ENH 617: Applied Ecology

Lecture 1

Ecology: The study of INTERACTIONS between organisms (living things) and their environment

Applied Ecology: Influence/role of the human systems in these interactions

Environment: Includes the ATMOSPHERE, HYDROSPHERE, CROSPHERE, LITHOSPHERE, and BIOSPHERE

- Where all -living species (including humans), and non-animate phenomena exist

Topic- Changes and Challenges (Slide 25)

- Human activities have number of effects on environments mainly ECOLOGICAL SYSTEMS
- Abrupt changes and cause strong effects on a variety of interconnecting systems
- HUMAN POPULATIONS have grown dramatically in the last 100-200 years
- Need to use SCIENCE: understand underlying interactions and systems that occur in natural systems
    - Science to understand what abrupt changes to ecology (interactions among living things and with their environments

What Scientists do? (Slide 35)

1. Identify problem and what is known about the problem
2. Ask question(s) to be investigated and propose a scientific question
3. Make testable predictions, gather data through experiments and observations
4. Accept/reject hypothesis

Scientific theory: well-tested, widely accepted hypothesis

Using science to inform actions on ecology & environment (Slide 36)

1. Focus on key issues, communicate through policy-relevant form
2. Clarify issues, identify potential management options & estimate consequences of decisions
3. Clearly and simply communicate key findings to all participants
4. Evaluate if final decision is consistent with scientific information
5. Avoid advocacy of any particular solution

Topic- Wicked Problems (Alberta to BC pipelines)

Stakeholders: People involved in or affected by a course of action/policy/plan

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Alberta to BC pipelines (Slide 45)

- "Northern Gateway" 1st of 2 major proposals – To help extract bitumen to reach west coast
- "Trans Mountain" is 2nd
- Pipeline story illustrated "wicked problems" among stakeholders
  - Stakeholders: Citizens, oil company, federal government, Aboriginal people's, etc….

Pipeline Complexity (Slide 54)

- International Consequence: Increase in CO_2 emissions → climate change
- National implications: Scale of project, trans-provincial issues, federal jurisdictions, global trade
- Provincial, regional, and local concerns: Place-specific impacts of the infrastructure required (e.g. Haida Gwai islands)
- Ethical issues: Rights of Aboriginal people; making major contribution to further negative impacts to environmental problems

What happened? Northern Gateway Proposal (Slide 55-57)

- Previous/current federal government STRONGLY SUPPORTS PROJECT
  - Saw benefits to all Canadians, forgot about environmental concerns
- Scientists called for an assessment accounting for effects to all resource developments involved
- Politically appointed federal panel dismissed the call for assessment
- BC government (of the time) has FIVE REQUIREMENTS to SUPPORT PROPOSAL
  1. Completion of an environmental review process
  2. Proper marine oil spill response, prevention & recovery system in place
  3. "" land oil spill "" (" same as #2 but for land oil spill)
  4. Address Aboriginal rights and benefits
  5. BC receives fair share of fiscal and economic benefits – reflect level of risk borne
- First Nations leaders REFUSE TO ALLOW THE PROJECT TO GO THROUGH SACRED LAND AND SOIL (Protests on the land)

Trans Mountain Pipeline (Slide 60)

- Originally owned and operated by Kinder Morgan called "Kinder Morgan Pipeline"
- Used since 1953
- Expansion proposed in 2013 to increase capacity of 300, 000 barrels/day to 890, 000 barrels/day
- Route from Vancouver traverses the Strait of Juan de Fuca

How humans interact with the environment? (Slide 65)

Environment as a source of resources

Resources: Included forests, wildlife, oceans, rivers, lakes, minerals, and petroleum

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Different Perspectives on environment and resources (Slide 67)

Anthropocentric view: Value defines relative to human interests, wants & needs. INSTRUMENTAL VALUE

Exocentric or Biocentric view: Defined as an aspect of the environment valued simply from its existence

INTRINSIC VALUE

Effects of humans on ecology/environment (Slide 67)

- Current era "Anthropocene"
- Humans have such a large effect on ecosystems/planetary processes because
    1. Human population (numbers) has grown considerably in 200 years

Population (Slide 69)

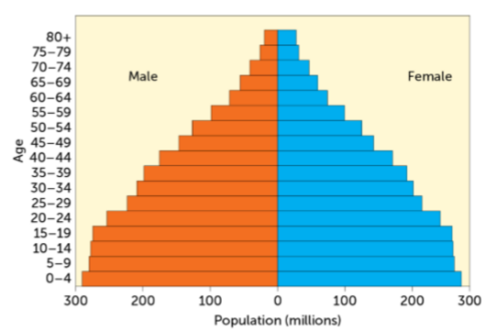
- Human life affects planetary life support system is NUMBER OF PEOPLE BEING SUPPORTED (7.4 billion)
- Global energy consumption has rise dramatically, as population increases, SO HAS POLLUTION
- 4.3 people born every second worldwide, 80 million per year
- Replacement-level fertility levels, UN predicts over 10.9 billion people by 2100

Studying human populations (Slide 71)

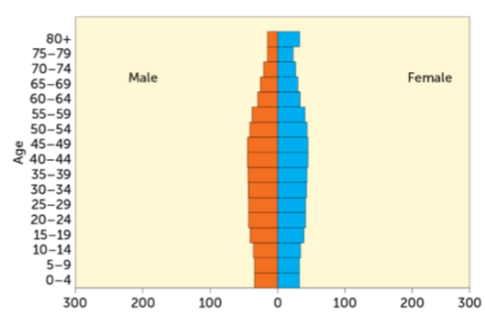
- Demographers: Study human populations, trends, growth and age structure
- Crude BIRTH rate: number of BIRTHS per 1000 people per year
- Crude DEATH rate: number of DEATHS per 1000 people per year
- Crude GROWTH rate: (CRUDE BIRTH RATE – CRUDE DEATH RATE)
- Total fertility rate: average number of children per woman in a population
- Replacement fertility rate: 2.0

Growth via migration (Slide 73)

- Humans move or migrate between countries
- Immigration: ARRIVAL of new people in a population
- Emigration: DEPARTURE of people from a population



Population age structure pyramids- slide 74



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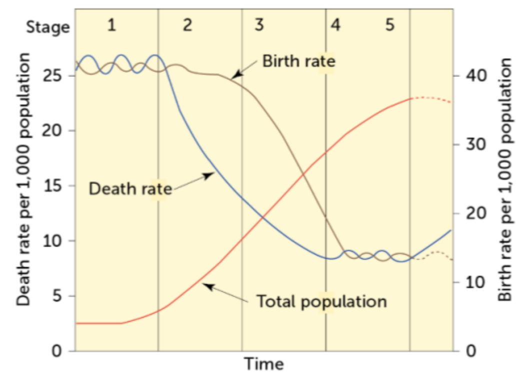
Demographic transition (Slide 75)

- Change of populations over time from high → low birth and death rates

Child mortality and total fertility (Slide 77)

- IF CRUDE GROWTH = TOTAL BIRHTS – TOTAL DEATHS
 (How does decreasing child mortality affect population growth?)



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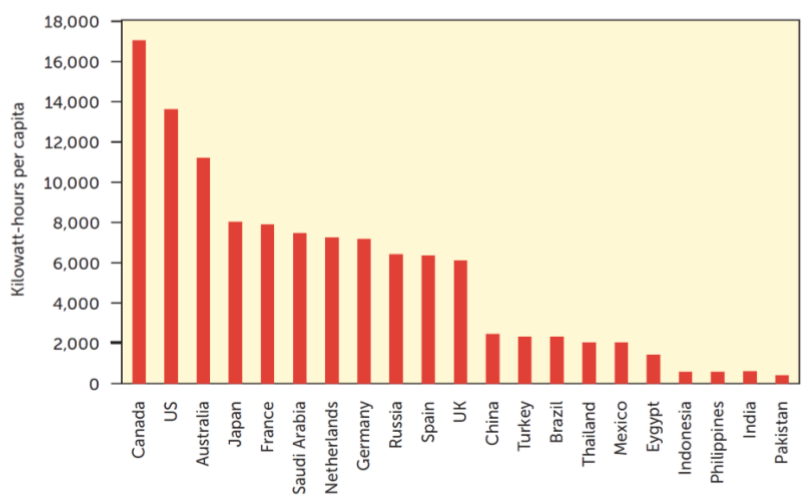
Child mortality and total fertility (Slide 78)

- In human populations, fertility (size of family) is affected by child mortality

Consumption is not the same in every human population (slide 81)

- NOT ALL HUMAN BEINGS have the same impact on LIFE SUPPORT SYSTEM
- Richest 20 % responsible for than 75% of global consumption. The poorest 20% consumes less than 2%
- Wealthiest countries use 25 TIMES MORE ENERGY PER CAPITA than poorest countries
- Canadians among top per capita consumers of energy in the world



Lecture 2

Introduction (Slide 16)

- Most energy on Earth derives from radiant energy; THE SUN
- Radiant energy transformed into chemical energy → mechanical energy

Energy (Slide 17)

- Energy is the capacity to do work and is measured in calories and joules
  - Calorie: Amount of heat needed to raise one gram (1 ml) of water one degrees Celsius (°C), starting at 15 degrees
  - Joule: Work that is done (or energy used) to produce 1 watt of power for one second
    - Could be kinetic energy of 50kg human moving very slowly (0.72 km/h)
- Potential Energy: Stored energy that is available for later use (e.g., gasoline)
- Kinetic Energy: Energy derived from an object's motion and mass (e.g., engine using gas)

"Quality" of Energy (Slide 18)

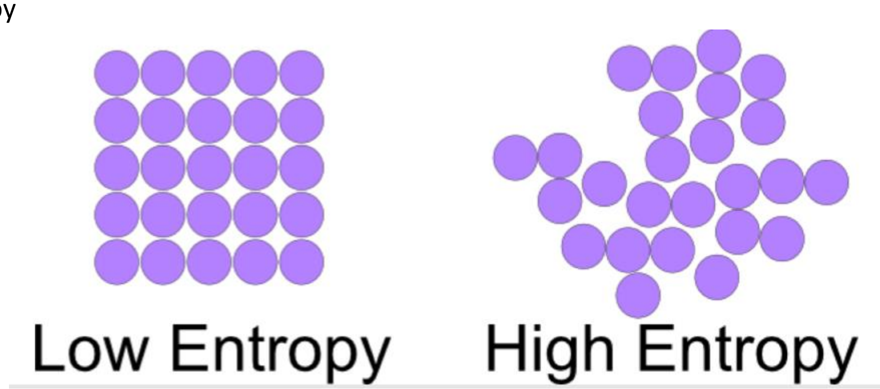
- Total energy of all moving atoms is referred to as heat, a "low-quality" energy
- "High-quality" energy (very hot fire, coal, gasoline) preferred for human uses, but energy disperses quickly

Energy follows "laws" of Physics (Slide 19-20)

- Laws of Thermodynamics: Energy transformations take place around us (trillions of transformations per second)
- 1st Law of Thermodynamics: Energy can neither be created nor destroyed; it is merely changed from one form into another

2nd Law of Thermodynamics: entropy (Slide 20)

- When energy is transformed from one form into another
- Will always be a decrease in the quality of usable energy; some energy "lost" as lower quality
- Dispersed energy to surrounding environment, often as HEAT
- ENTROPY: Measure of disorder or randomness of a system- high-quality, useful energy has low entropy



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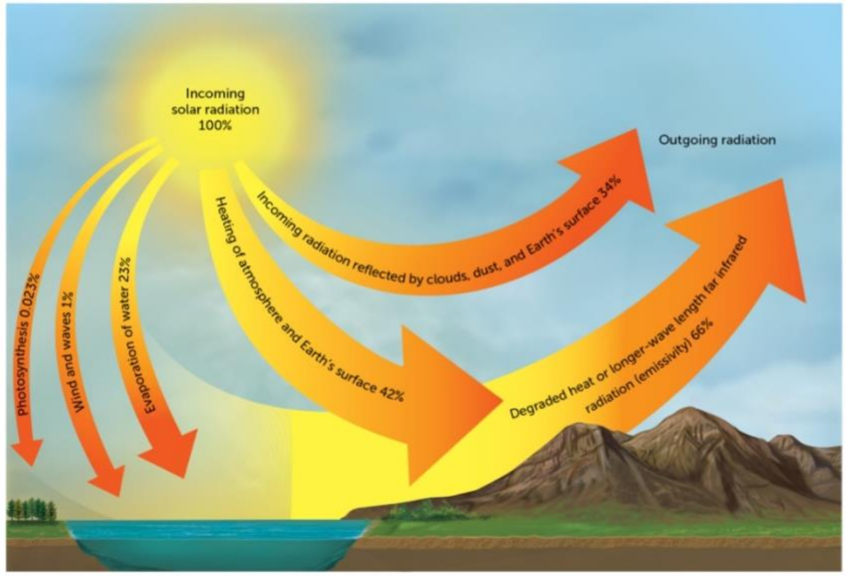
Significance of laws of thermodynamics to ecology (Slide 22)

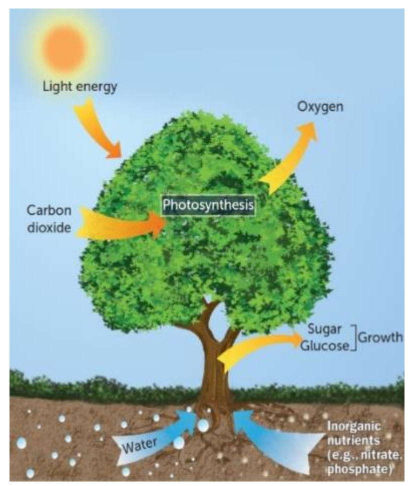
- Organisms must continuously expend energy to maintain themselves; when they use energy, some is lost
- Energy CANNOT be recycled; constantly being degraded, the more energy is transformed, the more energy gets dispersed it becomes less useful and lower quality (Heat is constantly being released)

Organisms and ecosystems use Photosynthesis & Cellular respiration to transform energy



Photosynthesis (Slide 26)

- Green pigments in plants; created by absorbing light from the sun
  - Green pigment is chlorophyll
- Plants combine CO_2 (CARBON DIOXIDE) and H_2O (WATER), using energy from the sun, into high energy carbohydrates (e.g., starches, cellulose, and sugars, during photosynthesis)
- Photosynthesis produces oxygen as a byproduct
  - FORMULA: $CO_2 + H_2O + \text{light energy} \rightarrow C_6H_{12}O_2$ (glucose) $+ O_2$



Yellow: Input
Green: Output

Producers (Slide 28-29)

- AUTOTROPHS (producers): Organisms with the ability to capture energy & manufacture matter
- HETEROTROPHS (consumers): All other organisms

2 KINDS OF AUTOTROPHS: PHOTOTROPHS & CHEMOAUTOTROPHS

- Phototrophs get energy from LIGHT
- Chemoautotrophs obtain energy from chemicals in their ENVIRONMENT

  - Phototrophs (plants, algae, and bacteria) and Chemoautotrophs (mainly bacterial) play critical role in Earth's biogeochemical cycles and in ecosystems as PRODUCERS
  - Photosynthesis itself produces billions of tons of biomass (living matter) throughout the globe

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Cellular respiration (Slide 31)

- Cellular respiration is another essential energy pathway in organisms
  - FORMULA: $C_6H_{12}O_2$ (glucose) + O_2 ⟶ CO_2 + H_2O + light energy

    Yellow: Input
    Green: Output

- Energy is released and can be used by organisms for growth and maintenance

Aerobic vs. Anaerobic (Slide 32)

- Cellular respiration will not occur without organisms having access to OXYGEN OR THEY WILL DIE
  - Aerobic: Organisms that NEED OXYGEN to survive
  - Anaerobic organisms (such as some bacteria) CAN SURVIVE WITHOUT OXYGEN

Energy is transferred between organisms

- The flow can be mapped through food chains

Food Chains (Slide 34)

- Energy that is captured by the autotroph will pass onto organisms, the consumers, by means of a food chain
- Trophic level: Level of the food chain
- Herbivores eat producers and energy source for high consumers (carnivores)
- Omnivores (e.g., humans, raccoons, sea anemones, etc…) can get energy from DIFFERENT tropic levels

Humans occupying different trophic levels (Slide 36)

- When we eat vegetables, we are acting as primary consumers
- When we eat beef, we are at the third trophic level, acting as secondary consumers
- When we eat fish that have derived their energy from eating smaller organisms (e.g. salmon), we may be tertiary consumers

Decomposer Food Chains (Slide 37)

- Just as important as grazing food chains
- Based on dead organic material (detritus- high) in potential energy, difficult for typical consumer organisms to digest
- KEY ROLE: Breaking down plant and animal material products such as CO_2, H_2O, and inorganic forms oh phosphorus and nitrogen and other elements

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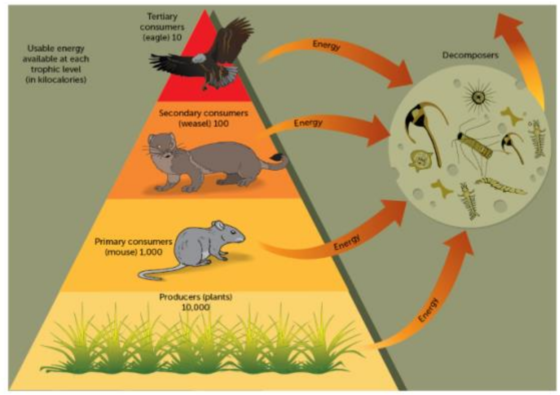
Where we see food chains? (Slide 39)

- Detrital food chains tend to dominate in forest ecosystems and freshwater ecosystems
- Grazing food chains dominate marine ecosystems
- Food chains often simplified representations from complex interactions (Usually there's many competing organisms and energy paths among the food chain- too complex)
- The more species (BIODIVERSITY) within an ecosystem and food chains, more resilient it is to stress- more alternative energy pathways (ecological redundancy or functional compensation)

Biotic Pyramids (Slide 41)

- 2nd law of thermodynamics describes energy flows from trophic level to trophic level, with a loss of usable energy at each succeeding transformation
- Energy efficiency: Amount of a systems total energy input that is transformed into work or some other usable form of energy.
- Species at the very top of the food chain are known as apex predators.



Productivity (Slide 42)

- Rate of energy that's transformed into biomass; (kilocalories per square metre/year
- Gross Primary Productivity (GPP) is the overall rate of biomass production
- Cellular respiration (R), must be subtracted from the GPP to reveal the net primary productivity (NPP); the amount of energy available to heterotrophs.

What happens to "productivity"?

I. Most productive ecosystems are wetlands and tropical rainforests.
II. Humans harvest 40% of all terrestrial NPP for their own use.

Organizing Life (Slide 46)

Ecosphere can be broken down into smaller units

- Organism: Smallest level as an individual
- Population: Group of individuals of the same species
- Community: All populations of all species interacting in a given space

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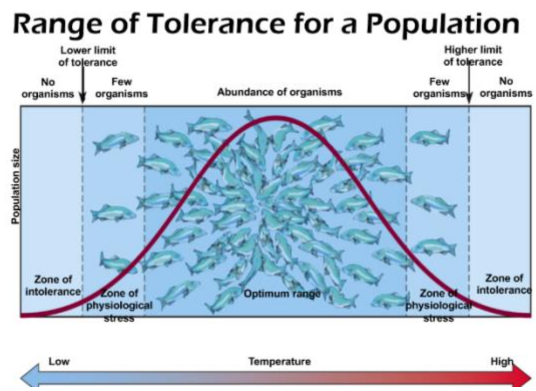
<u>What’s an Ecosystem? (Slide 47)</u>

- Collections of communities interacting with physical environment
- Open systems and exchange material and organisms with other ecosystems
- Similar ecosystems can be grouped as an ecozone representing their dominant vegetations and animal communities
- Ecozones can be grouped into biomes, based upon dominant vegetation and adaptations from other organisms to that particular environment

<u>Abiotic Components (Slide 50-52)</u>

- Food chains constitute the living or biotic components of ecosystems
- Abiotic components play an important role in determining how these biotic components of ecosystems are distributed.
- Key factors: light, temperature, wind, water, and soil characteristics (soil type, nutrient status, pH).
- Range of tolerance: Variations in physical and chemical environment that a population can tolerate
- Limiting factor principle: Too much or too little of any abiotic factor can limit or prevent grown of organisms and the population



Skipping Soil (Slide 54)

<u>Abiotic components often limit productivity and diversity (Slide 54-55)</u>

- Limiting factors
  - (rainfall, essential nutrients) that determine whether an organism can survive in a given ecosystem
- Dominant limiting factor
  - The weakest link in the chain of various factors necessary for an organism’s survival
- Range of tolerance
  - range of conditions that different organisms can tolerate and still survive
- Optimum range
  - range of conditions that is ideal for a species
- Zone of physiological stress
  - Conditions can be tolerated by certain individuals within the population, but are not optimal
  - Relatively few individuals can exist

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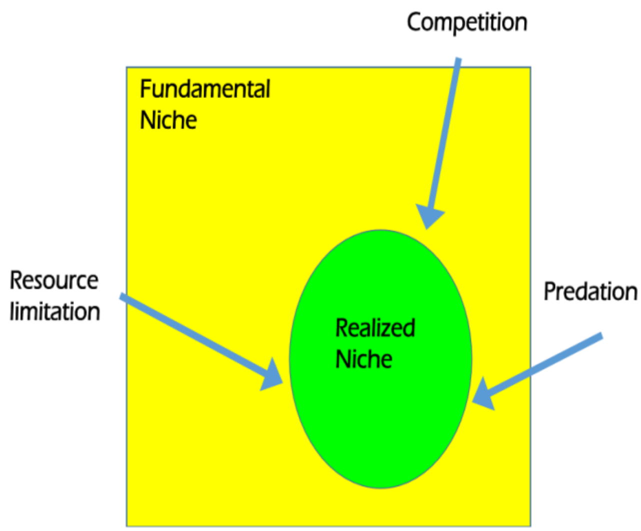
Biotic Components (Slide 57-59)



- Each species needs a specific combination of the physical, chemical, and biological conditions for its growth—the niche of that species.
- Where the species lives is known as the habitat
- Competitive exclusion principle tells us that no two species can occupy the same niche
- Most have a fundamental niche- range of conditions that can occupy, narrow realized niche, representing the range actually occupied
  - Specialist species have narrow niches (susceptible to population fluctuations)
  - Generalist species have very broad niche
- Generalist species
  - Broad niche: wide range of tolerance
- Specialist species
  - Narrow niche: narrow range of tolerance

Competition (Slide 60)

- Intraspecific competition
  - occurs among members of the same species
- Interspecific competition
  - occurs between different species.

Competition may be reduced through resources in which the resources are used at different times or in different ways by species with an overlap of fundamental niches.

Predation (Slide 62)

- Predator: Benefits at the expense of a prey species
  - Optimal foraging theory recognizes that there is a point of compensation between the benefit of obtaining the prey and the costs of doing so.

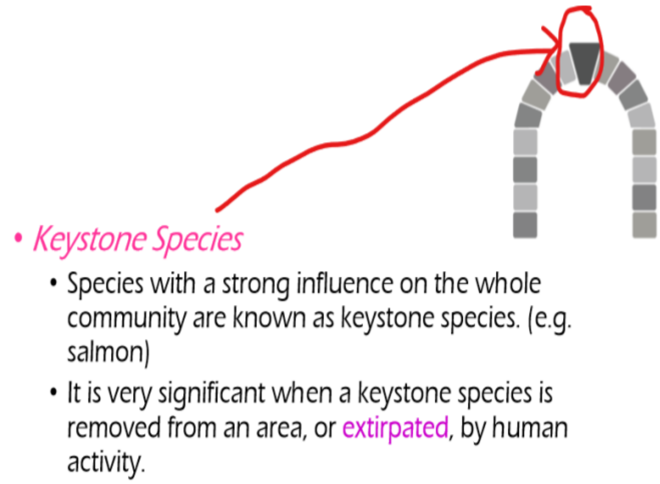
Other biotic relationships (Slide 63)

- Parasitism
  - special type of predator prey relationship
  - Predator lives on or in its prey (host)
- Mutualism
  - The relationship benefits both species (nitrogen-fixing bacteria and their host plants)
- Commensalism
  - Interactions that seem to benefit only one partner but do not harm the other (e.g., Oxpeckers and black rhinoceros)

Keystone Species (Slide 65)

Anadromous: migrating between fresh and saline waters (e.g., Salmon)

Semelparous: Breed only once



Biodiversity (Slide 73-80)

- Sum of all variability in ecosystems and on Earth
- Often a sign of ecosystems' health
- Offers resilience to environmental change and disruption

- Genetic diversity (richness)
  - Variability in genetic makeup among individuals of the same species; ultimate source of biodiversity at all levels
- Species diversity (species richness)
  - The total number of species in an area
- Ecosystem diversity
  - The variety of ecosystems in an area

Biodiversity protects against ecological collapse

- Biodiversity hotspots
  - Areas with high numbers of endemic species; found mainly in tropical areas
  - Endemic species are particular to a certain area, and found nowhere else on Earth (in Canada there are approximately 54 endemic species of vascular plants, mammals, freshwater fish, and molluscs).

See textbook Table 2.1 ~ Biodiversity Goals and Targets for Canada