Chapter 3 - Systems and Feedback

Case Study: Amboseli National Park

Illustrates the law of **environmental unity** [*everything effects everything else, you can't do just one thing*] and some of the difficulties in assessing environmental cause and effect. "The most obvious answer may not always be the right answer."

1. In 1950 the fever tree woodlands disappeared and were replaced by short grasses. – This was initially blamed on overgrazing and elephants.

2. Ground water is salty in this area, during the dry years it is low and favors the fever trees – in wet times it rises and the salt is bad for the tree roots, favoring grasses and brush.

3. The saltiness results from water percolating down mount Kilamanjaro.

Open v. Closed Systems

Systems are open or closed for particular factors such as energy, water, or chemical substances, an **open system** exchanges this factor with other systems a **closed system** does not. *"Earth is an open system with regard to energy [it receives energy from and releases it to space] and a closed system in regard to material."*

Feedback: negative and positive

In **negative feedback** the output decreases the input. Tends to support stability. *Input: People move to a city. Output: The results of crowding such as pollution, cause people to move away from the city.*

In **positive feedback** the output increases the input. Tends to be destabilizing. *Input: People move to the city. Output: The resulting business increases job supply attracting more people to the city.*

Exponential Growth / Doubling Time / Rule of 70. [Fig 3.9 p. 44]

Exponential growth is most important in describing elements of population growth. It is when the rate (percent) growth is constant. [This is a contrast to arithmetic growth where the number growth is constant.]

When exponential growth occurs the population will double in a predictable and repeating time period called the **doubling time.** Doubling time may be estimated using the **Rule of 70**. Divide the number 70 by the percent growth rate to get the doubling time in years.

70 ÷ 3.5% = 20yrs

Environmental Unity

The idea that everything effects everything else

Systems have Inputs and Outputs

Steady state is when the input of a material equals the output.

Other changes result in an increase or decrease in **stock**.

The **average residence time** describes how long a certain material resides in a pool. To calculate it, divide the total size of the pool by the average rate of transfer.

School population = 1600: 400 new freshman: 400 graduating seniors
(400 + 400) ÷ 2 = 400 [average rate of transfer]
1600 ÷ 400 = 4yrs [average residence time]

Input/output as cause and effect: add fertilizer to plants [input] grow more of the plant [output].

Life Alters Earth

Life interacts with air, soil, and water.

The **biosphere** is the region of earth where life exists – it is a wide range including deep oceans and tall mountains.

"We know of no single organism, population, or species that both produces all its own food and completely recycles all its own metabolic products."

Ecosystems

Consist of the living community and its non-living surroundings. May be large or small, artificial or natural, managed or unmanaged.

Gaia Hypothesis

The idea of earth and its life as a living organism, where the life alters its own environment in a process analogous to homeostasis.

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Chapter 4 – The Human Population and the Environment

Case Study – The Great Tsunami of 2004

This case study describes the relative mathematical impact of the loss of life in Indonesia in 2004. Although over 230,000 died, the growth of the earth replaced those lives in a few days. This is meant to illustrate both the power of exponential growth and the massive current human population

Numbers (2004)

Five most populous Countries

China – 1.3 billion
India – 1.1 billion
USA – 304 million
Indonesia – 240 million
Brazil – 195 million

Then Pakistan, Nigeria, Bangladesh, Russia, Japan.

90% of pop growth in developing nations in Africa and Asia.

Growth rate in developing nations (excluding China) 1.8%, in developed nations 0.1%. China is excluded due to its strict legal restriction s on birth rate.

Age Structure [Figure 4.2 p 59]

One good predictor of future human population.

Nations with pyramid-shaped age structure diagrams indicate a growing population and high birth rate. A column-shaped age structure tends to indicate reproduction around replacement rate and low infant and juvenile death rates, which means low or no growth.

Working Out Population Growth (p. 580

Growth Rate = Birth Rate – Death Rate

Can be crude or as percents. Crude rate is how many per thousand. Birth and death rates are commonly given as crude, but growth is often given as a decimal or percent. For instance:

In less developed countries the current crude birth rate is 24/1000, the current crude death rate is 8/1000. The growth rate is 1.6%

(24 – 8)/1000 multiply result by 100.

Although this rate may change over time, in general populations can be considered to be going through exponential growth and their doubling time can be approximated using the Rule of 70 (see chapter 3).

A brief history of Human Population Growth (p. 61)

(1) Hunters and gatherers – a few million people

(2) Rise of agriculture – first major increase in human population

(3) Industrial revolution: sanitation, health care, food supply – rapid increase

(4) The Present – growth slow in industrialized nations but increasing rapidly in less developed nations. (see fig 4.4 p. 61)

Logistic Growth Curve

Many population in nature follow a logistic growth curve, in which the potential for exponential growth is limited by competition and eventually by a carrying capacity. This curve may be used to make predictionas about populations, but is especially limited for predicting human population growth because: (a) it assumes a constant environment (b) all individuals in a populationa are not identical (c) improvements in health, medicine, and food supply effect the limiting factors (d) making predictions requires an inflection point, but it is not yet known whether humans have reached this point.

The Demographic Transition [Figure 4.8, p 65]

This is a three stage process that describes how populations change during industrialization.

Stage I – an undeveloped country has high birth and death rates. The high death rate includes high infant and juvenile mortality.

Stage II – as nutrition and medical treatment improve, the death rate decreases, this results in an increased growth rate (see "Working Out Population Growth" above).

Stage III – as the population becomes more affluent the birth rate begins to decrease, slowing the growth rate until eventually the birth and death rates become about equal again.

[Note that even though the birth and death rates decrease throughout this process, because the birth rate is higher than the death rate during the demographic transition, the population goes through great growth.]

Population And Technology

"The danger that the human population poses to the environment is the result of two factors: the number of people and the impact of each person on the environment" (p. 64). "Technology not only increases our use of resources but also causes us to affect the environment in many new ways" (p. 66). Examples: CFCs and automobiles.

Due to resource use and energy consumption, each individual in an industrialized nation has a larger impact on the environment than each new individual in an undeveloped nation. The impact of an individual on the environment is sometimes called their "ecological footprint."

Malthus

In 1798 Thomas Malthus published his *Essay on the Principle of Population* in which he observed that human populations was growing faster than their ability to gather resources did (he discussed food in particular). He concluded that the populations cannot grow indefinitely. His predictions of mass famine and disease have not arisen, and neither have the predictions of others such as the Ehrlichs. However, the Earth is undeniably finite.

Causes of Death [Figure 4.9 p 68]

One key in the demographic transition is that as nations become industrialized the causes of death shift greatly. This trend is generally that there are less deaths from epidemic diseases such as tuberculosis, cholera, and other infectious diseases and more deaths from chronic disease such as heart disease and cancer which tend to kill only at more advanced ages. Modern medicine has found effective ways to treat and prevent infectious disease, but hits is not yet the case with chronic diseases, although modern medicine has found ways to delay death from these chronic conditions.

Life Expectancy [Figure 4.10 p 69]

Life expectancy varies by nation, sex, age, and other factors. It even changes as one gets older. **Average life expectancy** has been increasing but the maximum age has not changed for thousands of years.

Ways to Stop/Slow Population Growth

1. Delay the age of first childbearing by women
2. Breast feeding – this delays resumption of ovulation
3. Other methods of birth control: abstinence, the pill, etc…
4. Govermnet regulation – for example China

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Chapter 5 The Biogeochemical Cycles

Case Study: Lake Washington
Illustrates how disruptions in chemical cycles can affect ecosystems. Effluent from local sewage plants flows into Lake Washington near Seattle. The phosphorous [which had been a **limiting factor**] being added by the effluent caused an algal bloom that blocked light from entering the lake. This affected the oxygen content [due to slowed photosynthesis] and the fishing in the lake.

Chemicals and Nutrients

Macronutrients are required in large amounts by all life. These include the "Big Six" (SPONCH), also calcium, sodium, potassium.

Sulfur – important element in many proteins

Phosphorous – important in ATP, DNA, RNA, phospholipids

Oxygen – major component in all cellular building blocks

Nitrogen – major component of nucleic acids and proteins

Carbon – the fundamental building block of life

Hydrogen – major component in all cellular building blocks

Micronutrients are required either in small amounts by all life or in moderate amounts by only some living things [Figure 5.5 p. 82].

Nutrients in Earth's crust by rank

Oxygen 45.2%; Silicon 29.5%; aluminum 8.0%; iron 5.8%; calcium 5.1%; magnesium 2.8%.

Basic Concepts of Cycles

Elements with a gas phase cycle quickly, those without tend to end up in ocean sediment and cycle slowly. In general, metals do not have a gas phase. One example of a cycling metal nutrient is calcium.

Life has changed cycles resulting in, for instance, fertile soils.

Technology is effecting cycles both with benefits [food production] and dangers [pollution, global warming].

CYCLES

Tectonic Cycle [Fig 5.6 p. 84]

Plate tectonics explains the creation and destruction of the earth's crust. Creation is at divergent plate boundaries such as the mid-ocean ridge, destruction is at subduction zones.

Hydrologic (Water) Cycle [Fig 5.8 p. 86]

The source of energy for this cycle is solar energy which drives the evaporation of water from oceans, lakes, streams, etc and transpiration of water from the leaves of plants.

Some water stats – 97% is in oceans, 2% is in glaciers and ice caps, the rest is in bodies of fresh water and the atmosphere.

Carbon Cycle [Fig 5.14 p. 91]

GREENHOUSE GAS - VERY IMPORTANT IN GLOBAL WARMING DEBATE

Not very abundant in the Earth's crust.

Early Earth had a high CO_2 atmosphere.

Removed from atmosphere by **photosynthesis** – then it travels through food chains. Marine organisms remove carbonate ions from water to make shells (calcium carbonate), when they die this can become sedimentary rocks.

Released to atmosphere through **respiration**, decomposition, volcanoes, and burning of fossil fuels.

Major Reservoirs: (1) marine sediments and sedimentary rocks; (2) Storage in shallow ocean waters; (3) fossil fuels (4) soil storage (from decomposed organic matter) (4) atmosphere.

Carbon-Silicate Cycle

In the atmosphere CO2 joins water to make **carbonic acid.** This makes rain slightly acidic. This causes a small amount of erosion of the silicate minerals that make rocks. One result of this erosion is carbonate, which is then used for shells of marine organisms.

Nitrogen Cycle [Fig 5.19 p. 95]

IMPORTANT NUTRIENT IN WATER POLLUTION – CAUSES EUTROPHICATION

RELEASED AS NO_2 WHEN FOSSIL FUELS ARE BURNED – ACID RAIN AND SMOG ISSUE

Nitrogen comprises 78% of atmosphere, but is not available directly to living things due to strength of N2 triple bond. Must first be converted to ammonium by bacteria (90%) or lightning (10%) in **nitrogen fixation**. Ammonium is then taken up by the roots of plants, then it travels through food chains. Nitrogen is released back into the soil during decomposition and can be cycled through plants again, or bacteria may return it to the atmosphere in **denitrification**.

Some plants classified as legumes (peas, peanuts, soy beans) have symiotic relationships with nitrogen fixing bacteria that wlive in their roots. These plants can return more nitrogen to the soil than they take and are important in crop rotation. Nitrogen-fixing bacteria can also be found in the gut of ruminants (Cow poop is good fertilizer.) (see Chapter___).

Electric sparks can be used to artificially fix nitrogen This technology has resulted in increased availability of fertilizer, but also to the increased potential of nitrogen pollution in streams, ponds, and lakes.

Major Reservoirs: (1) atmosphere as N2; (2) Soil in organic compounds; (3) land plants.

Phosphorous Cycle [Fig 5.20 p. 96]

ISSUES RELATED TO EUTROPHICATION (see Lake Washington case study) AND MINING

Metallic element, so no gas phase ∴ cycles slowly.

Enters biota through uptake by plants and bacteria, then travels through food chains. Compounds are not water-soluble and end up settling in lakes and oceans then becoming sedimentary rock.

Birds eat fish, the fish eat algae in high nutrient areas of the ocean. These areas of the ocean receive the nutrients (including phosphorous) from the ocean floor through upwelling (see Chap 14). The birds release phosphorous-rich droppings called guano on offshore islands. This guano can be mined for fertilizer.

Sedimentary rocks may also be mined for fertilizer. One example is Bone Valley near Tampa Bay, Florida.

Availability of nutrients related to limiting factors.

Carbon is more available than nitrogen and nitrogen is more available than phosphorous.

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Chapter 6 – Ecosystems and Ecological Communities

Case Study – The Acorn Connection

This case study describes the relationships between oak trees, mice, deer, ticks, humans, and annual climatic differences in effecting the incidence of lyme disease.

When acorn production is high, so is the mouse population. Mice also carry tick larvae, which carry the micro-organism responsible for Lyme disease. These ticks then jump to deer and can be passed to humans.

Mice also feed on the larvae of the gypsy moths, which feed on oak leaves. When acorn production is low, the moth population is high, this results in the forest leaves being eaten. Light then reaches the forest floor, where other species can thrive.

This is an excellent example of interconnectedness including the role of non-living aspects such as the yearly climate.

Ecosystems

An ecosystem is an **ecological community**, a set of interacting species, and its nonliving environment.

Sustained life on earth is a characteristic of ecosystems.

Ecosystems must have: at least one autotroph, a species that produces its own food, and at least one decomposer. It must also have a fluid medium such as water or air. It must cycle elements and must transfer energy.

Energy Flow: Food Chains and Food Webs

The position of any organism in a food chain or web is designated by its **trophic level**. Autotrophs are at the first trophic level. Organisms which eat only autotrophs are at the second trophic level, organisms which eat these are at the third, and so on. If an organisms consumes at more than one level, it is designated by the highest level at which it consumes.

Examples of several food chains are given on pages 108 – 110.
In the ocean the primary producers (autotrophs) are **phytoplankton**.

The Community Effect

The community effect describes indirect interactions between species. One example is the interaction between sea otters, kelp, and sea urchins. Seas urchins like to eat the base of kelp plants. This damages the kelp. When otters are present they eat the urchins, which indirectly protects the health of the kelp. Many species use the kelp as a breeding ground, so the interactions between the otters and urchins indirectly effect the kelp and many other species dependent on the kelp.

Ecosystems

Consist of the living community and its non-living surroundings. The boundaries of an ecosystem can be difficult to define. Some have clear borders like the edge of a lake. Watersheds can also be used to define an ecosystem. Ecosystems may be large or small, artificial or natural, managed or unmanaged. Ecosystem management is based on concepts of energy flow and nutrient cycling.

Edit: 11/08

Chapter 7 – Biological Diversity and Biogeography

Biological Evolution

Diversity of life on earth is explained by biological evolution which is driven by several forces. Some of these are:

a) mutation – a change in the DNA of an organism. These are sometimes harmful and very rarely beneficial, but occur each time a cell divides, including the "germ cells" which are passed on to offspring.

b) natural selection – because of the limits on the survival of every member of a species, many individuals die either very young, or before reproducing. Any traits which assist individuals in surviving and reproducing will be passed on to the next generation in a higher proportion thatn those traits which are not beneficial. One example of this is the peppered moths

c) Migration – when individuals move from one population to another they bring with them new traits and genes.

d) genetic drift – when populations become very small, the random change of particular genes getting passed to the next generation can cause some alleles to become either very rare or very common regardless of their survival potential. This is something like the chance of flipping heads 4 times in a row as opposed to 100 times in a row.

EXAMPLE: Mosquitos and the Malaria Parasite (Closer Look 7.1)

Due to over-application of DDT to fight mosquitos and chlorinique to fight the Plasmodium pathogen of malaria, both of those species adapted through natural selection to be resistant to those chemicals.

Evolution of Life on Earth

Early earth had a high concentration of CO2, the emergence of photosynthetic bacteria about 3.5 billion years ago created oxygen gas in our atmosphere for the first time.

Basic Concepts of Biological Diversity

Four measures:

Genetic Diversity – number of genetic characteristics

Habitat Diversity – diversity of habitats in a given area

Species diversity: richness; total number of species: evenness; relative abundance: dominance – the most abundant species (see p 119)

Number of species (estimates) Total between 1.4 – 100 million

Virus – 1000
Bacteria – 75000
Fungi – 100,000
Protests – 60,000
Plants –
  Algae – 10-20,000
  Conifers – 550
  Flowering Plants – 23,000
Animals - >1,000,000
  Insects – 750,000
  Vertebrates – 44,000
  Mammals – 4000

The Competitive Exclusion Principle [grey and red squirrels]

"Two species that have exactly the same requirements cannot coexist in exactly the same habitat."

The American Grey squirrel was introduced [exotic species] to England and out-competed the Red squirrel BUT they appear to not have the exact same requirements because red squirrels are more persistent in areas with hazelnuts.

A niche is the conditions of an organisms life. There are both ideal and realized niches. When niches are overlapped by habitat the competitive exclusion principle generally leaves one out [Fig. 7.10 pg. 130 and 7.11 pg 131]

Symbiosis

Symbiosis is when two species benefit one another a classic example are plants and their pollinators, the book also gives the example of bacteria in the gut of ruminants [fig 7.12, p 132].

Parasitism is when one species lives at the expense of a living host; a flea and a dog. **Predation** is when one species hunts and kills another for food. **Competition** is when two species compete for the same resources, generally affected by natural selection and adaptation.

Factors that effect biodiversity [Table 7.3 p .129]

Variation in habitats, moderate disturbances, and high diversity at other trophic levels are a few major factors that increase diversity. Please see the table for a more complete discussion.

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Biome	Temperature	Rainfall	Seasonal Patterns	Soils	Flora (Plants)	Fauna (Animals)	Names / Locations	FUN FACTS! (sort of… not really)
Tundra	▪ Low average temperatures	▪ Low rainfall		▪ Permafrost (perma-nently frozen ground)	▪ Treeless plains ▪ Grasses and their relatives (sedges, mosses, lichens, flowering dwarf shrubs, and mat-forming plants)	▪ Artic tundras have some large (caribou) and small mammals, birds, and insects ▪ Alpine tundras have small rodents and insects	▪ Antarctica ▪ Artic tundras cover the large territories ▪ Alpine tundras occupy small, isolated areas	▪ Two kinds of tundra: arctic, which occurs at high latitudes, and alpine, which occurs at high elevation
Taiga (Boreal Forests)	▪ Cold climates of high latitudes and high altitudes		▪ Disturbances (fires, storms, and outbreaks of insects) are common		▪ Conifers (spruces, firs, larches, pines) ▪ Dense stands of relatively small trees less than 30m tall ▪ Stands rarely more than 90 years old	▪ Few large mammals (moose, deer, wolves, and bears), small carnivores (foxes), small rodents (squirrels and rabbits), many insects, and migratory birds	▪ North America and Eurasia ▪ Cover very large areas	▪ Only 20 major species ▪ Contain commercially valuable trees ▪ Some of Earth's largest remaining wilderness areas
Temperate Deciduous Forests	▪ Warmer climates than boreal forests		▪ Fire is a natural, recurring feature		▪ Tall, deciduous trees (maples, beeches, oaks, hickories, chestnuts) ▪ Little vegetation near the ground	▪ Large mammals ▪ Small mammals that live in trees and those that feed on soil organisms and small plants ▪ Birds and insects	▪ Regions long dominated by civilization (China, Japan, Western Europe, US, Canada)	
Temperate Rain Forests	▪ Temperatures are moderate ▪ Winters are wet and relatively mild	▪ Precipita-tion exceeds 250 cm/yr			▪ Evergreen conifers ▪ Douglas firs, western cedars, redwoods ▪ Tallest trees in the world (long-lived)	▪ Salmon, spotted owl, and the marbled murrelet, an oceanic bird	▪ Northern Hemisphere ▪ California, Oregon, Washington, Canada ▪ Southern Hemisphere (new Zealand)	▪ Low diversity of plants and animals ▪ North American timber crops
Temperate Woodlands	▪ Climate is slightly drier than deciduous forests		▪ Fire is a common disturbance; many species require it		▪ Small trees (pinon pines and evergreen oaks) ▪ Wide spaces between trees	▪ Large mammals such as mule deer in Ponderosa pine	▪ North America (New England south to Georgia and the Caribbean islands)	▪ Economic value; pines used for timber, pulp, and paper
Temperate Shrublands (Chaparrals)	▪ Drier climates ▪ Moderate, sunny climate	▪ Low rainfall concentrate d in the cool season	▪ Vegetation adapted to fire ▪ Erosion can be severe if it rains after a fire		▪ Dense stands of shrubs ▪ Aromatic vegetation (sage) → aromatic compounds toxic to competing plants ▪ Stands rarely more than 50 years old	▪ Few large mammals ▪ Small mammals and reptiles	▪ Mediterranean ▪ Coast of California and in Chile and South Africa ▪ Human settlement	▪ Only 5% of Earth's land area ▪ Highly modified by human action ▪ Important for watershed and erosion control
Temperate Grasslands	▪ Regions too dry for forests and too moist for deserts		▪ Fire is a natural, recurring feature ▪ Plants adapted to certain kinds of grazing	▪ Deep organic layer from decaying roots and stems ▪ Good for agriculture	▪ Grasses and other flowering plants (perennials) ▪ Small grains	▪ Large hoofed herbivores that provide meat (cattle and American bison) ▪ Large mammals (wild horses, antelopes, pronghorn, kangaroos)	▪ North American prairies, steppes of Eurasia, plains of eastern and southern Africa, pampas of South America	▪ Most of the food of the world ▪ Grasslands and grazing mammals evolved together ▪ Hunting and gathering cultures

Tropical Rain Forests	▪ Average temperature is relatively high and relatively constant	▪ Rainfall is high and relatively frequent		▪ Soil low in nutrient ▪ Chemical elements held in living vegetation	▪ Diversity of vegetation ▪ 2/3 of the 300,000 known species of flowering plants occur in the tropics	▪ Many species of animals ▪ Mammals tend to live in trees, some are ground dwellers ▪ Insect and other invertebrates	▪ Northern South America, Central America, western Africa, northeastern Australia, Indonesia, the Philippines, Borneo, Hawaii, parts of Malaysia	▪ Hunting and gathering cultures ▪ Relatively few civilizations ▪ Occur in remote regions of Earth
Tropical Seasonal Forests and Savannas	▪ Low latitudes ▪ Average temperature is high and constant	▪ Rainfall is abundant but seasonal	▪ Disturbances (fire, herbivory) is common		▪ Number of plant species is high	▪ Greatest abundance of large mammals	▪ India, Southeast Asia, Africa, and South and Central America ▪ Savannas of Africa	▪ Areas of lower rainfall are tropical savannas
Deserts	▪ Low latitudes	▪ Driest regions; rainfall less than 50 cm/yr	▪ Occasional fires and cold weather ▪ Infrequent intense rains	▪ Little or no organic matter ▪ Abundant nutrients	▪ Specialized vegetation	▪ Nonmammalian vertebrates (snakes and reptiles) ▪ Small mammals (kangaroo mice)	▪ Sahara of North Africa; deserts of US ▪ Cold deserts in Utah, Nevada, and western Asia	
Wetlands				▪ Special soil environment with little oxygen	▪ Dominant plants are small (small trees to shrubs, sedges, and mosses) ▪ Produces coal ▪ Edible plants	▪ Bacteria survive in oxygen-less soil ▪ Crabs and shellfish ▪ Insects, birds, and amphibians ▪ Snakes, reptiles, mammals		▪ Standing water ▪ Freshwater swamps, marshes, bogs, saltwater marshes
Freshwaters				▪ Estuaries rich in nutrients	▪ Rooted flowering plants like water lilies	▪ Floating algae called phytoplankton ▪ Small invertebrate animals, herbivores, and carnivores, finfish, shellfish		▪ Critical for water supply ▪ Lakes, ponds, rivers, streams ▪ Conservation effort
Intertidal Areas			▪ Disturbances are common (tides and sea level)			▪ Large algae (kelp) ▪ Birds and attached shellfish; fish	▪ Areas exposed to air during low tide and ocean waters during high tide	▪ Polluted by human activities
Open Ocean					▪ Low diversity of algae	▪ Many species of large animals, but at low density	▪ Pelagic region ▪ Open waters in all of the oceans	▪ Low in nitrogen and phosphorus ▪ Chemical deserts
Benthos	▪ Cold				▪ No photosynthesis ▪ No plants		▪ Bottom portion of the ocean	▪ Dead organic matter that falls from above
Upwellings	▪ Cold and dark			▪ Rich in nutrients		▪ Algae and animals that depend on algae ▪ Commercial fish	▪ North America, South America, West Africa, Artic, Antarctica	▪ Upwellings bring nutrients to surface
Hydro-thermal Vents	▪ Boiling point in waters of vents to the frigid waters of the deep ocean			▪ High concentra-tion of sulfur compound		▪ Chemosynthetic bacteria ▪ Giant clams, worms		▪ Deep ocean; vents of hot water ▪ Water pressure high

Chapter 9 – Biological Productivity and Energy Flow

Case Study – Can the world Produce Enough food for Africa?
Over 200 million people in Africa are malnourished. Human population in sub-saharan africa has increased from 335 million in 1975 to 751million in 2005. The combination of growth and malnourishment highlights the question of productivity.

Biological Production

Organic matter is called **biomass**, this measure is expressed as mass per unit area. When the amount of biomass changes it is called **biological production**. The amount of change over a given time is called **Net production**. Production can be expressed in three ways: biomass, energy stored, carbon stored.

Two Kinds of Biological Production

Primary Production is what **autotrophs** (plants, bacteria) do when they perform **photosynthesis**. This usually involves storing the carbon from CO2 in the atmosphere with some components of H2O using the energy from sunlight. Some autotrophs called **chemoautotrophs** use sulfur compounds and heat from deep ocean vents to store energy.

Secondary Production is done by **heterotrophs** when they ingest or absorb organic matter produced by another living thing.

Releasing stored energy is done through **respiration**, which breaks the carbon bonds to release energy and releases the CO2 that was fixed during photosynthesis.

Laws of Thermodynamics (The Limit on Production)

The First Law of thermodynamics merely states that energy and matter cannot be created nor destroyed, but can be changed in form.

The Second Law of Thermodynamics is the one which is more important to this concept, it states that whenever energy is converted it de creases in total usefulness. Some of the energy may get organized into a very useful form, but this will be balanced by the release of low quality energy, usually in the form of heat. This is demonstrated by "A Closer Look 9.1" on page 171, which shows that energy from coal can be used to make a highly organized shape in a table leg, but that much energy is released as heat.

The second law helps us understand some important concepts in ecosystems, such as the shape of an energy pyramid. The limits of energy flow are demonstrated by the impossible frog-mosquito ecosystem [fig 9.7 p. 170]. This could not work because some of the energy from the frogs blood would be converted (lost) to heat by the mosquito and some of the energy from the mosquito will be converted to heat (lost) by the frog.

Efficiency

One measure of the effect of the second law in ecosystems is **trophic level efficiency,** which relates the energy in one trophic level to that below it. The trophic level efficiency of herbivores appears to be about 1% with tat of wolves (which expend a lot of energy hunting) is 0.01%. A general rule is that less than 10% is passed from one level to the next. The rest is lost as heat.

Examples of Energy Flow

Examples of energy flow in an old field, a stream or river, an ocean, and a deep-sea vent (chemosynthesis) are given on page 172-173. Some key points are that some streams and rivers can have high secondary production (greater than their primary production) because leaves and such can wash into the stream from other areas. Also, it is important to be familiar with the roles of **phytoplankton** (small algae and other plant like organisms) and **zooplankton** (very small heterotrophs which feed on phytoplankton, this can include the shrip-like **krill**) in ocean ecosystems.

Should People Eat Lower on the Food Chain?

The critical thinking issue on page 173 highlights the pros and cons of the ecological argument for vegetarianism. The bottom line is that the argument suggests than less total land is used per person if people eat plants rather than having those plants first fed to animals. The most important counter argument is one of land use, and that some land is better used for growth of forage crops than for food crops.

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Chapter 10 – Ecological Restoration

Ecological succession [begins page 182]

The change in plant and animal life over time as an area responds to a disturbance or climatic change is called **succession**. There are two types of succession: **primary succession**, which is the development of life on land that previously had no life on it, such as a volcano or the land exposed by a receding glacier; and **secondary succession**, which is the recovery of an ecosystem after a disturbance such as a fire, hurricane, or flood. Primary succession generally starts a pattern such as lichen, moss, grasses, small shrubs, trees, big trees. Appropriate animal life follows. In secondary succession, there is generally fertile soil left behind and seeds of late successional species may begin growing right away.

Early successional species have the following attributes; rapid growing, short lived, do weel in bright lights, like rich nutrient soil, and have rapidly and widely dispersing seeds. They are sometimes also called **pioneer species**.

Late successional species are slower growing and longer lived, tend to do well in shade and have persistent, but not widely dispersed seeds.

Figure 9.7 (p 163) shows patterns of diversity, species type and chemical storage during stages of succession. In general, middle succession is highest in all of these.

Patterns of Interaction

Species can influence other species during succession.

Facilitation is when one species helps pave the way for success of a later species. One example is species that create shade for late successional species. **Interference** is when species prevents the entrance of a later successional species. An example is dense mats of grass forming after deforestation in rainforests, these prevent other species from seeding. **Life history differences** describes when two species appear at the same time because of their own life cycles, not because one influences the other.

Chronic Patchiness

Chronic patchiness occurs in areas with frequent disturbances, poor nutrient cycling or harsh environments. Deserts are one example.

Chapter 11 – Producing enough food for the world

Case Study – Food for China

This case study highlights the problem of food supply in developing countries. As countries go through the demographic transition (see chapter 4) they become larger consumers of meat. Since each calorie of meat requires more land than each calorie of plant food, this presents an issue for developing countries.

Can we feed the world?

About 11% of the world's land is in use fro agriculture. Humans continue to alter land to make it arable – as the world's population increases we will have to make choices about how to alter that land and which land to alter. Certainly a key for the future is to increase production per unit area.

How we Starve

There are two main types nutrition issues, undernourishment (not enough food) and malnourishment (deficiency of one or more nutrients such a s protein or a particular vitamin or mineral).

What we eat and what we grow

Crops

Only 150 species have been cultivated, most of the world's food is supplied by only 14 species: wheat, rice, maize, potatoes, sweet potatoes, manioc, sugarcane, sugarbeet, common beans, soy beans, barley, sorghum, coconuts, bananas. **Fig. 11.8** p. 189 shows where the top three are grown. Some crops are **forage**, which are grown for animals to eat.

Crops can be classified as **cash crops**, to be sold in a large market (and not always food, consider tobacco and cotton) or **subsistence crops**, which are used directly by the farmer or sold locally.

Livestock

The major domestic animals are **ruminants** which have a four chambered stomach including symbiotic bacteria that help digest the high cellulose content of plants. Mainly cattle, sheep and goats. These animals are maintained on **pasture**, land plowed and planted to feed the animals, and **rangeland**, which is used to feed the animals without plowing and planting. In the US, much rangeland is managed by the **Bureau of Land Management (BLM).**

Aquaculture

Production of food from aquatic environments – usually applied to animal species. The main example is growing of fish in rice ponds. **Mariculture** is aquaculture in the ocean, mainly it currently involves rafts growing species such as oysters and mussels.

An Ecological Perspective on Agriculture

Farming creates an **agroecosystem** which differs from normal ecosystems by: (1) stopping ecological succession (see chapter 9) by weeding and planting on cleared land; (2) planting a **monoculture**, or only one species in a field; (3) crops are planted in neat, regular rows, this makes it easy for pests to hurt the plants; (4) food chains are greatly simplified; (5) plowing is unlike any natural process.

One way to lessen the effects of monoculture is **crop rotation**, or growing different crops in different fields year after year. This means that nutrients will not be depleted as much as if only one crop was grown every year.

Limiting Factors

"An agricultural limiting factor is the single requirement for growth that is available in the least supply in comparison to the need of the crop." Usually this is a macronutrient such as nitrogen or phosphorous. Some micronutrients could be molybdenum, copper, zinc, manganese, iron, boron, and chlorine. There is not always one limiting nutrient due to synergistic effects (ex. Increasing nitrogen might promote enzymes that could increase intake of phosphorous).

The Future of Agriculture [Fig 11.12, p.206]

Demand-based agriculture is based on highly mechanized farming and a high demand for resources. **Resource-based agriculture** is based on conservation, production is limited by the availability of resources. Organic farming is a third approach describe later in the chapter.

Increasing Yield per Acre

The Green revolution began following World War II, the result was the development of crop strains with higher yields, disease resistance. However these strains required increase fertilization and irrigation – carrying new environmental impacts.

Drip irrigation could improve crop yield by carefully supplying crops with the proper amount of water while also decreasing water consumption. **Hydroponics** could use fertilized water directly without requiring arable land.

[missing – Traditional Farming Methods – p 208]

Organic Farming

Defined by three qualities: more like natural ecosystems than monoculture; minimizes negative environmental impacts; the resulting food contains no artifical compounds (especially pesticides on plants and hormones in livestock).

Alternatives to monoculture

Problem: farmers use climate prediction to choose seed varieties to plant – when they are wrong, productivity can be very low. Alternatives: plant a mix of crops in a field – smaller yield but smaller risk; carefully suiting crop planting to land use (some places are better suited to different kinds of crops **[figure 11.15. p 210]**

Eating Lower on the food chain

Why eat lower ont eh food chain? The second law of thermodynamics says that useful energy is always lost in transformation. Trophic level efficiency is less thatn 10% - so humans can use land more wisely by eating plants, rather than by feeding those plant to animals and eating animals (which would require 10 times more land).

Counterarguments: some land that is good for forage would be terrible for crops; food is more htan just calories – animals are an important source of protein and minerals; domestica animals often have other purposes uch as plowing and excrement used for fertilizer and fuel.

Genetically modified food

Genetically modified crops (GMCs) offer both promise and controversy. Three practices: faster development of hybrids; introduction of the terminator gene; cross species gene transfer. Some goals include better nitrogen fixation, tolerance to drought, heat, cold, soils.

Climate change and Agriculture

Although some areas may have improved crop yield, worldwide climate change is more likely to decrease than increase crop yield. The areas of the world with the best crop soils also have the best climate. Climate change could also effect evapotranspiration patterns, impacting irrigation water supplies.

Optimum Environmental Conditions

The growth of particular crops depend on a combination of environmental factors including rainfall, temperature, and soil type. This can be affected by irrigation (like California's central valley) and application of fertilizer. But some crop growth might be heavily effected by global warming (see chap 21.).

11% of Earth's surface is considered suitable for plant crop (**arable**). 19% of US is arable, over 80% in production, 20% of these considered impacted by urban development. About 79% of wetland destruction is due to agriculture.

World Food Supply

"Today, sufficient food is produced to provide adequate calories for the entire human population, but distribution is uneven and inequitable."

Limits to Food Production

(1) Only some lands can be used for agriculture

(2) many crops have reached limit of benefit from fertilizer

(3) climatic change (global warming) is more likely to decrease yield than to increase it. Crop production is expected to move northward (Canada and Russia) where soils are not as well suited to crop growth.

Ways to Increase the food Supply

(1) **Improved irrigation** – especially drip irrigation, which involves underground pipes slowly putting water into the soil, rather than soaking the surface and creating runoff.

(2) Increasing the amount of Agricultural land – **hydroponics** is the growing of plants in nutrient enriched water, therefore the soil type is not an issue. This can also be done inside a greenhouse, which decreases the effects of climates.

(3) Eating lower on the food chain – Since the second law of thermodynamics shows us that energy is lost to heat in conversion, it is logical that an acre of land can support more humans if they eat plant than if they eat animals that feed on those plants (about 90% more). HOWEVER, (1) "land too poor for crops can make excellent rangeland." (2) animals provide the major source of protein in developed countries. (3) domestic animals can serve other purposes; beasts of burden, wool, leather.

(4) Modification of food distribution

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CHAPTER 12 – EFFECTS OF AGRICULTURE ON THE ENVIRONMENT

[missing – case study]

How Agriculture Changes the Environment

There are both primary (on-site) and secondary (off-site) effects of agriculture. These effects can also be classified as:

Local – erosion of soils, loss of soils, increase in stream sediment

Regional – desertification, pollution, increased sediment in large rivers and estuaries

Global – climate change, chemical cycling effects

"Major environmental problems that result from agriculture include deforestation, desertification, soil erosion, overgrazing, degradation of water resources, salinization, accumulation of tokic metals, accumulation of toxic organic compounds, and water pollution including eutrophication."

Our Eroding Soils

Before farmed, soil generally has a high organic content, but since the plants grown on agriculture land are cleared, few nutrients are left behind to replenish the soil, also plowing increases erosion and leaching, which decrease nutrient content. Two kinds of fertilizer are used to combat this problem: traditionally organic fertilizers such as manure are used. Industry can now create nitrogen fertilizers using electricity to fix nitrogen and by mining phosphorous (see chapter 4).

When land is cleared soil begins to lose its fertility. Once the cover is lost it is exposed directly to wind and water which erode the soil. Nutrients are also **leached** from the soil when water flows through it. Plowing turns the soil over in order to increase production, this brings nutrients up from the zone of accumulation [Fig 12.2 p. 220] to the top of the soil. It also exposes land to the effects of erosion and leaching. 90% of US agricultural land is not using land conservation methods.

Where Eroded Soil Goes - Sediment

Much of the soil eroded from farms ends up in waterways as sediment. Sediments fill in otherwise productive waters destroying some fisheries. In tropical waters, sediments can destroy choral reefs. Nitrates and ammonia can cause eutrophication.

Making Soils Sustainable

Contour plowing – plowing perpendicular to the slope, whis way water does not rush down the furrows in downhill areas. This has recently been the most effective method to reduce soil erosion.

Fall plowing: multiculture: strip cropping: terracing: crop rotation.

No-till agriculture – not plowing, using herbicides to keep down weeds, Stema and roots are left behind.

Controlling Pests

Pests are undesirable competitors, parasites or predators. Pests account for 30% loss of potential harvest and 10% loss of harvested crop. Pre-harvest loss is due to weeds, diseases, and herbivores (mostly insects). Post-harvest is mainly herbivores (insects and rodents).

Major pests are insects, nematodes (worms that eat the roots), bacterial and viral diseases (tobacco mosaic virus, dutch elm disease), weeds, rodents and birds.

Weeds

Weeds are the major problem in terms of crop loss They compete with crops for light, water, and nutrients. Ex. Soybean crop can be reduced 60% of there is cocklebur weed competing. Weed control accounts for 60% of all pesticide sold in US.

History of Pesticides

Early pesticides were **broad spectrum**, they killed lots of things, but this sometimes included some beneficial organisms, and the pesticides could also be harmful to humans. The ideal pesticide is a **magic bullet,** a **narrow spectrum** pesticide which kills a single species but harms nothing else.

DDT [Closer look 12.2 pg 228]

DDT is a chlorinated hydrocarbon. It appeared to have no effect on people and kill only insects. It was used during wartime to protect soldiers against malaria and yellow fever (and is still used this way). It did not dissolve in water, which made it seem like not an environmental problem (as you'll see this ends up being the key to the problem).

BUT.. (1) it has long term effects on non-insects, especially its effect on egg thinning in exposed birds and increased cancer in other organisms (2) it is stored in fats (because it is not water-soluble) and so it is passed up the food chain through **biomagnification.** The DDT found its way into water where it was absorbed by algae → plankton → little fish → big fish → birds (like brown pelican and golden eagle or bald eagle). As a result

DDT was banned in US in 1971, but US still produces it for oversees use (mostly for disease control).

Secondary pest outbreaks

Secondary pet outbreaks occur when a pest appears to have been beaten, but a pest population booms again. This occurs two ways: (1) a competing pest species gets a chance to thrive because its competition is gone; (2) natural selection has occurred and a resistant population has emerged.

Integrated Pest Management (IPM)

IPM is an ecosystem approach to pest management.

(1) use natural enemies like parasites, diseases and predators

(2) plant a greater diversity of crops

(3) no-till agriculture – enemies of nematodes build up in soil

(4) careful application of highly specific chemicals

Biological Control

Predator, parasites, parasites.

Ex. Ladybugs eat aphids on rose bushes

Ex. A bacteria, *Bacillus thuringiensis* kills larae of of many caterpillars, which love to eat leaves. Some wasps also lay eggs in caterpillars, killing them. These wasps are narrow spectrum

Ex. Sex pheremones, which confuse and trap pest species.

Generically Modified Crops

New Hybrids

This mimics a natural process of hybridization. The concern is the creation of "superhybrids" that are s productive they grow where not wanted and become pests.

The Terminator Gene

A gene that makes crops infertile – designed to prevent the spread of gmcs into natural populations. An economic concern is farmers in developing nations that would have to buy new seeds each year, rather than being able to grow seeds from their on crop.

Gene Transfer

Genes can be moved from one species to another – ex. A gene from a bacteria toxic to caterpillars move to potatoes and corn. Rice has been modified to improve nutritional value (bet carotene).

Grazing

Grazing is when livestock roam a piece of land eating the vegetation which grows there. **Overgrazing** reduces the diversity of plant species and can lead to an overabundance of the plants undesirable to the livestock. It can also increase erosion due to vegetation loss. Goats can be especially damaging.

In modern industrialized agriculture, cows are raised on range then transported to **feedlots**, where they are fed grain and live in high densities. The animal waste can be a pollution problem, especially after large rainfalls. This applies to cattle and pigs (swine).

Cattle, sheep, goats and horses have been exported to all over the world. One recent major impact of this has been the cutting of rainforest to create pasture for cattle in order to make money. The soil does not recover and the land becomes desertified quickly.

Game ranching is maintaining wild animals to be harvested for meat, leather, and other products. It is done with zebra and bison.

Desertification

The crucial factor in deserts is the amount of water available in the soil for plants to use. There are 5 natural desert regions on earth, but human activities (especially agriculture) are creating new deserts. About 33% of earth should be desert, but 43% of land is desert.

Desertification is caused when **marginal lands**, which have just enough rainfall to make the area more productive than a desert, are used for crop production and grazing. When the topsoil is ost to erosion, the land can no longer hold moisture and the land is desertified.

Causes of desertification:

bad farming practices
overgrazing
conversion of range to crop in marginal lands
poor forestry practices
poisoning of soils (by pesticides or industrial processes)
irrigation leading to high salt content in soils

Symptoms of desertification:

Lowering of water table
Increase salt content of soil
Reduced surface water
Increased soil erosion
Loss of native vegetation

Preventing Desertification

Monitor symptoms like aquifers and soils
Use proper methods of soil and forest management

Does Farming change the biosphere? (Global Effects of Agriculture)

Agriculture changes land cover which changes **albedo**, the reflection of light, evaporation of water roughness of surface and rate of chemical cycling.

Agriculture increases CO2 by: (1) using a lot of fossil fuels for machinery; (2) clearing land, which increases soil decomposition.

Agriculture can effect climate through fire, which is sometimes used to clear land. Fires release particulates.

Agriculture uses artificial fertilizers. Thgis may be leading to significant changes in the global nitrogen cycle. Excess runoff can create eutrophication.

Agriculture reduces diversity in competing ecosystems.

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Chapter 13 - Forests

Case Study – Wildfires and Park Management

Historically we prevented fires at all costs. WE now know that a) fires serve many ecosystem functions, such as nutrient renewal, and b) preventing naturally occurring fires allows fuel to accumulate so that when fires occur they are much more destructive.

Modern Conflicts over Forests

Forestry is also known as **silviculture**. Modern conflicts over forests arise from conflicts over forest use for resources and its value to ecosystems and species. Some Public services functions of forests include erosion prevention, water availability, species habitats and recreation.

The life of a tree

Trees take CO2 from the atmosphere and H2O from the soil. They use these resources together with sunlight to carry out photosynthesis. The also transpire H2O from their leaves.

Each species of tree has a niche – some prefer wet environments, others dry, for instance [fig 13.7 p 244]

A Forester's view of a Forest

Terms: **even-aged stands** - all the trees are the same age; **uneven-aged stands** - some young, some old, some in the middle; **virgin forest** – never been cut (that we know of); **second growth** – growing in an area which has been previously cut; rotation time – time between cuttings of a forest.

There is no convincing scientific evidence that an ecosystem of old growth is different than a second growth ecosystem – as a result, surrogate issues such as endangered species are often used to preserve old growth forests.

Clear Cutting and its Alternatives

Effects of Clear cutting [fig 13.9], or cutting all trees in a stand at once, include increased erosion, increased leaching of nutrients, this causes increased sedimentation downstream and increased nitrate content in nearby waters, which can cause eutrophication and increased BOD.

Alternatives to clear cutting include: **selective cutting –** cutting some, but not all trees in the stand; **shelterwood cutting** – dead and undesirable trees cut first, this always leaves some young trees in the forest; **strip cutting –** trees are cut in strips of clear cut close together, this leaves woodland corridors; **seed tree cutting** – cut trees with low seed production, and leave those with higher production, so forests grow back quickly, a form of artificial selection.

Plantation Forestry

Trees are planted as crops.

Sustainable Forestry

As with any other renewable resource, a goal with forestry is sustainability. One strategy to economically support sustainable forestry is the certification of forestry practices. In this approach, lumber from sustainable forests would carry a stamp so that consumers could choose to support these practices.

A Global Perspective on Forests

Atmospheric effects of vegetation: 1) changing albedo, 2) increasing transpiration, 3) a carbon sink, 4) changing windflow. In general – forests=good [fig. 13.11].

Forests cover about 27% of earth, Commercial grade forest is forest which is economically profitable. About 70% of US forest is privately owned [fig 13.12].

Deforestation

"Most experts believe that there is a worldwide, and perhaps rapid, net decrease in total forest area and biomass"

Global and regional effects

Ex. Deforestation in Nepal leads to sedimantation and flooding in India

Causes of deforestation

Reasons to cut include: lumber, paper, fuel, clearing for agriculture. About 50% of all wood cut in the world is for **firewood**. Most of this is in developing countries. **Indirect Deforestation:** loss from pollution or disease. Global warming could also impact forests over vast regions, many trees would not be able to grow in their current locations.

The World Firewood Shortage

63% of all wood worldwide is for fire, yet firewood is only 5% of the world's energy use. It is a majo source of energy in Africa, Central America, and southeast asia. Forest is not well managed in these places.

Indirect Deforestation

Global warming and Acid Rain can harm forests.

Multiple Use

In the US the national forest are part of the Department of Agriculture and are called the "Land of Many Uses." The many uses included lumber, recreation, mining, water.

Community forestry [closer look 13.1]

In developing countries where there is a nearby forest used for fuel wood it can be effective to establish a community cooperation related to which stands of trees to cut and which to not cut.

Parks and Preserves

Parks are an area preserved, as opposed to the use approach of forests. This can include the preservation of monumental natural resources such as the grand canyon or Yosemite valley. They may also be used for wildlife conservation, maintenance of wildlife for hunting, and outdoor recreation. Corridors are often useful in creating parks so that wildlife can migrate from one area to another, this strategy can help preserve diversity. The formation of a park can result in the edge effect, "which means that many species escape from the cut area and seek refuge in the border of the forest." Also, near the borders of parks moisture can be reduced and winds can be increased, decreasing the diversity for a certain depth into the forest, the smaller the forest the greater percentage this is.

Conserving Wilderness

Wilderness is an area undisturbed by people where the only people are visitors who do not remain. Int eh US wilderness is protected by the **Wilderness Act of 1964**, this act defined wilderness and asserted its ecological value,

CHAPTER 14 – WILDLIFE, FISHERIES, AND ENDANGERED SPECIES

Goals of conservation

(1) wild creature, wild habitat
(2) wild creature, managed habitat
(3)zoo preservation
(4) preservation of DNA

Reasons for the conservation of Endangered Species [closer look 14.1]

Utilitarian – usefulness to humans

Genetic characteristics for crops, etc; Medical and chemical uses; New crops; Indigenous peoples; Pollution control; tourism; medical research.

Ecological – links in the web

Forest conservation; global aspects of bacteria, etc

Aesthetic – species add beauty and quality of life

Moral – all life forms have a right to exist

Traditional Wildlife management

Wildlife is a **renewable resource**, because they can potentially be regrown at the same rate as they are used. Two types: **Maximum Sustainable Yield (MSY)** and **Optimum Sustainable Yield (OSY). MSY** is the maximum produced that can be continued without a reduction in yield. **OSY** is the maximum that can be produced indefinitely and sustain the agro-ecosystem [figs 14.3 and 14.4]. The goal is sustainability. This is a problem because populations rarely follow the logistical growth curve, and there can be annual variation. If the potential harvest is over-estimated, the population can be greatly reduced over time.

[missing - grizzly bear and bison]

Improved approaches to Wildlife Management

1. a safety factor (so harvest is underestimated)
2. concern with the ecological community, not just the harvested organism
3. maintenance of the ecosystem of the target species
4. continual monitoring and assessment

Age Structure

This is a key, consider the fishery issue.

Management Techniques

Set limits on sex, age, or size of harvested individuals; manipulate habitat by changing abundance of food, water, or shelter; set limit on number (ex. Moose monitoing in Maine to keep pop. From dropping below a certain level).

Life in the Oceans

There are three important food webs in the ocean, each of these is described on p276**. Planktonic foodwebs**: phytoplankton → zooplnakton → small fish (or baleen whales) → big fish**; Intertidal food webs**: kelp → shellfish → fish, etc..; **Reef food webs**: very diverse, based on algae that live symbiotically with the coral.

[missing: harvests as estimates of numbers]

Fisheries

20 species of fish and shellfish make up 60% of annual catch and 90% of monetary value. Harvest peaked in 1989 and has been decreasing, probably due to overfishing. Fisheries occur in relatively few areas of the ocean, mainly on continental shelves and areas of upwelling [fig 14.10 p. 275]. **Upwelling** occurs where wind blows water away from shore, water rises from the ocean floor to replace the blown water, bringing with it nutrients (nitrogen and phosphorous) from the ocean floor. These nutrients feed the phytoplankton, driving a food chain that supports the fish. Equatorial areas are also somewhat productive, since there is so much yearly sunshine. Continental shelves make up only 10% of ocean, but provide 90% of annual fish catch.

Table 14.3 tells a few stories of the failure of fisheries. Most of these hinge on the failure of the use of logistical growth in management, for instance, the Peruvian fishery continued to harvest at estimated MSY amounts in an El Nino year, when upwelling was reduced and less fish were present. Figure 13.15 on p. 279 shows how the age of salmon caught has decreased on the Columbia river over 20 years. This is a major symptom of overfishing and is part of a positive feedback loop decreasing fish populations. Limiting the size and age of harvested fish is thought to be key in managing the worlds fisheries for sustainability.

Conservation of Whales and other Marine Mammals [pg 273]

Whales were heavily harvested in the past, but once petroleum was developed most of their resources area not useful on the world market, but may still be of use in cultural contexts suach as for Eskimos, who use them for subsistence. In 1931 21 countries signed the **Convention for the Regulation of**

Whaling. In 1946 the **International Whaling Commission** (IWC) was formed and has since established a moratorium on whaling, but this is not respected by all nations.

Extinction

Extinction is a normal part of life on earth at an average rate of about 1 species per year. In recent ears this rate is thought to have greatly increased. There have been 5 mass extinctions [Fig 12.7] which involved changes on earth not related to humans. Many ecologists believe we are now in the midst of a 6th mass extinction due to human activities.

Causes of extinction

Species can become extinct due to:

Population risk – low birth rates in low populations can result in extinction.

Environmental risk – effected by physical surroundings or relationships through predation/parasitism/mutualism – see butterfly example p.236.

Natural Catastrophe – A suddenchange in the environment of a small population

Genetic risk – in small populations, inbreeding can result in an accumulation of detrimental recessive traits

Common Traits of Endangered species

Long lived
Large
Low reproductive rates
Large territories required
Specialist species

How people cause extinctions

Currently humans have the largest impact on endangerment and extinction through **habitat destruction**, although hunting has played a large role in the past, especially with bird species [fig 12.11]. Another huge effect is the introduction of exotic species [pg 633]. And pollution is another.

Introduction of Exotic Species

Exotic Species can be introduced intentionally (on purpose) or **inadvertently** (accidentally). Many food plants and domestic animals have been introduced on purpose all over earth. An example of inadvertent introduction from an earlier chapter is purple loosestrife. **Other inadvertent introductions** include diseases such as smallpox; pests such as mice, rats, and weeds; fish and shellfish, such as the lamprey, and zebra mussel. Introduced species area problem when they out compete native species and especially if there are no natural predators or if plant species are not adapted with natural defenses for introduced herbivores. An excellent example of the problem of introduced species can be found in the environmental issue from chapter 29, p 633.

What is being done to help conserve biological diversity and endangered species?

EMERGENCY ACTIONS – stop the harvesting.

MINIMUM VIABLE POPULATION SIZE – **the 50/500 rule** states that to decrease the genetic risk of a small population there must be 50 mating pairs, since every individual is not part of a mating pair, there should be a minimum population of 500.

ECOLOGICAL ISLANDS – as habitat becomes fragmented it is important to consider **island biogeography**, even on land, if habitat is changes by deforesting, smaller plots of habitat will support smaller levels of diversity. Using **corridors** between these islands can reduce risk. [See fog. 13.12]

Introducing Exotic Species to Minimize Effects on Native Species

An example is the introduction of the dung beetle to decompose the cattle dun gin Australia, where there were no natural decomposers adapted to cow dung.

The Endangered Species Act

The endangered Species act of 1973 made it illegal to import, export, sell, harm, harass, or capture any endangered species. But probably most important is it required protection of the habitat of endangered species.

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Pollutant	Definition	Sources	Examples	Effects	Other
Infectious Agents	▪ Spread from the interactions between individuals and food, water, air, or soil	▪ Spread through airplane travelers or terrorist activity ▪ Transmitted through ventilation systems	▪ HIV, hantavirus, dengue fever ▪ Legionellosis (Legionnaires' disease), Giardiasis, Salmonella, Malaria, Lyme Borreliosis (Lyme disease), Cryptosporidosis, Anthrax	▪ Inhalation anthrax killed several people ▪ Ebola virus in Africa causes external and internal bleeding resulting in death of 80% of those infected	▪ Diseases that can be controlled by manipulating the environment are classified as environmental health concerns ▪ Greatest mortality in developing countries is caused by environmentally transmitted infectious disease
Toxic Heavy Metals	▪ Metals with relatively high atomic weight that pose health hazards to people and ecosystems	▪ Found in soil or water not contaminated by humans ▪ By-product of mining, refining, and use of other elements	▪ Mercury, lead, cadmium, nickel, gold, platinum, silver, bismuth, arsenic, selenium, cadmium, chromium, thallium	▪ Direct physiological toxic effects ▪ Stored or incorporated in living tissue (fatty body tissue)	▪ Content of heavy metals in our bodies is the *body burden* ▪ Mercury, thallium, and lead are very toxic to humans ▪ Mercury is the "Mad Hatter" element
Toxic Pathways	▪ Chemical elements released from rocks or human processes can become concentrated in humans through many pathways	▪ Natural sources of mercury come from volcanic eruptions and erosion of natural mercury deposits ▪ Human input of mercury through burning coal in power plants, incinerating waste, and processing metals ▪ Deposition from the atmosphere through precipitation	▪ Cadmium, which influences the risk of heart disease, may enter the environment via ash from burning coal ▪ Mercury pollutes aquatic ecosystems	▪ Sedimentation of mercury at the bottom of the pond ▪ Mercury that enters fish may be taken up by animals that eat the fish ▪ Release of mercury by resuspension in the water, where eventually the mercury enters the food chain or is released into the atmosphere through volatilization (conversion of liquid mercury to a vapor form) ▪ Mercury poisoning	▪ **BIOMAGNIFICATION** ▪ Coal burned → ash disposed of in landfill → cadmium taken into plants as they grow →becomes more concentrated as it moves through the food chain ▪ Once inorganic mercury enters the water, methylation can change it to methyl mercury which is much more harmful (toxic) than inorganic mercury and is eliminated more slowly from animals' systems
Organic Compounds & Synthetic Organic Compounds	▪ Compounds of carbon produced naturally by living organisms or synthetically by human industrial processes	▪ Synthetic organic compounds used in industrial processes, pest control, pharmaceuticals, and food additives		▪ So many of them and so many uses that they can produce many different kinds of effects ▪ May produce a hazard for many years	▪ Have produced 20 million synthetic chemicals and new ones are appearing at a rate of about 1 million per year ▪ Up to 100,000 chemicals are being or have been used
Persistent Organic Pollutants	▪ Carbon-based molecular structure ▪ Persistent in the environment ▪ Soluble in fat and likely to accumulate in living tissue	▪ Manufactured by humans ▪ Occurs in forms that can be transported by wind, water, and sediments for long distances	▪ Aldrin, Atrazine, DDt, Dieldrin, Endrin, Dioxins ▪ Polychlorinated biphenyls (PCBs) are heat-stable oils used as insulator in electric transformers	▪ Polluting and toxic ▪ Carried by surface runoff into streams and rivers ▪ Moving up the food chain, the concentration increased ▪ Passed on to people	
Hormonally Active Agents (HAAs)	▪ Chemicals that cause developmental and reproductive abnormalities in animals, including humans		▪ Herbicides, pesticides, phthalates, and PCBs	▪ Genital abnormalities, low egg production, reproductive problems ▪ Thinning of eggshells, decline in populations, reduced viability of offspring, changes in sexual behavior	▪ Some chemical agents in sufficient concentrations will affect human reproduction through endocrine and hormonal disruption ▪ Endocrine system regulates and control growth, development, and reproduction

Radiation				▪ Excessive exposure is linked to serious health problems, including cancer	
Thermal Pollution	▪ Heat released into water or air produces undesirable effects	▪ Natural events, such as forest fires and volcanic eruptions ▪ Human-induced events, such as agricultural burning ▪ Electric power plants that produce electricity in steam generators	▪ Changes average water temperature and the concentration of dissolved oxygen ▪ Changes the river's species composition ▪ Fish spawning cycles disrupted, fish have a heightened susceptibility to disease, warmer water causes physical stress in some fish and make them easier prey ▪ Change the type and abundance of food available for fish		▪ Heat can be released into the air by cooling towers or heated cater can be temporarily stored in artificial lagoons ▪ Used heated water to grow organisms of commercial value
Particulates	▪ Small particles of dust released into the atmosphere by natural processes and human activities	▪ Modern farming and combustion of oil and coal ▪ Dust storms, fires, and volcanic eruptions	▪ Many chemical toxins, such as heavy metals, entire the biosphere as particulates	▪ Impact on global environment ▪ Linked to global climate change and stratospheric ozone depletion	▪ Nontoxic particulates can link with toxic substances, creating as synergetic threat
Asbestos	▪ Several minerals that take the form of small, elongated particles, or fibers	▪ Industrial use of asbestos in fire prevention and protection from overheating of materials ▪ Used as insulation	▪ White asbestos which comes from the mineral chrysolite not harmful ▪ Chocidolite asbestos (blue asbestos) are hazardous and can cause lung disease	▪ Asbestosis (a lung disease caused by the inhalation of asbestos) and cancer ▪ Can cause tumors to develop if the fivers are embedded in lung tissue	▪ Spent a lot of money removing asbestos from school buildings
Electromagnetic Fields		▪ Electric motors, electric transmission lines for utilities, and electrical appliances		▪ No association between childhood leukemia and measured exposure to magnetic fields	▪ Statistics can predict the strength of the relationship between variables such as exposure to a toxin and the incidence of a disease, but statistics cannot prove a cause-and-effect relationship between them
Noise Pollution	▪ Unwanted sound ▪ Sound is a form of energy that travels as waves	▪ Noise of a lawn mower or motorcycle ▪ Amplified rock music	▪ Environmental effects of noise depend not only on the total energy, but also on the sounds' pitch, frequency, and time pattern and the length of exposure to the sound ▪ Very loud noise cause pain, and high levels can cause permanent hearing loss		▪ Sensation of loudness is related to the intensity of the energy carried by the sound waves and is measure in units of decibels ▪ Decibel scale increase exponentially as a power of 10
Voluntary Exposure	▪ Voluntary exposure to toxins and potentially harmful chemicals is sometimes referred to as exposure to personal pollutants	▪ Tobacco, alcohol, and other drugs ▪ Tobacco contains a variety of components that are toxic, carcinogenic, radioactive, and addictive	▪ Causes human ills, including death and chronic disease, criminal activity such as reckless driving and manslaughter, loss of careers, street crime, and the straining of human relations on at all levels ▪ When abused, alcohol causes serious problems ▪ Death in automobile accidents, violent crimes, and other criminal activities, alcohol overdose ▪ Chronic alcoholism causes liver and heart disease ▪ Illegal drugs degrade the mind and/or body ▪ Synthetic (designer) drugs cause health problems and death		▪ 30% of all cancers in the US are tied to smoking-related disorders ▪ Cigarette smoking causes approximately 80% of lung cancers ▪ Secondhand smoke and tobacco products are also dangerous

Chapter 17 – Energy: Some Basics

The case study for this chapter merely points out that ancient civilization experienced energy shortages and turned to passive solar energy by designing to take advantage of the environment.

Energy Basics

First law of thermodynamics – energy is neither created nor destroyed, but changes form

Second law of thermodynamics – Every time energy is used (converted) the quality of the energy decreases. However, there can be local increases in energy quality if it is balanced by an overall decrease in energy quality. **Entropy** is the word that describes the movement of energy from low to high quality. When there is a lot of low quality energy, entropy is said to be high.

Chemical and potential energy are high quality, heat is very low quality energy. Heat is released as waste from most energy conversions, providing for most of the decrease in energy quality.

Energy Efficiency

Efficiency is a way of expressing how much of the energy input is applied to doing the desired work. For example, a light bulb has 5% efficiency because 5% of the electricity supplied to the light bulb is used to make light, the other 95% is wasted as heat. This strict balance of energy is called the **first law efficiency.** There is also **second law efficiency** which has to do with matching the energy supplied to the **end use**. For example, it is more efficient to use 90 degree ground water to heat a home to 80 degrees than it is to use a 1000 degree flame supplied by natural gas.

Energy Sources and Consumption

5% of the worlds pop uses 25% of energy (these are in developed countries).

90% of US energy is produced by fossil fuels. These are non-renewable.

The US imports more oil than it produces.

Figure 17.5 shows that consumption of energy in the Us is about equally split between Transportation (including commercial trucking and airplane flights), Residential/commercial use (lights, appliances), and Industrial (factories, etc…).

Units – common units of energy include the BTU, which is often used to measure the heat producing potential of natural gas; Watts, which express how much energy something uses per second, and kilowatt-hours, which expresses the total amount of energy consumed over some time (electric bills say how many kWh your household consumed in a month).

Energy Conservation, Increased Efficiency, and Cogeneration

Conservation – getting along with less use (like by turning off lights when you leave the room or have lower wattage appliances)

Cogeneration – using the heat wasted from a process to heat air inside buildings. Our car heaters do this by using the heat wasted from the engine to heat the air inside the car.

Building Design – Several ways of decreasing energy demand can be found in building design. (a) Windows and overhangs can supply shade in summer but allow sunlight to enter windows in winter. (b) insulation, caulking, weather stripping, double-paned windows, etc..

Industrial energy – Industry has greatly increased its efficiency by cogeneration and using energy efficient machinery.

Automobile design – several types of energy efficient automobiles are in use and development. (a) **hybrid vehicles** have a gas engine which, when running, charges a battery, the gas is used for acceleration and the battery is engaged for cruising speeds. They can get up to 80 miles to the gallon. (b) **electric vehicles** run on electricity only, but they must be charged using electricity which may be creating pollution elsewhere, they tend to accelerate slowly, have low top speeds, and short ranges (60 miles per charge). (c) **hydrogen fuel cells** combine hydrogen directly with oxygen to create electricity. They have only water as their waste. For now hydrogen is only being recovered by processing fossil fuels, but there is research being done into getting hydrogen from the splitting of water.

Energy Policy

The **hard path** refers to a possible energy future where we build on the status quo, it is highly centralized and depends on improving existing technologies. The **soft path** is a term coined by **Amory Lovins** and describe an alternative future path based on decentralized energy, integrated energy management and a focus on matching energy supply to end use (second law efficiency)

Integrated Energy management

This is when a variety of energy sources are used from region to region utilizing many technologies and matching the energy source to the end use. Fossil fuels would still be utilized in a limited amount to produce electricity.

Chapter 18 – Fossil Fuels and the Environment

Case Study: Fuel Efficiency in U.S. passenger Cars and Light Duty Vehicles
Key point – at the time it was written there had been a increase in fuel mileage of light trucks and passenger vehicles (cars), but there had still been an increase in gas consumption because the number of vehicles on the road had increased. The main point was that even if we increase efficiency and decrease consumption we will still someday run out of fossil fuels. Since then we have had two major changes: SUVs which use lots of gas, and electric and hybrid vehicles.

What are fossil fuels?

Coal, oil, and natural gas are fossil fuels. They are formed when plants are buried and decompose in an anaerobic environment. This converts the carbohydrates to **hydrocarbons**. Because of this, fossil fuels can be considered a form of stored solar energy. Fossil fules provide about 90% of the energy consumed in the world and in the US (see fig. 16.1).

Crude Oil and Natural Gas

Crude oil (petroleum) and natural gas are generally found in tectonically active areas like plate boundaries. They are found in rock that is coarse grained and somewhat porous, often sand stone or limestone. Because of the low density of oil and gas they migrate upwards in rocks and are captured under a non-porous cap rock shuch as shale (see fig 16.2).

Petroleum Production

Production is the word used to describe the process of getting petroleum out of the ground. This is done by drilling down into the oil reservoir. 25% of the oil can be removed using **primary production** in which the natural pressure of the oil makes it flow up the drill pipe. In **secondary recovery** steam, water or other gases are pumped in to push oil out. This increases the yield to 60%.

65% of the proven oil reserves are located in 1% of the world's fields, mostly in the Middle East (see fig. 16.3). As of 2000 the proven reserves would last 45 years at current consumption rates.

The estimate of recoverable **natural gas** is 70 years at current consumption rates, but estimates of new reserves make that 120 years. Gas is transported in pipelines.

Environmental effects of oil and natural gas

Recovery:

Disruption of land during building, surface and groundwater pollution from leaks and infiltration, release of air pollutants, land **subsidence**, disruption of fragile ecosystems.

In ocean drilling oil can also seep into the water, drilling muds that have heavy metals can be released, and there can be an aesthetic effect on the ocean view.

Refining:

At refineries crude oil is separated into its usable substance like gasoline, tar, motor oil… Impacts include spills and leaks

Delivery and Use:

Oil spills from oil tankers (boats) or pipelines. Effects on sea birds and animals are dramatic, but usually short lived.

Air pollution – See Chapter 22

Oil Alternatives – oil shale and tar sands

Oil shale and tar sands contain fossil fuels in geologic material from which it is more difficult to recover them. They are more expensive than oil to recover, but as the price of oil rises they may become more practical alternatives.

Oil Shale is fine grained sedimentary rock that contains hydrocarbons which can be released and collected when heated above 500 degrees.

Tar sands are snad or sediments with thick tar oil which cannot be removed by drilling since it is too thick.

Environmental impacts of recover of these two fuels is similar to caol (see below) since they must be mined.

Coal

Coal forms the same way as oil, but begins as "peat," partially decomposed vegetation, instead of from buried plants. Coal is "by far the world's most abundant fossil fuel." There are four types of coal:

Anthracite	high energy	low sulfur	rare
Bituminous	high energy	high sulfur	common
Subbituminous	low energy	lowest sulfur	mid
Lignite	lowest energy	low sulfur	common

Large coal deposits are found in China, the US, Russia, and parts of Europe. Current coal deposits could last over 250 years.

Environmental Impacts of coal

Most coal is recovered by **strip mining** in which huge holes are dug in the earth to recover the coal in the area. The impact of these mines varies based on the climate and topography, in dry areas the impacts may not be as drastic as wetter areas. One major impact is **acid mine drainage**. This is when water leaches sulfuric acid from the banks of mine spoils and tailings. Sulfurous deposits are found with coal, including pyrite (FeS_2).

Other impacts of strip mines include aesthetic degradation and habitat destruction.

The *Surface Mining Control and Regulation Act of 1977* requires that all mined land be restored appropriate ot its previous use.

Underground mining is when tunnels are dug into the ground to dig out coal. And are common on the east coast of the United States. Environmental impacts include: acid mine drainage, land subsidence, and underground coal fires.

Coal Transport

Coal is usually transported by train or truck but can also be moved in a slurry pipeline**, in which crushed coal is pushed using moving water.**

Chapter 19 - Alternative Energy and the Environment

Case Study: Spirit Lake Community School District in Iowa, Going with the Wind
This case study is merely an example of one local decision to decrease power costs by using a local renewable resource to offset pollution and to educate.

Introduction to Alternative Energy Sources

Alternative energy refers to all sources of energy besides fossil fuels, which comprise 90% of all energy consumed by people. Alternative fuels can be classified as **nonrenewable** (geothermal and nuclear) and **renewable** (all others). All renewable forms of alternative energy can be viewed as direct or indirect solar energy (see fig. 19.1 on pg. 387).

Although one pro of alternative energy is the vast abundance of energy available (see Table 19.1 pg. 388) one con is that many forms, such as wind and solar, are intermittent and not always available when desired.

Solar Energy

The amount of solar energy reaching the earth's surface is about 7,000 times as much as earth's energy demands. However, there is a lot of variation daily and seasonally depending on site. There are several ways to utilize solar energy.

Passive solar energy systems involve no moving parts, but use design to maximize natural cooling and heating related to sunlight. See fig. 19.3 pg. 389

Solar collectors usually provide hot air for space heating or hot water. They are comprised of a box with a black interior for absorbing light and producing heat and a glass top that lets light in but keeps the hot air from escaping. Tubes of water or air pass through the box and become heated. (See fig 19.4, pg. 390)

Photovoltaics convert sunlight directly to electricity using superconducting materials. They are especially useful in remote locations in rural areas and developing nations that are not "on the grid." Although their operation involves no moving parts and no emissions, their production can involve some very hazardous materials. Also, they can require large amounts of space for bigger projects.

Power Towers utilize a large network of mirrors to focus a large amount of sunlight on a single point, heating a working fluid to create steam as in a conventional thermoelectric power plant. fig 19.7, pg 392)A trough design like the Luz power plant uses parabolic mirrors that heat a long tube of oil to create steam (see fig. 19.8, pg. 393).

Hydrogen

Hydrogen is the most abundant material in the universe as it is two thirds of every water molecule. It can be used to generate electricity in a **fuel cell**. In a fuel cell the electrons and protons of hydrogen are separated by a special membrane, the electrons must then flow through a wire to be reunited with their protons and oxygen gas to form water (fig 19.9, pg. 394). This electron flow is electricity which can be used to do work such as in an electrical car engine. Fuel cells would require only hydrogen for fuel and create only water vapor as exhaust, but the production of hydrogen requires energy. If that energy was supplied by other renewables the impact would be decreased. Also, a key component of the special catalyst membrane in fuel cells is platinum, which makes them very expensive.

Water Power

Water power is a form of stored solar energy, since sunlight drives the evaporation that provides the potential energy in falling water. Water stored behind a dam falls and turns turbines which drive electrical generators (fig 19.10a pg 395). Although large scale hydropower supplies about 10% of US electricity, and more in some other, wetter countries, it is highly site specific and most good sites have already been developed. A bullet list of negative impacts of large scale hydropower is found on page 396.

Small scale systems include *micro-hydropower* systems, such as decentralized systems on smaller streams and creeks, and pump storage systems, which utilize off-peak excess electricity to pump water uphill to store potential energy which could later be utilized during peak hours (fig. 19.10 b and c, pg 395).

Tidal Power

Only a few sites on earth have the beneficial combination of a high tidal range (up to 50 ft) and a relatively narrow bay to take advantage of tidal power. A dam is built across the entrance to the bay, during high tide, the water is kept out of the bay and then flows in through generators, the opposite is the during low tide.

Wind Power

Wind is another form of solar energy, since wind is created by the differential heating of earth's surface causes air masses to move. Wind power is gathered with a windmill style wind turbine that is connected directly to a generator. Wind power is highly variable in time, place, and intensity.

Wind often increases in velocity over hilltops and through mountain passes (fig 19.12, p 397). Good locations include, Texas, the Palm Springs area and Oregon.

Negative environmental impacts of wind power include the death of birds of prey, land use, and aesthetic degradation.

Biofuels

Biofuel is energy recovered from biomass.

Chapter 22 -Water Pollution and Treatment

Case Study: Outbreak

This case study points out that the primary water pollution problem in the world (although not so much in developed countries) is the lack of clean disease-free drinking water. One such disease that occurs in epidemics is cholera, which causes diarrhea and can result in death from dehydration. Another one, which occurred in the US in 1993 is *Cryptosporidiosis*.

Water pollution Basics

Water pollution is the degradation of water quality. In terms of water for human consumption this relates to whether the water is suitable to be consumed. In terms of water in the environment (and not intended for human consumption) it can refer to how degradation of water quality disrupts ecosystems. Some **major sources of surface water pollution** are urban and agricultural runoff, runoff from industrial sites and sediment from erosion. Some **major sources of groundwater pollution** are leaks from waste disposal (landfills) leaks from buried tanks and seeps and spills from mines, pipelines and industrial sites. An excellent list is Table 20.1.

WATER POLLUTANTS

The kinds of pollutants regulated in our dirnking water are listed in table 20.3.

Biochemical Oxygen Demand (BOD)

When dead organic matter enters stream or other bodies of water, bacteria begin to decompose it. The bacteria use oxygen and multiply quickly, using even more oxygen from the water. The amount of oxygen in the water is called **dissolved oxygen (DO).** Normal levels of DO in a healthy pond or stream would be 6-9 ppm, but below 5 it becomes difficult for heterotrophs such as fish to survive. See fig 20.2 for an example of BOD pollution resulting from a spill from a sewage treatment plant.

Waterborne Disease

In order to measure the chance of disease causing bacteria being present in a body of water we count **fecal coliform bacteria**. Although the bacteria are not generally dangerous, their presence indicates the chance that other bacteria associated with animal waste could be present.

Nutrients

Major nutrients that pollute water are phosphorous and nitrogen. This pollution results from agricultural runoff of fertilizers, urban runoff from fertilizers and detergents, and increased runoff resulting from deforestation. Over 90% of all nitrogen added to the environment is from agriculture (including runoff from feedlots). These nutrients can result in eutrophication (see A Clocer Look 20.2).

Oil

Oil can be a pollutant in surface water. This can happen from leaks from undersea drilling and from leaks from Oil tankers (ships). The most famous recent tanker spill was from the *Exxon Valdez* (prounounced val-deez') which spilled 250,000 barrels of oil into the Prince William Sound in coastal Alaska in 1989 (fig. 20.6 and 20.7). this resulted in the death of many seals and sea birds. The short term results can be dramatic, but the long term effects may not be significant (also see Durand Notes for chapter 16). Accumulated small leaks from normal shipping probably release more total oil than spills.

Sediment

"**By volume and mass, sediment is our greatest water pollutant. Sediment** is made of particles of gravel, sand, and silt. It results from erosion and it reduces the quality of the water it is in. The presence of sediment is measured as **turbidity**, which is a measure of how much light can travel through the water. Sediment is caused by land conversion: from forest to clearing, agricultural use, deforestation.

Acid Mine Drainage

Acid mine drainage refers to water leaving the site of a mine where it has leached sulfur compound from mine tailings. This water has then been converted to sulfuric acid and can pollute surface and ground water. It comes mostly from coal mines but can alos come from metal mines. A common sulfur compound it interacts with at these sites is pyrite (fool's gold). This is a significant problem on the east coast, where the acid water has polluted streams.

Surface Water Pollution

Pollutions can come from **point sources**, such as a pipe or single building, or **non-point sources**, such as the acuumulated runoff of an urban or agricultural community.

Ground Water Pollution

About 50% of US residents depend on groundwater for their water source. As much as 75% of the 175,000 waste disposal sites in the us may be leaking plumes that are migrating towards groundwater.

Groundwater pollution v. Surface water pollution

a) groundwater lacks oxygen, kills aerobic bacteria, but can harbor anaerobic ones so bacterial breakdown of pollutants does not occur

b) the rate of movement in the ground is low, so poluttants are not diluted.

Salt Water Intrusion (see A Closer Look 20.3 p. 427)

A salt water intrusion occurs in coastal areas where groundwater is being overdrafted. The spot where the well reaches the water table creates both a cone of depression and a cone of ascension (fig 20.11) (like the way a dip forms in a thick shake around the straw when you suck on it). The cone of ascension can sick in salt water.

Wastewater Treatment

This includes treatment of water used in industry, commerce (stores and restaurants) and in household use (sinks, toilets, showers). In some areas it also includes the water from gutters that flows into storm drains.

Septic tanks for household treatment (fig20.13)

Septic tanks are used in rural areas with no centralized sewer wywtem A pipe leads to an underground tank which separates solids from liquids, uses bacteria to decopmpose the waste and then slowly discharge the treated a series of pipes that disperses it throughout a field.

Wastewater Treatment Plants (sewage plants) (fig. 20.14)

Primary Treatment

A) Incoming water passes through screens to collect larger objects

B) Water is sent to the **grit chamber**, where the flow slows down to allow particles like stones and sand to settle and be removed

Secondary Treatment involves activated sludge, in which bacteria, nutrients (sludge) and oxygen are combined ot encourage the breakdown of organics that still remain in the water. The resulting sludge is removed and recycled back into activated sludge tanks to continue the breakdown of organics in more incoming water. Th other sludge moves to a sludge digester where breakdown is completed by anaerobic bacteria.This process produces methane, which is often used to produce electricity in treatment plants. This resulting sludge is then dried and disposed of in landfills or used for agricultural fertilizer, it is now known as "**biosolids.**"

Advanced Wastewater Treatment (tertiary treatment)

To remove pollutants such as dissolved nitrates phosphates and heavy metals special processes must be used sucha s filters or chemical application. This could also include chlorination or disinfection by UV or ozone as in treatment for domestic use.

Water Treatment for Domestic Use

Water is treated after it is taken form the ground or from surface water, but before people consume it or us it for other household reasons, such as cooking. The water is filtered and then treated with a disinfectant such as chlorine (or UV or ozone treatment). Some water is also additionally filtered in the home.

Land Application of Wastewater (grey water) (fig 20.15)

1) return wastewater to to crops

Chapter 26 – Ozone Depletion

Case Study: Epidemic of Skcin Cancers in the US
This case study puts forth the widely believed idea that the increase of skin cancers in the US is correlated with ozone depletion. It also examines the statisctics related to expected increase in cancer (about 2% increase for a 1% decrease in ozone) and shows this this cannot account for the 90% increase in cancers since 1975. Skin cancer, therefore has multiple causes including increased voluntary exposure to uv through tanning.

Ozone Basics
The chemical formula for ozone is O3. It is formed as an angular molecule and is unstable – therefore it reacts well. About 90% of the ozone found in the atmosphere is found in the stratosphere. OZONE IN THE TROPOSPHERE BAD: OZONE IN THE STRATOSPHERE GOOD.

There are three types of ultraviolet light, UVA, UVB, and UVC. UVA has the longest wavelength. It is relatively harmless and much of it reaches earth. UVC can be very harmful, but is filtered by O2, UUVB causes damage to DNA and is filtered by ozone in the stratosphere. When Ozone (O3) absorbs ultraviolet radiation it breaks down into O2 and an atom of O.

Ozone in the atmosphere is measured in "**Dobson Units**" which is equal to 1 ppb.

Ozone depletion
Here's the idea: CFCs emitted in the lower atmosphere by human activity are stable and can persist for up to 100 years. Because of this they can eventually find their way into the stratosphere. Once they are there the UV light will break them apart releasing atomic chlorine (Cl), this chlorine breaks apart ozone, and uv that would have absorbed by breaking that ozone is now allowed to pass to the surface of the earth.
Here are the reactions that deplete ozone

$$Cl + O3 \rightarrow ClO\ O2$$

$$ClO + O \rightarrow Cl + 02$$

One of the reasons this can be so damaging to ozone is that Cl acts as a catalyst, in other words, it is not used up in the reaction. It is thought that one Cl atom can destroy up to 100,000 molecules of ozone.

Uses of CFCs and other ozone depleting chemicals
The major uses of CFCs and other ozone depleting chemicals are in air conditioning, making foams (such as stryrofoam) and in fire extinguishers (table 24.1) . CFCs were once used as a propellant in hair spray, but that has been illegal since the late 1970s.

Chlorine sinks in the stratosphere
There are two main ways that chlorine can be absorbed in the stratosphere and slow its ability to destroy ozone. (1) the ClO that results from the first step in ozone depletion (see first column of theses notes) can combine with N)2 to form ClONO2. (2) Cl may combine with methane to form Hcl (hydrochloric acid) which can rain out, removing the Cl from the stratosphere.

The Antartic Ozone "Hole"
The most pronounced depletion of ozone occurs over the Antartica during Antartic spring (this occurs in April since it is south of the equator). There has been a consistent increase in the

size of the “Hole,” which is really an area of thinning, since the 1970s.

Polar Stratospheric Clouds

These special clouds have a lot to do with why the ozone hole is greater in antartic spring. During winter in antartica, the low amount of sunshine means that the air above the pole gets very cold (below 100 farenheit). At these temperature polar stratospheric clouds can form. When these clouds form the NO2 in the stratosphere gets tied up in the clouds as nitric acid. When these particle get big enough they fall to the earth, this removes the nitric acid (and the NO2 it came from) from the stratosphere. When the sun returns in spring, there is no NO2 to act as a chlorine sink and the rate of ozone depletion is especially high.

Environmental Effects of Ozone Depletion

Increase in skin cancer and cataracts; decrease in primary productivity in the oceans as the increased uv damages the phytoplankton, this can damage the ocean food chain as well as remove the role of ocean phytoplankton as a carbon sink. This may in turn impact global warming. Damage of crops such as corn, wheat, etc… Weakening of immune systems – this may be a particularlyl damaging impact in areas of Africa where AIDS is found in high frequency. Greatest impacts are in New Zealand and in Southern Australia and the tip of South America (Chile).

The Montreal Protocol

The Montreal Protocol is an international agreement to decrease the emissions of CFCs to 50% of 1986 levels. It was signed by 27 nations, including the US and has since grown by 119 countries.

How do we reduce CFCs?

Collection and reuse, as in from refrigerators and automobile air conditioners.

Substitites for CFCs. The main two are **hydrofluorocarbons (HFCs)** and **hydrochlorofluorocarbons (HCFCs)**. HFCs do not contain Cl, the fluorine in them can react similarly to Cl in the stratosphere, but not as effectively, so they damage many less ozone molecules (about 1000 times less). HCFCs containa hydrogen instead of a chlorine, this makes them less persistent, so they break up in the troposphere and the chlorine does not find its way into the stratosphere.

Chapter 30 Waste Management

Case Study: Fresh Kills Landfill, New York City

Discusses one of the largest landfills in the world. It used to receive 21,000 tons of trash a day, but after recylceing it receives 12 –14,000. The city now "exports" trash to other areas, because there is not enough space in new york city to store all the trash generated in new york city. The landfill will be converted to a park. Challenges include controlling **leachate** which is the liquid formed when water percolates through a landfill and absorbs pollutants from the garbage (or **refuse**). Fresh kill swill generate over 1 million gallons per day.

Modern trends in waste management

The dominant trend today is Integrated Waste Management (IWM) this includes reuse, reduction, recycling, somposting, landfill, and incineration.

Reduce Reuse Recycle (the "Three Rs")

Reduce means to not produce or purchase as much waste *ie don't get a bag at the store if you don't need it, purchase products with less packaging*.

Reuse means just what it sounds like. Inbstead of throwing something away fond another use for it (this can also lead to reduction)

Recycle means to actually melt or crush used material and reprocess them into new materials. This can be done with paper,, other wood products, plastic, and glass.

It is suggested that using the three Rs could decrease the waste going to landfills by as much as 50% with recycling accounting for 30% of that reduction. Laws now require many cities to reduce their waste by recycling (or face heavy fines) and the public appears to be supportive in separating trash for collection by their cities.

What is in our trash

Mostly paper (fig. 27.2) then other materials. The largest single waste item is newspaper.

WAYS OF DEALING WITH WASTE

On Site Disposal – garbage disposals in our sinks. The waste then goes throught he sewage treatment process

Composting is the collection of biodegradable waste such as food and yard clippings in order to allow them to decompose into soil which can be used for fertilizer. In order to assist this the wste is exposed to enzymes and worms. This can be done on many scales, including household backyard composting which can be used in gardens.

Incineration is the burning of waste at high temperatures in order to reduce to ash and non combustibles. This reduces waste by about 50% (same as could be achieved with the 3 Rs. One advantage of is that the heat could be used to generate electricity. But incineration produces air pollution including pollutants related to acid rain and pollutants containing heavy metals. I n the us about 10% of waste is diposed of by incineration.

Sanitary landfill (fig 27.5) is the name given to a place where waste is collected, managed, and covered in order to reduce environmental impacts including access to the waste by insects and wildlife.

Leachate (see case study) is the most significant hazard, especially to groundwater. Leachate is managed by lining the bottom of the landfill with plastic and clay and installing pipes to collect the leachate and take it to a treament center.

Methane is also produced by the decomposition of the waste in the landfill, In order to manage the possible hazard of the methane burning, collection pipes are installed in a sanitary landfill to collect the methane and carry it to a power plant where it can be burned to generate electricity, or excess methane can be burned off safely.

Site selection – sanitary landfills are best placed in areas with a low water table, little rainfall, relatively impermeable soil, and not too close to homes.

Monitoring is an important aspect of a landfill. Wells are placed into the water table surrounding the landfill so that if any leachate leaks into the groundwater it can be detected early and appropriate actions can be taken.

Hazardous waste management

About 35,000 chemicals used in the US are considered potentially hazardous. Hazardous waste if not taken care of properly can be a major environmental problem as at **Love Canal (Closer Look 27.1)** where wate ws dumped from 1920 to 1950 and then houses were built over the site. In 1976-77 heavy rains and snows brought much of this hazardous waste to the surface. 200 homes and a school had to be destroyed to clean the site.

Hazardous waste is now disposed of in special sites that are designed similarly to sanitary landfills (fig 27.6).