5 Laws of Ecology	Meaning
Everything is connected to everything else	• What affects one part of the ecosystem will also affect something else • (i.e. food chains/webs, human influence, abiotic/biotic interactions)
Everything is always changing	• Natural systems are not static • Landscapes (i.e. erosion, river flow, natural disasters) • Animals adapting to their environment
There is no such thing as "away"	• There is no "away" to which things can be sent • Matter can't disappear and has to be dealt with, can be converted into other forms
No such thing as a free lunch	• Everything has a cost • Environmental, social, economic costs • Can be hidden
Earth has limits	• Earth does not have unlimited resources that we can continue to take from forever • Water/air/soil cannot absorb an infinite amount of waste

3 Pillars of Sustainability (3Ps)	Meaning
People (Social)	• We need to make sure that across the globe, people have a high quality of life without being too damaging to the environment • For example, it would be much better for the environment if we abolished cars, but this would mean that people might not be able to get to work/school and so we have to continue to used them. What's best for the environment is not necessarily best for people.
Prosperity (Economic)	• We need to sustain the economy and keep it from affecting the environment. • For example, it would be best for the economy to keep drilling oil and creating more jobs/exports, but this would be terrible for the environment. We need to keep both balanced to prevent a system collapse.

Planet (Environmental)	• We often forge that the environment and its resources are limited and take it for granted. • Have to protect environment from economic greed • Renewable energy, reducing emissions, sustainable fishing/agriculture, recycling, etc.

Blue Marble Image (1972)

– First full image of Earth from outer space, huge emotional impact, people started to care more about the Earth

Environmental Science:

- The study of the interaction between living and non-living components of the environment
- Special emphasis on issues (human influence) and solutions ($$$)

Environmentalism:

- Broad social movement dedicated to protecting the earth's life support systems for us and other species
- Ethical, moral, religious, spiritual, aesthetic reasons
- Aboriginal wisdom (traditional knowledge)

Environmental Timeline:

A: Pre-environmental Movement 1798-1830s	**Thomas Malthus (1798):** - "Doctrine of Population Growth and Resource Scarcity" - Said human pop. growth is faster than the growth of food supply - Misery, starvation, disease, illness, etc. **John Stuart Mill (1848):** - Pop. growth and increasing wealth can't continue forever - Growth/consumption must stabilize or we can't last forever **Henry David Thoreau (1854):** - Author, lived in the woods for a year → Walden - Promoted simplistic lifestyle, distinguished between urban/rural lifestyle
B: Conservation Movement 1832-1960	- Vanishing wilderness, agricultural expansion, people were alarmed - Clubs formed (Audubon Society, Sierra Club) - Preservation of wilderness/wildlife - Not motivated by science - Algonquin Park- 1893

C: Environmental Movement 1960s-1970s	- Smog events (London), Oil Spills, Birth Defects due to chemical exposure, Water bodies catching on fire - 1962- Rachel Carson → "Silent Spring" - Dangers of pesticide use & DDT - Ecology → study of how living organisms interact with their environment and other species - Tragedy of the Commons Idea developed - 1970- First Earth Day, April 22 - New organizations formed and brought issues to public attention, pressured GOV to respond (i.e. WWF, Greenpeace)
D: Sustainability Movement 1980s-Now	- Sustainability - Reduce, Reuse, Recycle - Incorporation of environmental design in products - Growing concern for → Nature Deficit Disorder

Tragedy of the Commons:

- Applied to any free, public resource
- Those using the resource act independently and out of self interest
- "If I don't use it, someone else will."
- EVENTUALLY… depletion of the resource
- Proposed solutions → Private property (fences), Co-operative groups to make laws
- Preserve the resources for future use

Overpopulation:

- Industrial revolution/medical advancements increased fertility rates, higher life expectancies, etc.
- 1600- ½ billion
- 1800- 1 billion
- 2000- 6 billion
- 2011- 7 billion (and counting)
- By 2050, we will peak at 9-10 billion
- Not an issue of physical space, but of resources (consumer society, developed nations vs. third world countries)
- All 7.4 billion of us could fit in Ontario with an average sized house
- Policies:
    - Some European countries → decreasing birth rates, want people to have more kids (pro-natalist) → Tax incentives, less $$$ for more children, future labour supply, implications of aging generation
    - China, overpopulated, one-child policy was instituted in order to maintain economic progress (1970 avg. 5.8 kids/woman, now avg. 0.6 kids/woman)
    - Issues → Government intrusion, Shrinking future work force, unbalanced sex ratio (abortion of female fetuses)
    - Policy benefited ECONOMY & ENVIRONMENT

Green Revolution:

- Agriculture
- Crop yields are increasing through the use of technology (GMOs, Irrigation, Fertilizers, etc.)

Food Chains vs. Food Webs:

- Both show the feed relationships and trophic levels
- Arrows point in the direction of energy flow
- Food webs are all the food chains in a ecosystem

Ecological Niche:

- A species lifestyle and relationship to all other organisms and resources in a particular ecosystem
- If two are similar, they compete

Biodiversity:

- Species Richness
- The number of different species in an ecosystem
- Deciduous Forest → MOST
- Tundra/Desert → LEAST

Abiotic:

- Non-living factors: temperature, pH, wind, clouds, water

Biotic:

- Living things: plants, animals, forests, rotting vegetation)

Predator:

- An animal that hunts and kills another animal for food

Scavenger:

- Searched for carrion to eat, raven, vulture

Detritivore:

- An organism that consumes dead matter and animal wastes (Ex. Earthworms and millipedes, maggot)

Decomposer:

- Organism that breaks down dead organisms and returns nutrients to soil (i.e. bacteria, fungi)

Habitat:

- The area an organism lives in

Producers:

- Make their own food (plants, algae, phytoplankton)

Consumers:

- Must eat other organisms for food (plants/animals)

Herbivore:

- Only eat plants, PRIMARY CONSUMER

Omnivore:

- Eat plants and animals (bears and humans)

Carnivore:

- Only eats meat, Secondary/Tertiary consumer (wolf, falcon)

*There are less individuals at the top of any food chain than at the bottom

Earth's 4 Spheres:

1. Lithosphere: Earth's outer crust

2. Hydrosphere: Water bodies

3. Atmosphere: Air/gas surrounding Earth (N2, O2, CO2, H2O)

4. Biosphere: All the living parts of Earth

Individual → Species → Population → Community → Ecosystem → Biome → Biosphere

- I: A single organism
- S: Organisms that mate and produce fertile offspring
- P: All individuals of one species living in one area
- C: All living organisms in one area
- E: All biotic/abiotic components in a specific area
- B: A collection of similar ecosystems in an area
- B: All the living parts of the erth

Energy Pyramids:

- All energy in an ecosystem begins with the sun
- As animals live and feed, the energy decreases at each trophic level
- This is because energy is always lost through heat, movement and life processes
- 90% is lost at each level, and 10% is passed up
- *MAX food chain length is 5/6 levels

Population Levels:

- Increase → Births, Immigration
- Decrease → Deaths, Emmigration
- % Population Growth = $\frac{(B+I)-(D+E)x\ 100}{initial\ population}$

Limiting Factors:

- Factors that limit population size
- Density Dependant: limits because of the size of the population (i.e. disease, habitat, food supply)
- The bigger the population, the more the factor will act)
- Density Independent: limits that affect the population regardless of its size (i.e. natural disaster, pesticides, global warming.)

Carrying Capacity:

- The maximum population of a single species that can be indefinitely supported by an ecosystem (usually fluctuates at an average)

Rachel Carson:

- DDT: deadly to wildlife (eagles, falcons) → bird sanctuary was sprayed and birds were killed
- Forced people to see the environment in a new way
- Put it as a concern of the public
- Environmental laws (Senate held hearings about pesticides)

Photosynthesis & Cellular Respiration:

- CR: Glucose + Oxygen → Carbon Dioxide + Water + Energy
  - $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$ + Energy (ATP)
- P: Sunlight Energy + Water + Carbon Dioxide → Oxygen + Glucose
  - Sunlight Energy + $H_2O + CO_2 \rightarrow O_2 + C_6H_{12}O_6$

Competition:

- Organisms compete for a resource (food, water, habitat, mates)
- Interspecific → Different Species
- Intraspecific → Same Species
- Example: Wolf vs. Raven for a carcass, 2 Moose for mates

Symbiosis: Organisms live in close contact with each other

Mutualism	Beneficial to both organisms	Clownfish & Sea Anemone
Parasitism	One is benefited, the other is hurt	Sea Lamprey and Fish
Commensalism	One benefits, the other in unaffected	Bird & Tree

Geochemical Cycle:

Carbon Cycle	- Carbon → The building block of life - Found in sugars, fats, proteins, DNA, etc. - CO_2 gas in atmosphere

	- Will dissolve in water (oceans) - Fossil fuels – dead plant/ animal matter - Buried and compressed over millions of years - Ocean organisms – combine CO2 with calcium to form their shells (CaCO3) - Inorganic: extracted from ores and minerals - Organic: Found in plants and living things - Resevoirs: oceans, plants, animals, rocks, etc.
Nitrogen Cycle	- 79 % of air is Nitrogen Gas (N2) - Crucial component of organic chemicals - N2 in the air cannot be used directly by plants and animals - -Bacteria convert the nitrogen into nitrates, which plants take up through the roots (nitrogen fixation) - Animals eat the plants to get nitrogen - When animals/plants die, decomposers convert compounds back into N2 and back into the air and soil
Water Cycle	- Precipitation- Rain, snow, hail, etc. - Evaporation- liquid to vapour - Condensation- gaseous h2o to liquid - Infiltration- soaking into the ground - Percolation- Water moves through soil - Surface runoff- water runs along surface - Groundwater flow- movement underground

6 Biomes of Canada:

Tundra	-Permafrost, low vegetation (no trees), short growing season, low biodiversity
Boreal Forest/Taiga	-coniferous trees, ponds, lakes, bags, heavy snow, every province
Temperate Deciduous Forest	-highest biodiversity, rich soil, high rainfall, deciduous trees, here!
Grassland/Prairies	-low rainfall, can't support trees, rich/deep soils, converted to farms
Temperate Rainforest	-deciduous/evergreen trees, mild temp, most rainfall, tallest trees
Desert	-BC/Yukon, Sand or Sandy Soil, low rainfall, many days of sunshine

Ecological Footprint:

-measured in hectares (100m x 100m)

-How much area of land and water is required to live a certain lifestyle

Soil Formation:

- Soil is abiotic and biotic
- 50% porous spaces, 45% pulverized rock and 5% organic matter
- Rests on bedrock (parent material of the abiotic portion)
- Long slow process
- 3 cm of soil → 500-1000 years
- Soil is constantly being eroded

Erosion:

- The movement of soil from one location to another

5 basic functions of soil:

- Medium for plant growth
- Habitat for soil organisms
- Engineering medium
- Water supply/purification
- Recycling nutrients and organic wastes

Weathering Types:

Mechanical	-Soil begins when rocks are broken down into smaller particles by natural forces (i.e. wind, water, ice)
Chemical	-Chemicals from the rock, in water (acid rain) or even oxygen in the air further the erosion process -Change the chemical composition of the soil
Biological	-Plants, animals and microorganisms assist in either the mechanical or chemical weathering

Soil Horizons:

O- Organic Material : Leaf Litter (undecomposed)

A- Topsoil (Surface Soil) →mineral and humus formed from decomposition of plants and leaves
B- Subsoil → accumulation of clay and organic materials, Most organic matter/soil life
C- Unweathered bedrock (parent material)

Organic Matter: enhances water and nutrient holding capacity and improves soil structure

Humus: is usually dark and the “glue” that will hold soil particles together

Sand:

- 1-5 mm diameter (Biggest, highest permeability)

Silt:

- 0.1-10 mm (Middle, medium permeability)

Clay:

- 0.001 mm – 0.1 mm (smallest, low permeability)

Loam:

- Best soil for agricultural purposes
- Rich soils consisting of sand, silt, clay (40:40:20) and humus

Permeability:

- The rate at which water can flow through the soil (cm^3 per hour)

Porosity:

- The volume of the spaces between the soil particles (can be filled with water or gas)

Soil Organisms:

- Earthworms, spiders, centipedes, beetles, bacteria, protozoans
- Decompositions of dead plants/animals
- Infiltration/storage of water (create channels and aggregates, increases water flow rate)
- Recycling nutrients (N into Nitrates)
- Topsoil & Organic Horizon
- Late spring-mid fall

Dust Bowl (1930-1936)

- American mid-west
- Decades of intense crop farming, plowing up the native grasslands, not allowing soil to "rest" and replenish itself, soil left exposed between plantings
- + severe drought = Dust Bowl
- Soil turned to dust and blew away (top layer gone → 400,000 km^3 of farmland useless)
- Stock market crash in 1929 meant years of poverty
- Roosevelt implemented Soil Conservation strategies by the late 1930's

Erosion:

- After erosion, soil may become pollution in water/air
- Land loses fertility
- Natural/Geologic → rounding off of mountains, depositing of sediment in river deltas
- Accelerated Erosion → Removes topsoil at an excessive rate due to anthropogenic causes

Factors affecting Erosion

1. Rainfall/run-off
2. Soil physical characteristics → lower permeability = more erosion
3. Slope of the land → steeper the slope, the greater the erosion
4. Root systems → roots hold the soil in place

5. Vegetation and residue cover → protects soil from raindrop splash, slows down movement of water t

Small-scale Solutions:

1. Silt fences→ placed at the bottoms of slopes to hold the soil in place but let the water flow through, keeps sediment out of streams
2. Planting shrubs/trees → roots hold the soil in place, limbs and leaves slow the impact of rain and fallen leaves cover the ground

Agricultural Solutions:

1. Plant on the contour line → planting around a slope rather than up and down, helps slow the flow of water, more time for water to enter soil instead of run off
2. Rotate crops → planting different crops on land from one year to the next, leaves residue on the surface to help hold the soil in place
3. Allowing the land to lie fallow → no crops planted for 1 year, natural vegetation grows and a root, holds the soil in place
4. Terrace → ridges of earth pounds placed across a slope, allows for gradual drop of water flow, holds soil in place
5. Grassed strips → small strips covered with natural grass may be left near plowed areas – slows the flow of water and helps keep gullies from farming
6. Diversion ditches → small ditches built across slopes to slow water movement and divert it to a safe outlet
7. Strip cropping → planting alternating strips of crop on sloping land, slows the flow of water and holds topsoil in place
8. Wind breaks → rows of trees planted to slow blowing wind and help prevent wind erosion
9. Crop residue → following harvest, leave residue on field, allows for decay and nutrient replenishment
10. No-till farming → instead of tilling and loosening the soul, seeds are driven into the ground, soil remains clumped and resists erosion