Chapter 4- Evolution and Biodiversity

- EVOLUTION, NATURAL SELECTION, AND ADAPTATION
  - Biological evolution by natural selection involves the change in a population's genetic makeup through successive generations. It requires:
    - genetic variability
    - Mutations: random changes in the structure or number of DNA molecules in a cell that can be <u>inherited</u> by offspring.
    - Difference in traits must lead to <u>differential reproduction</u>
- Coevolution: Interacting species can engage in a back and forth genetic contest in which each gains a temporary genetic advantage over the other. This often happens between predators and prey species.
- New species can arise through hybridization.
  - Occurs when individuals to two distinct species crossbreed to produce a fertile offspring.
- Limits on Adaptation through Natural Selection
- A population's ability to adapt to new environmental conditions through natural selection is limited by its gene pool and how fast it can reproduce.
  - Evolution through natural selection is about the most descendants.

    - Organisms do not develop certain traits because they need them.
- GEOLOGIC PROCESSES, CLIMATE CHANGE, CATASTROPHES, AND EVOLUTION
    - The movement of continents has allowed species to move.
    - Changes in climate throughout the earth's history have shifted where plants and animals can live.
    - Asteroids and meteorites hitting the earth and upheavals of the earth from geologic processes have wiped out large numbers of species and created evolutionary opportunities by natural selection of new species.
- ECOLOGICAL NICHES AND ADAPTATION
    - Niche: a specific role or way of life of a species
        - ***Fundamental niche***: the full potential range of physical, chemical, and biological conditions and resources a species could theoretically use.
        - ***Realized niche***: to survive and avoid competition, a species usually occupies only part of its fundamental niche.
    - Generalist and Specialist Species: Broad and Narrow Niches
    - Specialized Feeding Niches- Resource partitioning reduces competition and allows sharing of limited resources.
- SPECIATION, EXTINCTION, AND BIODIVERSITY
    - Speciation: A new species can arise when member of a population become isolated for a long period of time, leads to reproductive isolation, resulting in speciation.
    - Genetic makeup changes, preventing them from producing fertile offspring with the original population if reunited.
- Extinction: Lights Out
    - Extinction occurs when the population cannot adapt to changing environmental conditions.
    - Five major *mass extinctions* have taken place over the past 500 million years. Each was at the end of a "period." (Cretaceous, Jurassic, etc.)
    - Many scientists say that we are now in the midst of a *sixth mass extinction,* caused primarily by human activities.
- GENETIC ENGINEERING AND THE FUTURE OF EVOLUTION
    - We have used ***artificial selection*** to change the genetic characteristics of populations with similar genes through ***selective breeding***.
- Genetic Engineering: Genetically Modified Organisms (GMO)

Chapter 5: Biodiversity, Species Interactions, and Population Control

- Species diversity and richness- The <u>number of different species and distribution</u>
- Species abundance- The <u>number of individuals</u> of each species
- Niche structure- The number of ecological niches, their resemblance, and how they interact
- What determines the number of species in an isolated ecosystem?
- *Species Equilibrium Model* or *Theory of Island Biogeography* (MacArthur and Wilson)
    - Size of the ecosystem
    - Degree of isolation
- Species Interactions
    - *Competition*
        - <u>Intraspecific competition</u> – competition between members of the <u>same species</u>
        - <u>Interspecific competition</u> – competition between members of two or more <u>different species</u>
            - Interference competition- One species limits another's access to some resources
            - Exploitation competition- Competing species have equal access to resources but differ in how fast or efficiently they exploit it
        - Competitive Exclusion Principle- *The niches of two species cannot overlap completely or significantly for very long.* Leads to <u>resource partitioning</u>
    - *Predation*- members of one species (*predator*) feed directly on all or part of a living organism of another species (*prey*).
        - *Predator tactics*- pursuit and ambush
    - Symbiotic Species Interactions- relationships in which species live together in an intimate association.
        - *Parasitism*- One species (*parasite*) feeds on part of another organism (*host*) by living on or in the host.
        - *Mutualism*- Two species interact in ways that <u>benefit both</u>
        - *Commensalism*- symbiotic relationship that <u>benefits one</u> species but <u>neither harms nor helps the other</u> species
- POPULATION DYNAMICS AND CARRYING CAPACITY
    - Most populations live in clumps although other patterns occur based on resource distribution.
        - Populations increase through births and immigration; Populations decrease through deaths and emigration
    - Age Structure: How fast a population grows or declines depends on its age structure.
        - ***Prereproductive age***: not mature enough to reproduce.
        - ***Reproductive age***: those capable of reproduction.
        - ***Postreproductive age***: those too old to reproduce.
    - The intrinsic rate of increase (***r***) is the rate at which a population would grow if it had unlimited resources. **R- Selected species** have many offspring quickly, but many die.
    - Carrying capacity (***K***): the maximum population of a given species that a particular habitat can sustain indefinitely without degrading the habitat. **K-Selected species** have fewer offspring, more likely to survive to adulthood.
    - Population density: the number of individuals in a population found in a particular area or volume.
        - A population's density can affect how rapidly it can grow or decline. e.g. biotic factors like disease

        - Some population control factors are not affected by population density. e.g. abiotic factors like weather
    - Types of Population Change Curves in Nature
        - ***Stable***: fluctuates slightly above and below carrying capacity.
        - ***Irruptive***: populations explode and then crash to a more stable level.
        - ***Cyclic***: populations fluctuate and regular cyclic or boom-and-bust cycles.
        - ***Irregular***: erratic changes possibly due to chaos or drastic change.
- ECOLOGICAL SUCCESSION: COMMUNITIES IN TRANSITION
    - ***Ecological succession***: the gradual change in species composition of a given area
    - ***Primary succession***: the gradual establishment of biotic communities in lifeless areas where there is no soil or sediment.
    - ***Secondary succession***: series of communities develop in places containing soil or sediment.
- ECOLOGICAL STABILITY AND SUSTAINABILITY
    - Inertia (persistence): the ability of a living system to resist being disturbed or altered.
    - Constancy: the ability of a living system to keep its numbers within the limits imposed by available resources.
    - Resilience: the ability of a living system to bounce back and repair damage after (a not too drastic) disturbance.
        - Having species diversity appears to increase the sustainability of many communities.

Chapter 6- Applying Population Ecology: The Human Population and Its Impact

- Rule of 70- Estimates doubling time for population undergoing exponential growth
    - Doubling time = 70/rate of population growth
- The number of children women have is affected by:
    - The cost of raising and educating them.
    - Education and employment opportunities.
    - Infant deaths.
    - Marriage age.
    - Availability of contraception and abortion.
- The ***baby bust*** that followed the ***baby boom*** was largely due to delayed marriage, contraception, and abortion.
- Death rates have declined because of:
    - Increased food supplies, better nutrition.
    - Advances in medicine.
    - Improved sanitation and personal hygiene.
- Measures of Overall Health
    - Life Expectancy- how long we live
    - Infant Mortality Rate- how many babies die
- The number of people in young, middle, and older age groups determines how fast populations grow or decline.
- POPULATION AGE STRUCTURE
- Populations with a large proportion of its people in the **prereproductive** ages 1-14 have a large potential for rapid population growth.
- Declining Fertility Rates: Fewer Babies per Woman
    - ***Replacement-level fertility***: the number of children a couple must bear to replace themselves.
    - ***Total fertility rate (TFR)***: the average number of children a woman has during her reproductive years.
- SOLUTIONS: INFLUENCING POPULATION SIZE
    - ***Demographic Transition***: As countries become economically developed, their birth and death rates tend to decline.
        - ***Preindustrial stage***: little population growth due to high infant mortality.
        - ***Transitional stage***: industrialization begins, death rates drop and birth rates remain high.
        - ***Industrial stage***: birth rate drops and approaches death rate.
        - ***Postindustrial stage***: birth rate and death rate are approximately equal.
- Current world population: **7,006,394,586**
  (as of3:37pm 4/11/2012, via US Census Bureau)
- SLOWING POPULATION GROWTH IN INDIA AND CHINA
- India's Failed Family Planning Program
- China's Family Planning Program

Chapter 7 - Climate and Terrestrial Biodiversity

- Weather is a local area's short-term physical conditions such as temperature and precipitation.
- Climate is a region's average weather conditions over a long time.
    - Latitude and elevation help determine climate.
- Solar Energy and Global Air Circulation: Distributing Heat
    - Global air circulation is affected by the uneven heating of the earth's surface by solar energy, seasonal changes in temperature and precipitation.
    - Coriolis Effect- Global air circulation is affected by the rotation of the earth on its axis.
    - Convection Currents- Global air circulation is affected by the properties of air water, and land.
        - Convection Cells- Heat and moisture are distributed over the earth's surface by vertical currents, which form six giant convection cells at different latitudes.
- Ocean Currents: Distributing Heat and Nutrients
    - Ocean currents influence climate by distributing heat from place to place and mixing and distributing nutrients.
- Global warming: Considerable scientific evidence and climate models indicate that large inputs of greenhouse gases from anthropogenic activities into the troposphere can enhance the natural greenhouse effect and change the earth's climate in <u>your lifetime</u>.
- Topography and Local Climate: Land Matters

        - Interactions between land and oceans and disruptions of airflows by mountains and cities affect local climates.
- SOIL: A RENEWABLE RESOURCE
    - Soil is a slowly renewed resource that provides most of the nutrients needed for plant growth and also helps purify water.
        - Soil formation begins when bedrock is broken down by physical, chemical and biological processes called ***weathering***.
    - ***Mature soils***, or soils that have developed over a long time are arranged in a series of horizontal layers called ***soil horizons***.
    - Infiltration: the downward movement of water through soil.
    - Leaching: dissolving of minerals and organic matter in upper layers carrying them to lower layers.
        - The soil type determines the degree of infiltration and leaching.
            - Sand- happens fastest
            - Silt
            - Clay- happens slowest

Chapter 8-Aquatic Biodiversity

- Core Case Study: Why Should We Care About Coral Reefs?
    - Coral reefs form in clear, warm coastal waters of the tropics and subtropics.
    - Formed by massive colonies of polyps.
    - Help moderate atmospheric temperature by removing CO_2 from the atmosphere.
    - Act as natural barriers that help protect some of the world's coastlines from erosion by battering waves and storms.
    - Provide habitats for a variety of marine organisms.
- AQUATIC ENVIRONMENTS
    - Saltwater and freshwater aquatic life zones cover almost three-fourths of the earth's surface
    - Aquatic systems contain floating, drifting, swimming, bottom-dwelling, and decomposer organisms.
        - Plankton: important group of weakly swimming, free-floating biota.
            - Phytoplankton (plant), Zooplankton (animal), Ultraplankton (photosynthetic bacteria)
        - Necton: fish, turtles, whales.
        - Benthos: bottom dwellers (barnacles, oysters).
        - Decomposers: breakdown organic compounds (mostly bacteria).
- Life in Layers
    - Life in most aquatic systems is found in surface, middle, and bottom layers.
        - Temperature, access to sunlight for photosynthesis, dissolved oxygen content, nutrient availability changes with depth.
        - Euphotic zone (upper layer in deep water habitats): sunlight can penetrate.
- SALTWATER LIFE ZONES
    - The coastal zone: the warm, nutrient-rich, shallow water that extends from the high-tide mark on land to the gently sloping, shallow edge of the continental shelf.
        - The coastal zone makes up less than 10% of the world's ocean area but contains 90% of all marine species.
        - Provides numerous ecological and economic services; Subject to human disturbance.
    - Estuaries include river mouths, inlets, bays, sounds, salt marshes in temperate zones and mangrove forests in tropical zones.
    - Mangrove Forests are found along about 70% of gently sloping sandy and silty coastlines in tropical and subtropical regions.
- Gravitational pull by moon and sun causes tides.
    - Intertidal Zone: area of shoreline between low and high tides.
    - Organisms in intertidal zone develop specialized niches to deal with daily changes in:
        - Temperature
        - Salinity
        - Wave action
- Barrier Islands- Low, narrow, sandy islands that form offshore from a coastline.
    - Primary and secondary dunes on gently sloping sandy barrier beaches protect land from erosion by the sea.
- Biological Zones in the Open Sea: Light Rules
    - ***Euphotic zone***: brightly lit surface layer.
        - Nutrient levels low, dissolved O_2 high, photosynthetic activity.
    - ***Bathyal zone***: dimly lit middle layer.
        - No photosynthetic activity, zooplankton and fish live there and migrate to euphotic zone to feed at night.
    - ***Abyssal zone***: dark bottom layer.
        - Very cold, little dissolved O_2.
- Freshwater life zones include:
    - ***Standing (lentic) water*** such as lakes, ponds, and inland wetlands.
    - ***Flowing (lotic) systems*** such as streams and rivers.
- Lakes: Water-Filled Depressions
    - Lakes are large natural bodies of standing freshwater formed from precipitation, runoff, and groundwater seepage consisting of:
        - ***Littoral zone*** (near shore, shallow, with rooted plants).
        - ***Limnetic zone*** (open, offshore area, sunlit).
        - ***Profundal zone*** (deep, open water, too dark for photosynthesis).
        - ***Benthic zone*** (bottom of lake, nourished by dead matter).
    - During summer and winter in deep temperate zone lakes the become stratified into temperature layers and will overturn.
- Effects of Plant Nutrients on Lakes
    - ***Oligotrophic*** (poorly nourished) lake: Usually newly formed lake with small supply of plant nutrient input.

    - ***Eutrophic*** (well nourished) lake: Over time, sediment, organic material, and inorganic nutrients wash into lakes causing excessive plant growth.
    - ***Cultural eutrophication***: Human inputs of nutrients from the atmosphere and urban and agricultural areas can accelerate the eutrophication process.
- Water flowing from mountains to the sea creates different aquatic conditions and habitats.
    - Source Zone
    - Transition Zone
    - Floodplain Zone
- **Chapter 9- Sustaining Biodiversity: The Species Approach**
- Core Case Study: The Passenger Pigeon - Gone Forever
    - Once the most numerous bird on earth.
    - In 1858, Passenger Pigeon hunting became a big business.
    - By 1900 they became extinct from over-harvest and habitat loss.
- SPECIES EXTINCTION
    - Species can become extinct:
        - ***Locally***: A species is no longer found in an area it once inhabited but is still found elsewhere in the world.
        - ***Ecologically***: Occurs when so few members of a species are left they no longer play its ecological role.
        - ***Globally (biologically)***: Species is no longer found on the earth.
- Endangered and Threatened Species: Ecological Smoke Alarms
    - ***Endangered species***: so few individual survivors that it could soon become extinct.
    - ***Threatened species***: still abundant in its natural range but is likely to become endangered in the near future.
- SPECIES EXTINCTION
    - Some species have characteristics that make them vulnerable to ecological and biological extinction. (small # of young, low reproductive rate, specialists, etc.)
    - The International Union for the Conservation of Nature and Natural Resources (IUCN) publishes an annual Red List, listing the world's threatened species.
- IMPORTANCE OF WILD SPECIES
    - We should not cause the premature extinction of species because of the economic and ecological services they provide.
    - Some believe that each wild species has an inherent right to exist.
    - Some people distinguish between the survival rights among various types of species (plants vs. animals).
- HABITAT LOSS, DEGRADATION, AND FRAGMENTATION
    - Conservation biologists summarize the most important causes of premature extinction as "HIPPO":
        - Habitat destruction, degradation, and fragmentation
        - Invasive species
        - Population growth
        - Pollution
        - Overexploitation
- PROTECTING WILD SPECIES: LEGAL AND ECONOMIC APPROACHES
    - International treaties have helped reduce the international trade of endangered and threatened species, but enforcement is difficult.
    - One of the most powerful is the 1975 Convention on International Trade of Endangered Species (CITES).
- The U.S. Endangered Species Act
    - One of the world's most far-reaching and controversial environmental laws is the 1973 U.S. Endangered Species Act (ESA).
    - ESA forbids federal agencies (besides defense department) to carry out / fund projects that would jeopardize an endangered species.
- PROTECTING WILD SPECIES: THE SANCTUARY APPROACH
    - The U.S. has set aside 544 federal refuges for wildlife, but many refuges are suffering from environmental degradation.
    - Gene banks, botanical gardens and using farms to raise threatened species can help prevent extinction, but these options lack funding and storage space.
    - Zoos and aquariums can help protect endangered animal species by preserving some individuals with the long-term goal of reintroduction, but suffer from lack of space and money.
- RECONCILIATION ECOLOGY
    - Reconciliation ecology involves finding ways to share places we dominate with other species.
        - Replacing monoculture grasses with native species.
        - Maintaining habitats for insect eating bats can keep down unwanted insects.
        - Reduction and elimination of pesticides to protect non-target organisms (such as vital insect pollinators).
- **Chapter 10- Sustaining Terrestrial Biodiversity: The Ecosystem Approach**
- Why Should We Care About Biodiversity?
    - *Use Value*: For the usefulness in terms of economic and ecological services.
    - *Nonuse Value*: existence, aesthetics, bequest for future generations.
- MANAGING AND SUSTAINING FORESTS

    - Forests provide a number of ecological and economic services that researchers have attempted to estimate their total monetary value.
    - Types of Forests
        - *Old-growth forest*: uncut or regenerated forest that has not been seriously disturbed for several hundred years.
            - 22% of world's forest.
            - Hosts many species with specialized niches.
        - *Second-growth forest*: a stand of trees resulting from natural secondary succession.
        - *Tree plantation*: planted stands of a particular tree species.
    - Harvesting Trees
        - Building roads into previously inaccessible forests paves the way for fragmentation, destruction, and degradation.
        - Trees can be harvested individually from diverse forests (selective cutting), an entire forest can be cut down (clear cutting), or portions of the forest is harvested (e.g. strip cutting).
    - We can use forests more sustainably by emphasizing:
        - Economic value of ecological services.
        - Harvesting trees no faster than they are replenished.
        - Protecting old-growth and vulnerable areas
- CASE STUDY: FOREST RESOURCES AND MANAGEMENT IN THE U.S.
    - U.S. forests cover more area than in 1920.
    - Since the 1960's, an increasing area of old growth and diverse second-growth forests have been clear-cut.
        - Often replace with tree farms.
        - Decreases biodiversity.
        - Disrupts ecosystem processes.
- Types and Effects of Forest Fires
    - Depending on their intensity, fires can benefit or harm forests.
    - Burn away flammable ground material.
    - Release valuable mineral nutrients.
- To reduce fire damage:
    - Set controlled surface fires.
    - Allow fires to burn on public lands if they don't threaten life and property.
    - Clear small areas around property subject to fire.
- In 2003, U.S. Congress passed the *Healthy Forest Restoration Act*:
    - Allows timber companies to cut medium and large trees in 71% of the national forests.
    - In return, must clear away smaller, more fire-prone trees and underbrush.
    - Some forest scientists believe this could increase severe fires by removing fire resistant trees and leaving highly flammable slash.
- Reducing Demand for Harvest Trees
    - Tree harvesting can be reduced by wasting less wood and making paper from fibers that do not come from trees.
    - Kenaf is a promising plant for paper production.
- American Forests in a Globalized Economy
    - Timber from tree plantations in temperate and tropical countries is decreasing the need for timber production in the U.S.
    - This could help preserve the biodiversity in the U.S. by decreasing pressure to clear-cut old-growth and second-growth forests.
- CASE STUDY: TROPICAL DEFORESTATION
    - Large areas of ecologically and economically important tropical forests are being cleared and degraded at a fast rate.
    - At least half of the world's terrestrial plant and animal species live in tropical rain forests.
    - Large areas of tropical forest are burned to make way for cattle ranches and crops.
- Kenya's Green Belt Movement: Individuals Matter
    - The main goal is to organize poor women to plant (for fuelwood) and protect millions of trees.
    - In 2004, awarded Nobel peace prize.
- MANAGING AND SUSTAINING GRASSLANDS
    - Almost half of the world's livestock graze on natural grasslands (rangelands) and managed grasslands (pastures).
    - Overgrazing occurs when too many animals graze for too long and exceed carrying capacity of a grassland area.
- NATIONAL PARKS
    - Local people invade park for wood, cropland, and other natural resources.
    - Loggers, miners, and wildlife poachers also deplete natural resources.
    - Many are too small to sustain large-animal species.
    - Many suffer from invasive species.
- NATURE RESERVES
    - Ecologists call for protecting more land to help sustain biodiversity, but powerful economic and political interests oppose doing this.
    - Currently 12% of earth's land area is protected. Only 5% is strictly protected from harmful human activities.

    - Conservation biologists call for full protection of at least 20% of earth's land area representing multiple examples of all biomes.
    - A model biosphere reserve that contains a protected inner core surrounded by two buffer zones that people can use for multiple use.
    - Geographic Information System (GIS) mapping can be used to understand and manage ecosystems.
        - Identify areas to establish and connect nature reserves in large ecoregions to prevent fragmentation.
        - Developers can use GIS to design housing developments with the least environmental impact.
    - We can prevent or slow down losses of biodiversity by concentrating efforts on protecting global hot spots where significant biodiversity is under immediate threat.
    - 34 hotspots identified by ecologists as important and endangered centers of biodiversity.
    - Wilderness is land legally set aside in a large enough area to prevent or minimize harm from human activities.
- ECOLOGICAL RESTORATION
    - *Restoration*: trying to return to a condition as similar as possible to original state.
    - *Rehabilitation*: attempting to turn a degraded ecosystem back to being functional.
    - *Replacement*: replacing a degraded ecosystem with another type of ecosystem.
    - *Creating artificial ecosystems*: such as artificial wetlands for flood reduction and sewage treatment.
- Eight priorities for protecting biodiversity:
    - Take immediate action to preserve world's biological hot spots.
    - Keep intact remaining old growth.
    - Complete mapping of world's biodiversity for inventory and decision making.
    - Determine world's marine hot spots.
    - Concentrate on protecting and restoring lake and river systems (most threatened ecosystems).
    - Ensure that the full range of the earths ecosystems are included in global conservation strategy.
    - Make conservation profitable.
    - Initiate ecological restoration products to heal some of the damage done and increase share of earth's land and water allotted to the rest of nature.

Chapter 11- Sustaining Aquatic Biodiversity

- HUMAN IMPACTS ON AQUATIC BIODIVERSITY
    - Human activities have destroyed, disrupted or degraded a large proportion of the world's coastal, marine and freshwater ecosystems.
    - Approximately 20% of the world's coral reefs have been destroyed.
    - We have destroyed more than 1/3 of the world's mangrove forests for shipping lanes.
    - Harmful invasive species are an increasing threat to marine and freshwater biodiversity.
        - Bioinvaders are blamed for about 2/3 of fish extinctions in the U.S. between 1900-2000.
    - Each year plastic items dumped from ships and left as litter on beaches threaten marine life.
- Overfishing and Extinction: Gone Fishing, Fish Gone
    - About 75% of the world's commercially valuable marine fish species are over fished or fished near their sustainable limits.
- Why is it Difficult to Protect Aquatic Biodiversity?
    - Rapid increasing human impacts, the invisibility of problems, citizen unawareness, and lack of legal jurisdiction hinder protection of aquatic biodiversity.
    - Human ecological footprint is expanding.
    - Many people incorrectly view the oceans as an inexhaustible resource. (What is this an example of?)
- PROTECTING AND SUSTAINING MARINE BIODIVERSITY
    - Since 1989 the U.S. government has required offshore shrimp trawlers to use turtle exclusion devices.
    - Sea turtle tourism brings in almost three times as much money as the sale of turtle products.
    - Six of the world's seven major turtle species are threatened or endangered because o human activities.
- Manatees are endangered due to:
    - Habitat loss.
    - Entanglement from fishing lines and nets.
    - Hit by speed boats.
    - Stress from cold.
    - Low reproductive rate
- Case Study: Commercial Whaling
    - After many of the world's whale species were overharvested, commercial whaling was banned in 1960, but the ban may be overturned.
    - Despite ban, Japan, Norway, and Iceland kill about 1,300 whales of certain species for scientific purposes.
    - Although meat is still sold commercially.
- PROTECTING, SUSTAINING, AND RESTORING WETLANDS
    - Requiring government permits for filling or destroying U.S. wetlands has slowed their loss, but attempts to weaken this protection continue.
    - Case Study: Restoring the Florida Everglades
        - The world's largest ecological restoration project involves trying to undo some of the damage inflicted on the Everglades by human activities.
        - 90% of park's wading birds have vanished.

        - Other vertebrate populations down 75-95%.
        - Large volumes of water that once flowed through the park have been diverted for crops and cities.
    - Lakes are difficult to manage and are vulnerable to planned or unplanned introductions of nonnative species.
        - For decades, invasions by nonnative species have caused major ecological and economic damage to North America's Great lakes.
        - Sea lamprey, zebra mussel, quagga mussel, Asian carp.
- PROTECTING, SUSTAINING, AND RESTORING LAKES AND RIVERS
    - Dams can provide many human benefits but can also disrupt some of the ecological services that rivers provide.
    - We can help sustain freshwater fisheries by building and protecting populations of desirable species, preventing over-fishing, and decreasing populations of less desirable species.
    - National Wild and Scenic Rivers Act (1968)- A federal law helps protect a tiny fraction of U.S. wild and scenic rivers from dams and other forms of development.

Chapter 12- Food, Soil Conservation, and Pest Management

- Many people cannot meet their basic energy needs <u>(undernutrition / hunger)</u> or protein and key nutrients (<u>malnutrition</u>).
    - The root cause of hunger and malnutrition is poverty.
- ***Food security*** means that every person in a given area has daily access to enough nutritious food to have an active and healthy life.
    - Need large amounts of ***macronutrients*** (protein, carbohydrates, and fats).
    - Need smaller amounts of ***micronutrients*** (vitamins such as A,C, and E).
- Overnutrition: Eating Too Much
- Wheat, rice, and corn provide more than half of the world's consumed calories.
    - Fish and shellfish are an important source of food for about 1 billion people mostly in Asia and in coastal areas of developing countries.
- Industrial Food Production: High Input Monocultures
    - Uses large amounts of fossil fuel energy, water, commercial fertilizers, and pesticides to produce monocultures.
    - Greenhouses are increasingly being used.
    - Plantations are being used in tropics for cash crops such as coffee, sugarcane, bananas.
- Livestock production in developed countries is industrialized:
    - Feedlots are used to fatten up cattle before slaughter.
    - Most pigs and chickens live in densely populated pens or cages.
    - Most livestock are fed grain grown on cropland.
    - Systems use a lot of energy and water and produce huge amounts of animal waste.
- Traditional Agriculture: Low Input Polyculture
    - ***Polyvarietal cultivation***: planting several genetic varieties.
    - ***Intercropping***: two or more different crops grown at the same time in a plot.
    - ***Agroforestry***: crops and trees are grown together.
    - ***Polyculture***: different plants are planted together.
- Soil erosion lowers soil fertility and can overload nearby bodies of water with eroded sediment.
    - ***Sheet erosion***: surface water or wind peels off thin layers of soil.
    - ***Rill erosion***: fast-flowing streams of surface water make small channels.
    - ***Gully erosion***: fast-flowing water join together to cut wider and deeper ditches or gullies.
- 1985 Food Security Act (Farm Act): farmers receive a subsidy for taking highly erodible land out of production and replanting it with soil saving plants for 10-15 years.
- Desertification: Degrading Drylands- About one-third of the world's land has lost some of its productivity because of drought and human activities that reduce or degrade topsoil.
- Salinization and Waterlogging- Repeated irrigation can reduce crop yields by causing salt buildup in the soil and waterlogging of crop plants.
- Modern farm machinery can plant crops without disturbing soil (no-till and minimum tillage)
- Fertilizers can help restore soil nutrients, but runoff of inorganic fertilizers can cause water pollution.
    - Terracing, contour planting, strip cropping, alley cropping, and windbreaks can reduce soil erosion.
- THE GREEN REVOLUTION AND ITS ENVIRONMENTAL IMPACT
    - Since 1950, high-input agriculture has produced more crops per unit of land through use of pesticides and fertilizers.
    - Modern agriculture has a greater harmful environmental impact than any human activity.
- THE GENE REVOLUTION
    - To increase crop yields, we can mix the genes of similar types of organisms and mix the genes of different organisms.
        - Controversy has arisen over the use of genetically modified food (GMF).
- PRODUCING MORE MEAT
    - About half of the world's meat is produced by livestock grazing on grass.
    - The other half is produced under factory-like conditions (feedlots).
    - Eating more chicken and farm-raised fish and less beef and pork reduces harmful environmental impacts of meat production.
- CATCHING AND RAISING MORE FISH AND SHELLFISH
    - Government subsidies given to the fishing industry are a major cause of overfishing.
    - Aquaculture: Aquatic Feedlots- Raising large numbers of fish and shellfish in ponds and cages is world's fastest growing type of food production.
    - Fish ranching involves holding species that live part of their lives in freshwater and part in saltwater.
        - Fish are held for the first few years, released, and then harvested when they return to spawn.
- SOLUTIONS: MOVING TOWARD GLOBAL FOOD SECURITY

    - People in urban areas could save money by growing more of their food.
- Governments use three main approaches to influence food production:
    - Control prices to keep prices artificially low.
    - Provide subsidies to keep farmers in business.
    - Let the marketplace decide rather that implementing price controls.
- PROTECTING FOOD RESOURCES: PEST MANAGEMENT- Organisms found in nature (such as spiders) control populations of most pest species as part of the earth's free ecological services.
    - We use chemicals to repel or kill pest organisms as plants have done for millions of years.
- Superpests are resistant to pesticides.
- Other Ways to Control Pests
- There are cultivation, biological, and ecological alternatives to conventional chemical pesticides.
    - Provide homes for the pest enemies.
    - Implant genetic resistance.
    - Bring in natural enemies.
    - Use pheromones to lure pests into traps.
    - Use hormones to disrupt life cycles.
- Integrated Pest Management (IPM)- An ecological approach to pest control uses a mix of cultivation and biological methods, and small amounts of selected chemical pesticides as a last resort.

Chapter 13- Water

- The land from which the surface water drains into a body of water is called its ***watershed*** or ***drainage basin***.
- Irrigation is the biggest user of water (70%), followed by industries (20%) and cities and residences (10%).
- Most aquifers are renewable resources unless water is removed faster than it is replenished or if they are contaminated.
- Groundwater overpumping can cause land to sink, and contaminate freshwater aquifers near coastal areas with saltwater.
- Sinkholes form when the roof of an underground cavern collapses after being drained of groundwater.
- Large dams and reservoirs can produce cheap electricity, reduce downstream flooding, and provide year-round water for irrigating cropland, but they also displace people and disrupt aquatic systems.
- Case Study: The Colorado Basin – an Overtapped Resource
    - The Colorado River has so many dams and withdrawals that it often does not reach the ocean.
        - 14 major dams and reservoirs, and canals.
        - Water is mostly used in desert area of the U.S.
        - Provides electricity from hydroelectric plants for 30 million people (1/10th of the U.S. population).
- Case Study: China's Three Gorges Dam
    - There is a debate over whether the advantages of the world's largest dam and reservoir will outweigh its disadvantages.
        - The dam will be 2 kilometers long.
        - The electric output will be that of 18 large coal-burning or nuclear power plants.
        - It will facilitate ship travel reducing transportation costs.
        - Dam will displace 1.2 million people.
        - Dam is built over seismatic fault and already has small cracks.
- Water Diversion-TRANSFERRING WATER FROM ONE PLACE TO ANOTHER
- Transferring water can make unproductive areas more productive but can cause environmental harm.
- Case Study: The Aral Sea Disaster
    - Diverting water from the Aral Sea and its two feeder rivers mostly for irrigation has created a major ecological, economic, and health disaster.
        - About 85% of the wetlands have been eliminated and roughly 50% of the local bird and mammal species have disappeared.
        - Since 1961, the sea's salinity has tripled and the water has dropped by 22 meters most likely causing 20 of the 24 native fish species to go extinct.
        - The Aral Sea was once the world's fourth largest freshwater lake.
- Removing salt from seawater by current methods is expensive and produces large amounts of salty wastewater that must be disposed of safely.
    - ***Distillation***: heating saltwater until it evaporates, leaves behind salt in solid form.
    - ***Reverse osmosis***: uses high pressure to force saltwater through a membrane filter.
    - Seeding clouds with tiny particles of chemicals to increase rainfall, towing icebergs or huge bags filled with freshwater to dry coastal areas have all been proposed but are unlikely to provide significant amounts of freshwater.
- TOO MUCH WATER
    - Heavy rainfall, rapid snowmelt, removal of vegetation, and destruction of wetlands cause flooding.
    - Floodplains, which usually include highly productive wetlands, help provide natural flood and erosion control, maintain high water quality, and recharge groundwater.
- INCREASING WATER SUPPLIES BY WASTING LESS WATER
    - 65-70% of the water people use throughout the world is lost through evaporation and leaks.
    - Water is underpriced through government subsidies.
    - Raising the Price of Water: A Key to Water Conservation

Chapter 14 - Geology and Nonrenewable Mineral Resources

- The earth's interior consists of:
    - ***Core***: innermost zone with solid inner core and molten outer core that is extremely hot.
    - ***Mantle***: solid rock with a rigid outer part (asthenosphere) that is melted pliable rock.
    - ***Crust***: Outermost zone which underlies the continents.
- Huge volumes of heated and molten rock moving around the earth's interior form massive solid plates that move extremely slowly across the earth's surface.
    - ***Tectonic plates***: huge rigid plates that are moved with convection cells or currents by floating on ***magma*** or molten rock.
- Weathering is an external process that wears the earth's surface down.

- The earth's crust consists of solid inorganic elements and compounds called minerals that can sometimes be used as resources.
    - ***Mineral resource***: is a concentration of naturally occurring material in or on the earth's crust that can be extracted and processed into useful materials at an affordable cost.
- The U.S. Geological Survey classifies mineral resources into four major categories:
    - ***Identified***: known location, quantity, and quality or existence known based on direct evidence and measurements.
    - ***Undiscovered***: potential supplies that are assumed to exist.
    - ***Reserves***: identified resources that can be extracted profitably.
    - Other: undiscovered or identified resources not classified as reserves
- A very slow chemical cycle recycles three types of rock found in the earth's crust:
    - Sedimentary rock (sandstone, limestone).
    - Metamorphic rock (slate, marble, quartzite).
    - Igneous rock (granite, pumice, basalt).
- A variety of methods are used to remove mineral resources from the earth based on mineral depth.
    - ***Surface mining***: shallow deposits are removed.
    - ***Subsurface mining***: deep deposits are removed.
    - Open-pit Mining- Machines dig holes and remove ores, sand, gravel, and stone.
        - Toxic groundwater can accumulate at the bottom.
    - Area Strip Mining- Earth movers strips away overburden, and giant shovels removes mineral deposit.
        - Often leaves highly erodible hills of rubble called ***spoil banks***.
    - Contour Strip Mining- Used on hilly or mountainous terrain.
        - Unless the land is restored, a wall of dirt is left in front of a highly erodible bank called a ***highwall***.
    - Mountaintop Removal- Machinery removes the tops of mountains to expose coal.
        - The resulting waste rock and dirt are dumped into the streams and valleys below.
- Metal ores are smelted or treated with (potentially toxic) chemicals to extract the desired metal.

Chapter 15- Nonrenewable Energy

- OIL- Crude oil (petroleum) is a thick liquid containing hydrocarbons that we extract from underground deposits and separate into products such as gasoline, heating oil and asphalt.
    - Based on boiling points, components are removed at various layers in a giant distillation column.
    - Burning oil for transportation accounts for 43% of global CO_2 emissions.
- NATURAL GAS- Natural gas, consisting mostly of methane, is often found above reservoirs of crude oil.
    - When a natural gas-field is tapped, gasses are liquefied and removed as liquefied petroleum gas (LPG).
    - Russia and Iran have almost half of the world's reserves of conventional gas.
    - Natural gas is versatile and clean-burning fuel, but it releases the greenhouse gases carbon dioxide (when burned) and methane (from leaks) into the troposphere.
- COAL- Coal is the most abundant fossil fuel, but compared to oil and natural gas it is not as versatile, has a high environmental impact, and releases much more CO_2 into the troposphere.
    - Coal reserves in the United States, Russia, and China could last hundreds to over a thousand years.
- NUCLEAR ENERGY- When isotopes of uranium and plutonium undergo controlled nuclear fission, the resulting heat produces steam that spins turbines to generate electricity.
    - After three or four years in a reactor, spent fuel rods are removed and stored in a deep pool of water contained in a steel-lined concrete container.
- Case Study: The Chernobyl Nuclear Power Plant Accident
    - The world's worst nuclear power plant accident occurred in 1986 in Ukraine.
    - The disaster was caused by poor reactor design and human error.
    - When a nuclear reactor reaches the end of its useful life, its highly radioactive materials must be kept from reaching the environment for thousands of years.

Chapter 16- Energy Efficiency and Renewable Energy

- REDUCING ENERGY WASTE AND IMPROVING ENERGY EFFICIENCY
    - 84% of all commercial energy used in the U.S. is wasted
    - 41% wasted due to 2nd law of thermodynamics
- Four widely used devices waste large amounts of energy:
    - ***Incandescent light bulb***: 95% is lost as heat.
    - ***Internal combustion engine***: 94% of the energy in its fuel is wasted.
    - ***Nuclear power plant***: 92% of energy is wasted through nuclear fuel and energy needed for waste management.
    - ***Coal-burning power plant***: 66% of the energy released by burning coal is lost.
- Hybrid gasoline-electric engines with an extra plug-in battery could be powered mostly by electricity produced by wind and get twice the mileage of current hybrid cars.
    - Currently plug-in power would be generated by coal and nuclear power plants.
- Fuel-Cell Vehicles- Fuel-efficient vehicles powered by a fuel cell that runs on hydrogen gas are being developed.
    - Combines hydrogen gas (H_2) and oxygen gas (O_2) fuel to produce electricity and water vapor ($2H_2+O_2 \rightarrow 2H_2O$).
    - Emits no air pollution or CO_2 if the hydrogen is produced from renewable-energy sources.
- We can save energy in buildings by getting heat from the sun, superinsulating them, and using plant covered green roofs.
- We can save energy in existing buildings by insulating them, plugging leaks, and using energy-efficient heating and cooling systems, appliances, and lighting.
- A variety of renewable-energy resources are available but their use has been hindered by a lack of government support compared to nonrenewable fossil fuels and nuclear power.
    - Direct solar
    - Wind
    - Geothermal
- Heating Buildings and Water with Solar Energy- We can heat buildings by orienting them toward the sun or by pumping a liquid such as water through rooftop collectors.
- Cooling Houses Naturally- We can cool houses by:

    - Superinsulating them.
    - Taking advantages of breezes.
    - Shading them.
    - Having light colored or green roofs.
    - Using geothermal cooling.
- Producing Electricity with Solar Cells- Solar cells convert sunlight to electricity.
    - Photovoltaic (PV) cells can provide electricity for a house of building using solar-cell roof shingles.
    - Solar cells can be used in rural villages with ample sunlight who are not connected to an electrical grid.
- PRODUCING ELECTRICITY FROM THE WATER CYCLE
    - Water flowing in rivers and streams can be trapped in reservoirs behind dams and released as needed to spin turbines and produce electricity.
- PRODUCING ELECTRICITY FROM WIND
    - Wind power is the world's most promising energy resource because it is abundant, inexhaustible, widely distributed, cheap, clean, and emits no greenhouse gases.
    - Wind turbines can be used individually to produce electricity. They are also used interconnected on wind farms.
- PRODUCING ENERGY FROM BIOMASS
    - Plant materials and animal wastes can be burned to provide heat or electricity or converted into gaseous or liquid biofuels.
    - Motor vehicles can run on ethanol, biodiesel, and methanol produced from plants and plant wastes.
    - The major advantages of biofuels are:
        - Crops used for production can be grown almost anywhere.
        - There is no net increase in CO_2 emissions.
        - Widely available and easy to store and transport.
- GEOTHERMAL ENERGY
    - Geothermal energy consists of heat stored in soil, underground rocks, and fluids in the earth's mantle.
    - We can use geothermal energy stored in the earth's mantle to heat and cool buildings and to produce electricity.
    - A geothermal heat pump (GHP) can heat and cool a house by exploiting the difference between the earth's surface and underground temperatures.
        - The house is heated in the winter by transferring heat from the ground into the house.
        - The process is reversed in the summer to cool the house.
- Governments can use a combination of subsidies, tax breaks, rebates, taxes and public education to promote or discourage use of various energy alternatives:
    - Can keep prices artificially low to encourage selected energy resources.
    - Can keep prices artificially high to discourage other energy resources.
    - Emphasize consumer education.

Chapter 18- Air Pollution

- STRUCTURE AND SCIENCE OF THE ATMOSPHERE
    - The atmosphere consists of several layers with different temperatures, pressures, and compositions.
        - The atmosphere's innermost layer (troposphere) is made up mostly of nitrogen and oxygen, with smaller amounts of water vapor and CO_2.
        - Ozone in the atmosphere's second layer (stratosphere) filters out most of the sun's UV radiation that is harmful to us and most other species.
- Major Air Pollutants
    - ***Carbon oxides***:
    - Carbon monoxide (CO) is a highly toxic gas that forms during the incomplete combustion of carbon-containing materials.
    - 7% of CO_2 in the troposphere occurs as a result of human activities (mostly burning fossil fuels).
    - <u>It is not regulated as a pollutant under the U.S. Clean Air Act</u>.
- ***Nitrogen oxides*** and ***nitric acid***:
    - Nitrogen oxide (NO) forms when nitrogen and oxygen gas in air react at the high-combustion temperatures in automobile engines and coal-burning plants. NO can also form from lightning and certain soil bacteria.
    - NO reacts with air to form NO_2.
    - NO_2 reacts with water vapor in the air to form nitric acid (HNO_3) and nitrate salts (NO_3^-) which are components of acid deposition.
- ***Sulfur dioxide (SO_2)*** and ***sulfuric acid***:
    - About one-third of SO_2 in the troposphere occurs naturally through the sulfur cycle.
    - Two-thirds come from human sources, mostly combustion ($S + O_2 \rightarrow SO_2$) of sulfur-containing coal and from oil refining and smelting of sulfide ores.
    - SO_2 in the atmosphere can be converted to sulfuric acid (H_2SO_4) and sulfate salts (SO_4^{2-}) that return to earth as a component of acid deposition.
- ***Suspended particulate matter (SPM)***:
    - Consists of a variety of solid particles and liquid droplets small and light enough to remain suspended in the air.
    - The most harmful forms of SPM are fine particles (PM-10, with an average diameter < 10 micrometers) and ultrafine particles (PM-2.5).
- ***Ozone (O_3)***:
    - Is a highly reactive gas that is a major component of photochemical smog.
    - It can
        - Cause and aggravate respiratory illness.
        - Can aggravate heart disease.

        - Damage plants, rubber in tires, fabrics, and paints.
- ***Volatile organic compounds (VOCs)***:
    - Most are hydrocarbons emitted by the leaves of many plants and methane.
    - About two thirds of global methane emissions come from human sources.
    - Other VOCs include industrial solvents such as trichloroethylene (TCE), benzene, and vinyl chloride.
    - Long-term exposure to benzene can cause cancer, blood disorders, and immune system damage.
- ***Radon (Rn)***:
    - Is a naturally occurring radioactive gas found in some types of soil and rock.
    - It can seep into homes and buildings sitting above such deposits.
    - Can cause lung cancer
- URBAN OUTDOOR AIR POLLUTION
    - Industrial smog is a mixture of sulfur dioxide, droplets of sulfuric acid, and a variety of suspended solid particles emitted mostly by burning coal.
        - In most developed countries where coal and heavy oil is burned, industrial smog is not a problem due to reasonably good pollution control or with tall smokestacks that transfer the pollutant to rural areas.
    - Photochemical smog is a mixture of air pollutants formed by the reaction of nitrogen oxides and volatile organic hydrocarbons under the influence of sunlight.
- ACID DEPOSITION
    - Sulfur dioxides, nitrogen oxides, and particulates can react in the atmosphere to produce acidic chemicals that can travel long distances before returning to the earth's surface.
    - Acid deposition consists of rain, snow, dust, or gas with a pH lower than 5.6.
    - Acid deposition contributes to chronic respiratory disease and can leach toxic metals (such as lead and mercury) from soils and rocks into acidic lakes used as sources for drinking water.
- INDOOR AIR POLLUTION
    - Indoor air pollution usually is a greater threat to human health than outdoor air pollution.
    - According to the EPA, the four most dangerous indoor air pollutants in developed countries are: Tobacco smoke, Formaldehyde, Radioactive radon-222 gas, Very small fine and ultrafine particles.
- The Clean Air Acts in the United States have greatly reduced outdoor air pollution from major pollutants: Carbon monoxide, Nitrogen oxides, Sulfur dioxides, Suspended particulate matter
    - To help reduce SO_2 emissions, the Clean Air Act authorized an emission trading (cap-and-trade) program.
- Solutions: Reducing Outdoor Air Pollution
    - ***Electrostatic precipitator***: are used to attract negatively charged particles in a smokestack into a collector.
    - ***Wet scrubber***: fine mists of water vapor trap particulates and convert them to a sludge that is collected and disposed of usually in a landfill.

Chapter 19- Climate Change and Ozone Depletion

- The Natural Greenhouse Effect- Three major factors shape the earth's climate:
    - The sun.
    - Greenhouse effect that warms the earth's lower troposphere and surface because of the presence of ***greenhouse gases***.
    - Oceans - Store CO_2 and heat, evaporate and receive water, move stored heat to other parts of the world.
- The major greenhouse gases in the lower atmosphere are water vapor, carbon dioxide, methane, and nitrous oxide.
- Since 1900, the earth's average tropospheric temperature has risen 0.6° C.
    - Over the past 50 years, Arctic temperatures have risen almost twice as fast as those in the rest of the world.
    - Glaciers and floating sea ice are melting and shrinking at increasing rates.
    - Warmer temperatures in Alaska, Russia, and the Arctic are melting permafrost releasing more CO_2 and CH_4 into the troposphere.
    - During the last century, the world's sea level rose by 10-20 cm, mostly due to runoff from melting and land-based ice and the expansion of ocean water as temperatures rise.
- CO_2 Levels on Photosynthesis- Increased CO_2 in the troposphere can increase plant photosynthesis (PS) but:
    - The increase in PS would slow as the plants reach maturity.
    - Carbon stored by the plants would be returned to the atmosphere as CO_2 when the plants die.
    - Increased PS decreases the amount of carbon stored in the soil.
- During this century rising seas levels are projected to flood low-lying urban areas, coastal estuaries, wetlands, coral reefs, and barrier islands and beaches.
- Global warming could alter ocean currents and cause both excessive warming and severe cooling.
- Global warming will increase deaths from spread of tropical diseases to temperate regions.
- Two ways to deal with global warming:
    - ***Mitigation*** that reduces greenhouse gas emissions.
    - ***Adaptation***, where we recognize that some warming is unavoidable and devise strategies to reduce its harmful effects.
- International Climate Negotiations: The Kyoto Protocol
    - Treaty on global warming which first phase went into effect January, 2005 with 189 countries participating.
    - It requires 38 participating developed countries to cut their emissions of CO_2, CH_4, and N_2O to 5.2% below their 1990 levels by 2012.

- OZONE DEPLETION IN THE STRATOSPHERE
    - Less ozone in the stratosphere allows for more harmful UV radiation to reach the earth's surface.
    - The ozone layer keeps about 95% of the sun's harmful UV radiation from reaching the earth's surface.
    - Chlorofluorocarbon (CFCs) have lowered the average concentrations of ozone in the stratosphere.
    - ***Ozone thinning***: caused by CFCs and other ozone depleting chemicals (ODCs).

Chapter 20- Water Pollution

- Core Case Study: Using Nature to Purify Sewage
- ***Water pollution*** is any chemical, biological, or physical change in water quality that has a harmful effect on living organisms or makes water unsuitable for desired uses.
    - ***Point source***: specific location (drain pipes, ditches, sewer lines).
    - ***Nonpoint source***: cannot be traced to a single site of discharge (atmospheric deposition, agricultural / industrial / residential runoff)
- Major Water Pollutants and Their Effects
    - A fecal coliform bacteria test is used to indicate the likely presence of disease-causing bacteria in water.
    - In a flowing stream, the breakdown of degradable wastes by bacteria depletes DO and creates an ***oxygen sag curve***.
        - This reduces or eliminates populations of organisms with high oxygen requirements.
- Dilution of pollutants in lakes is less effective than in most streams because most lake water is not mixed well and has little flow.
- Various human activities can overload lakes with plant nutrients, which decrease DO and kill some aquatic species.
    - ***Eutrophication***: the natural nutrient enrichment of a shallow lake, estuary or slow moving stream, mostly from runoff of plant nutrients from the surrounding land.
    - ***Cultural eutrophication***: human activities accelerate the input of plant nutrients (mostly nitrate- and phosphate-containing effluents) to a lake.
- OCEAN POLLUTION
    - Oceans, if they are not overloaded, can disperse and break down large quantities of degradable pollutants.
    - Harmful algal blooms (HAB) are caused by explosive growth of harmful algae from sewage and agricultural runoff.
    - Studies have shown it takes about 3 years for many forms of marine life to recover from large amounts of ***crude oil*** (oil directly from ground).
    - Recovery from exposure to ***refined oil*** (fuel oil, gasoline, etc…) can take 10-20 years for marine life to recover.
- PREVENTING AND REDUCING SURFACE WATER POLLUTION
    - The U.S. Clean Water Act sets standards for allowed levels of key water pollutants and requires polluters to get permits.
    - Septic tanks and various levels of sewage treatment can reduce point-source water pollution.
    - Raw sewage reaching a municipal sewage treatment plant typically undergoes:
        - ***Primary sewage treatment***: a physical process that uses screens and a grit tank to remove large floating objects and allows settling.
        - ***Secondary sewage treatment***: a biological process in which aerobic bacteria remove as much as 90% of dissolved and biodegradable, oxygen demanding organic wastes.
        - Advanced or tertiary sewage treatment: Uses series of chemical and physical processes to remove specific pollutants left (especially nitrates and phosphates).
        - Water is chlorinated to remove coloration and to kill disease-carrying bacteria and some viruses (disinfect).
- The U.S Safe Drinking Water Act requires the EPA to establish national drinking water standards (***maximum contaminant levels***) for any pollutant that may have adverse effects on human health.