Unit 4: Sustainability of Ecosystems

Mr. Gillam – Holy Heart

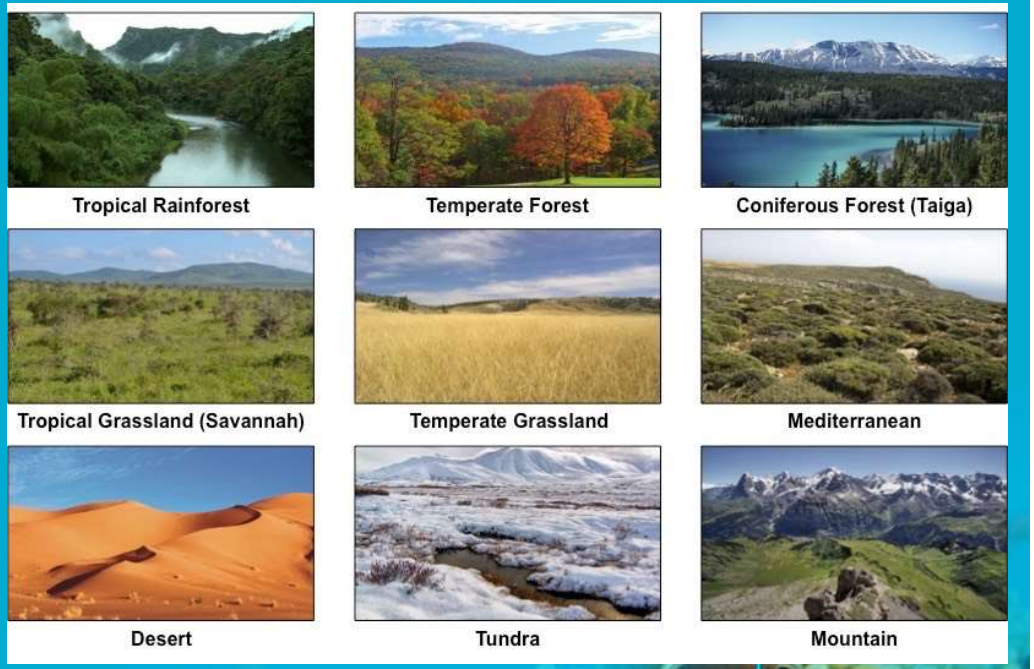
Grade 7 Science Review

- In Science 7, students studied ecosystems, their biotic and abiotic components, and the interrelationships among them. They described how ecosystems are organized and how energy is supplied to, and flows through them.

- Ecology
- Biotic factor
- Abiotic factor
- Organism
- Species
- Population
- Community
- Habitat
- Niche
- Producer
- Consumer
- Decomposer
- Herbivore
- Carnivore
- Omnivore
- Food chain
- Food web

Components of Sustainable Ecosystems

- **ecosystem** all the interacting parts of a biological community and its environment
- **sustainable ecosystem** an ecosystem that is capable of withstanding pressure and giving support to a variety of organisms

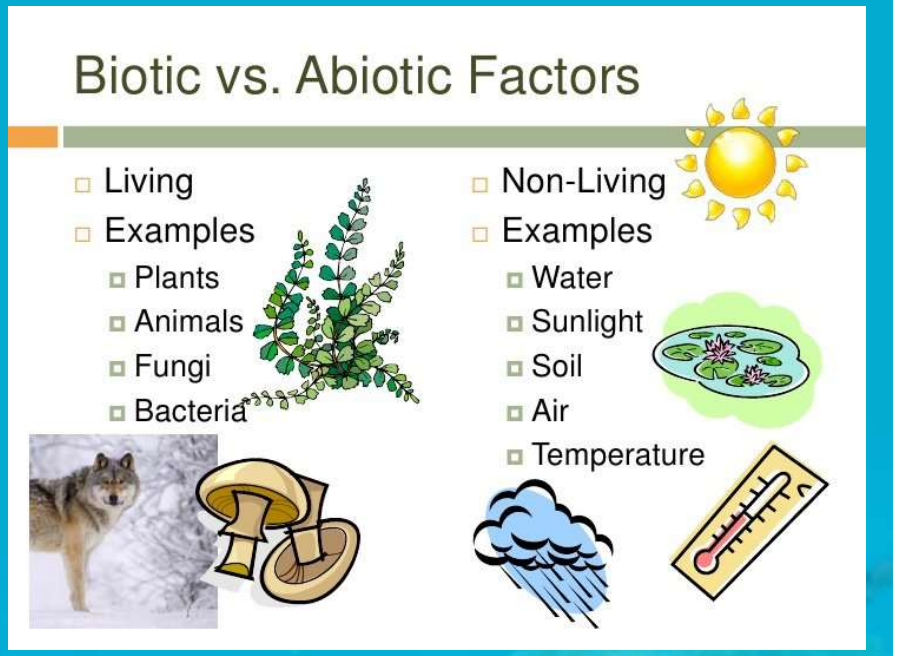


The Need for Sustainable Ecosystems

- Many organisms depend on more than one sustainable ecosystem to survive.
- For example, the grey-cheeked thrush. From May to August, populations of this bird breed in Canada's northern boreal forests, including throughout most of Labrador and the island of Newfoundland. In the fall, they fly thousands of kilometres to spend the winter in the dense tropical forests of South America. Because these birds, and many others, travel long distances each year, they depend on many ecosystems for food and shelter along their migratory route.

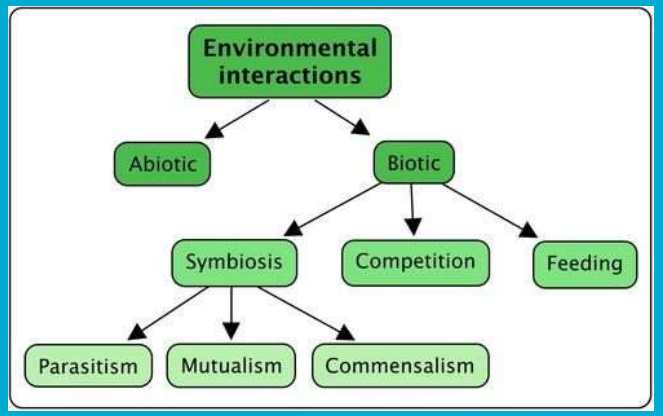
Biotic and Abiotic Parts of Ecosystems

- *Biotic* refers to the living parts of an ecosystem and the interactions among them. The biotic parts of an ecosystem include plants, animals, and micro-organisms.
- *Abiotic* refers to the non-living parts of an ecosystem. The abiotic parts of an ecosystem include water, oxygen, light, nutrients, and soil.



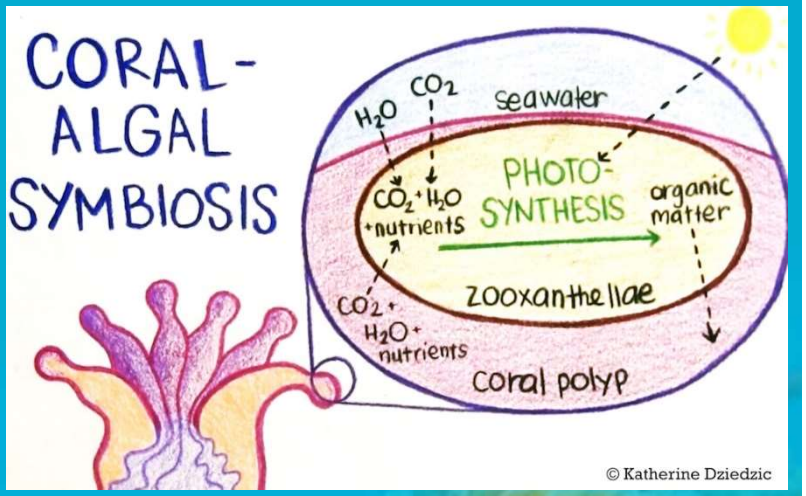
Biotic Characteristics of an Ecosystem and Sustainability

- Interactions among living things include symbiosis, predation, and competition.
- All biotic interactions in an ecosystem have some effect on the ability of that ecosystem to endure and to support all the organisms that are a part of it. In other words, all biotic interactions in an ecosystem affect its sustainability.



Symbiosis

- Symbiosis is the interaction between members of two different species that live together in a close association.
- For example, photosynthetic algae live inside the tissues of tropical reef-building corals. The algae provide the coral host with up to 90 percent of the coral's energy needs. At the same time, the coral provides the algae with protection, nutrients, and a constant supply of carbon dioxide for photosynthesis.



Symbiosis - Effects on Sustainability

- In 1998, about 16 percent of the world's tropical coral reefs were destroyed when the corals within them turned white.
- This is known as bleaching. Bleaching occurs because of a breakdown in the symbiotic relationship between the coral animal and its photosynthetic algal partner.
- Although not fully understood, scientists hypothesize that higher than normal temperatures cause the coral to lose the algae, which leads to bleaching.
- Elevated sea temperatures that last as little as six weeks can lead to coral death.

Predation

- Predation occurs when one organism (the predator) consumes another organism (its prey) for food. The river otter shown in the photograph is a predator. Its prey includes sea urchins, clams, crabs, and small fish. The otter is itself prey for other predators, such as wolves and killer whales. In this way, organisms are linked together through the food chain.

Predation – Effects on Sustainability

- The relationship between predators and their prey can influence the population of both the predator and the prey, as well as affect the entire ecosystem in which they live. Adult otters are at the top of their food chains.
- They are threatened mostly by humans, who hunt them for their fur. During the 1800s, this threat was severe enough to cause a decline in otter populations.
- However, conservation efforts have restored populations to sustainable levels.

Competition

- Competition takes place when two or more organisms vie for the same resources in the same place at the same time.
- For example, dandelions may block out light that grass needs to survive. They may soak up more water or soil nutrients, leaving less for the grass.
- Competition between two species, such as dandelions and grass is interspecific. Competition between members of the same species is intraspecific. Both can influence population size and success.

Abiotic Characteristics of an Ecosystem

Water

- All organisms need water to survive. Plants take up water through their roots. Some animals need water to help regulate their body temperature. Animals also use water to get rid of wastes. Many organisms live in freshwater and saltwater ecosystems.

Water – Effects on Sustainability

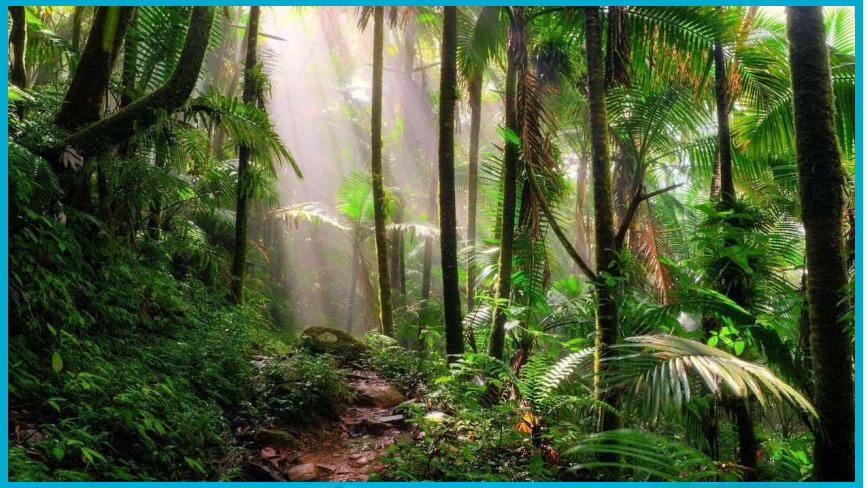
- Both natural processes and human activities can affect the amount and quality of water in an ecosystem.
- Water sources can dry out during long, hot periods with no rain.
- Chemicals from industries and agriculture can contaminate water.

Oxygen

- Many organisms, including plants and animals, need oxygen for their life processes. The oxygen that aquatic organisms need is dissolved in the water in which they live.
- Sometimes, as a result of human activities, oxygen levels in water can get so low that fish and other organisms cannot survive.

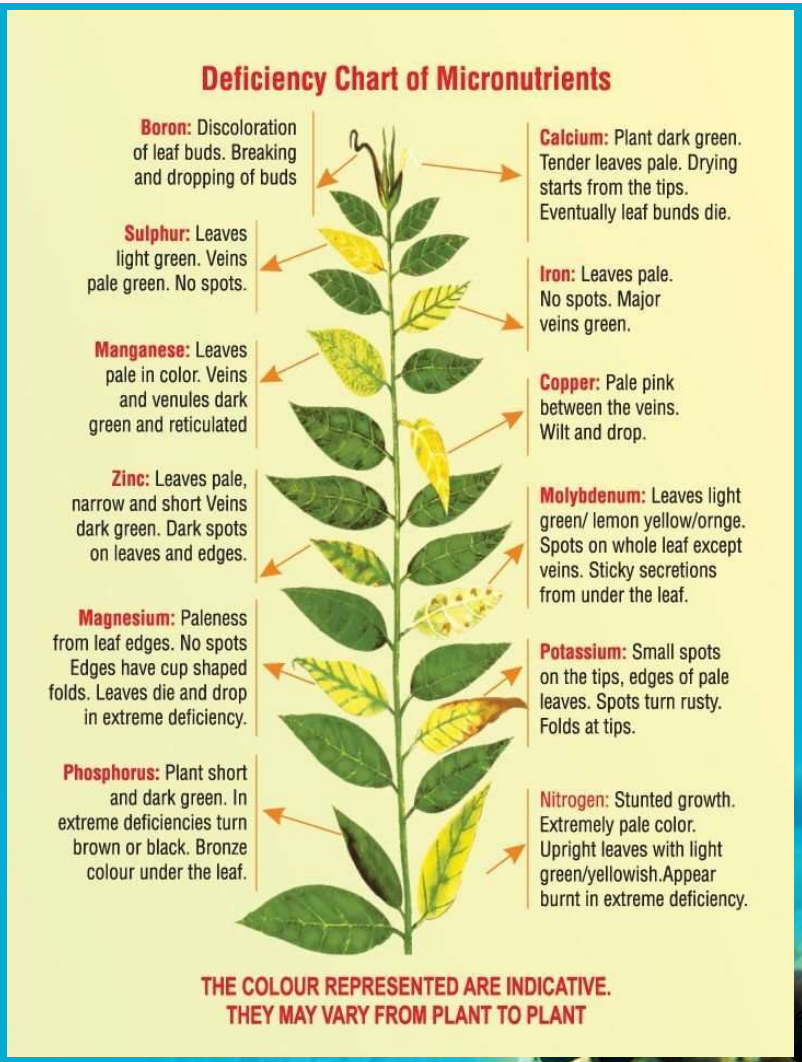
Light

- Plants and other organisms such as algae need light for photosynthesis, a life process in which organisms produce their own food.
- The amount of light that an ecosystem receives can vary. Plants near the floor of a forest may be shaded by taller trees. Light in an aquatic ecosystem can be affected by the amount of sediment in run-off.



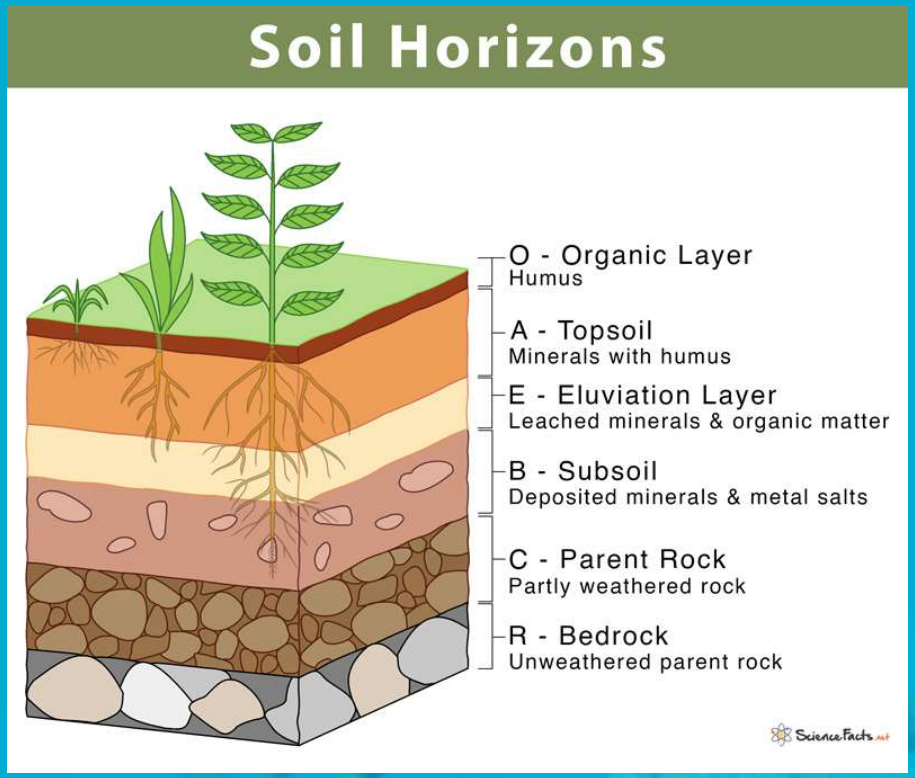
Nutrients

- All organisms need nutrients to grow. For example, plants and animals need nitrogen and phosphorus.
- Nutrient levels in an ecosystem can become unbalanced as a result of human activities.



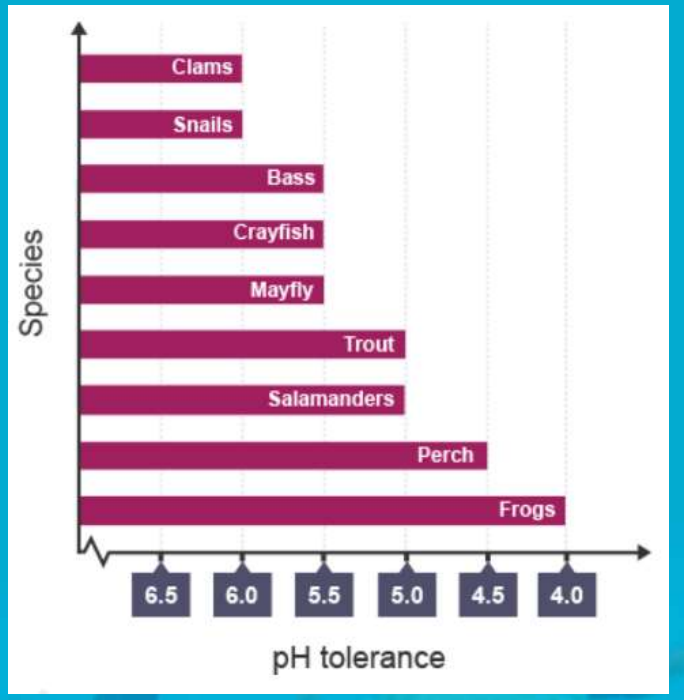
Soil

- Soil provides nutrients for plants and a habitat for many micro-organisms.
- Top layers of soil, which contain the most nutrients, can be washed away if there is heavy rain or if too many trees have been cut down.



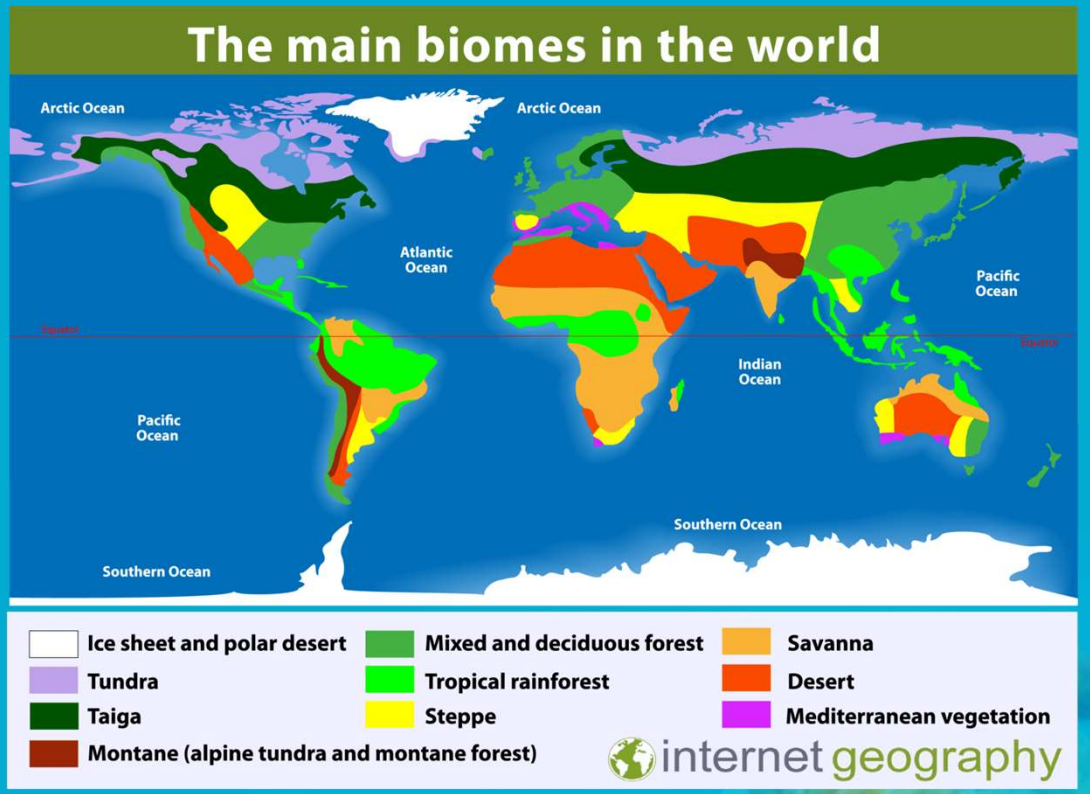
PH

- The pH of soils can have a huge effect on the plants that are able to grow in them. Some plants, like azaleas, grow best in acidic soils and will quickly die if planted in alkaline soils.
- Others, like clematis, prefer alkaline soils. Some, like hydrangeas, can grow in both.
- Hydrangeas are unusual in that their flower color changes in different soils. Just like universal indicator paper, hydrangea flowers are pink in acidic soils and blue in alkaline soils.
- The pH of water can also affect the aquatic organisms that are found there. Different species have evolved to survive at different pH levels found within water.



Different Geographic Locations Can Sustain Similar Ecosystems

- Biome Large geographical regions with a similar climate and dominant form of plant life.



Boreal Forests

- Boreal forests occur in the northern hemisphere between 45° and 65° north latitude across Canada and between 55° and 65° north latitude in Russia, Finland, and Scandinavia.
- Precipitation is 30 cm to 85 cm annually, with much of it falling in the form of snow. Temperatures are below freezing for half of the year and often drop as low as –40°C.
- As a result of these abiotic conditions, the short summer growing season averages 50 days.
- The terrain is often rough. Many marshes, shallow ponds, and wetlands hold vast amounts of water. The soil is very wet and low in nutrients.
- Bogs and peatland are especially widespread in Newfoundland and Labrador.

Boreal Forest

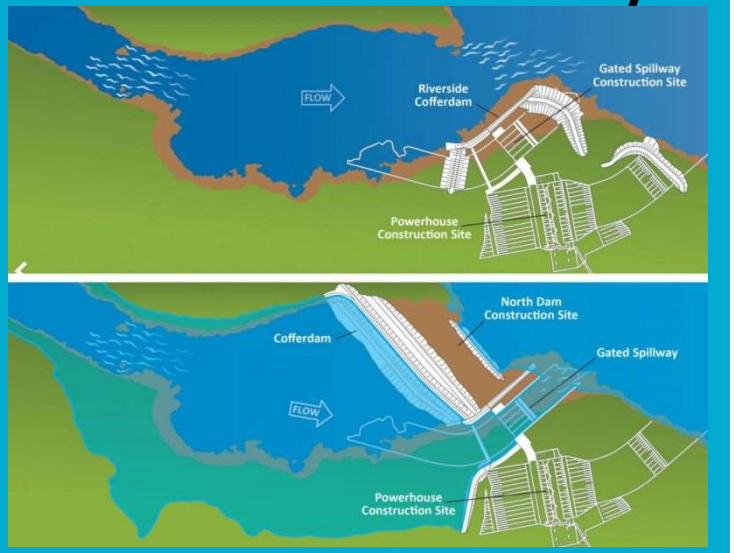
- Trees are mainly coniferous (cone-bearing), such as spruce and fir with small, pointed, waxy needles that resist water loss and allow snow to slide off easily.
- In regions dominated by balsam fir and white spruce, little light reaches the forest floor, so there are few understory plants.
- Common deciduous trees of this biome include larch, birch, and trembling aspen.
- Mosses and lichens carpet the ground and rocky surfaces, providing food for a variety of animals.

Boreal Forest Adaptations

- Insect-eating birds such as warblers migrate south in the fall.
- Seedeaters such as finches stay year-round.
- Small mammals such as voles and mice burrow in winter to stay warm.
- Larger mammals such as caribou have thick insulating coats.
- The fur of arctic hares changes from brown in summer to white in winter, which camouflages them from predators.
- Insects multiply rapidly and in large numbers in summer.
- Amphibians and reptiles are rare, because they are not adapted to survive low temperatures.

Boreal Forest - Threats to Sustainability

- The nearly 600 million hectares of boreal forest in North America (which includes Alaska) is one of the most intact forest regions in the world. It is also considered one of the least disturbed.
- Disturbances in the form of industrial development represent the greatest threat to this biome.
- Activities such as logging, mining, petroleum extraction, and the development of hydroelectric dams fragment the forest, divert the flow of water, and cause pollution of not only the land, but also its waters and surrounding air.



Activity - Science Watch

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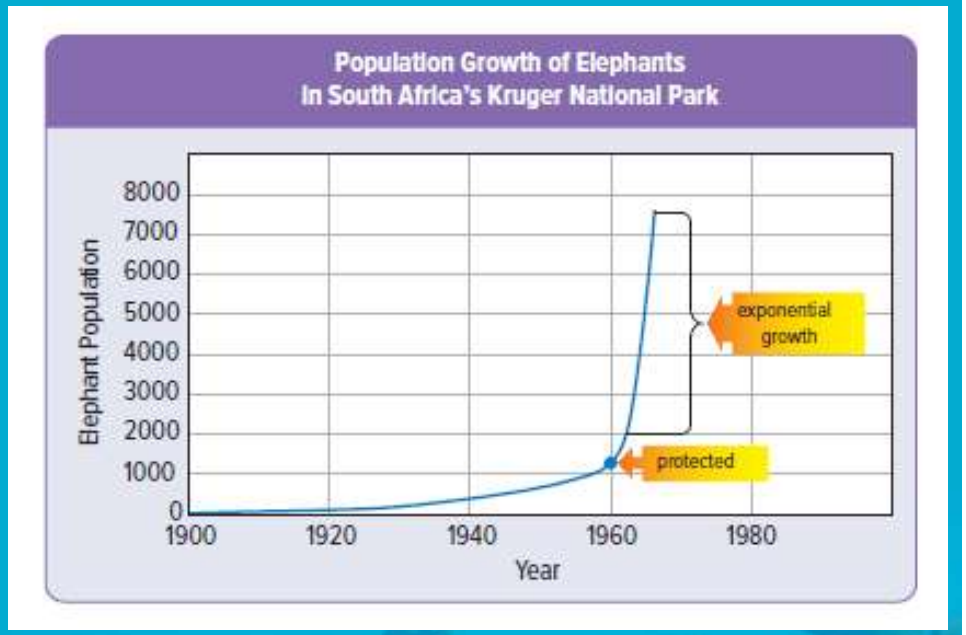
Populations and Sustainability

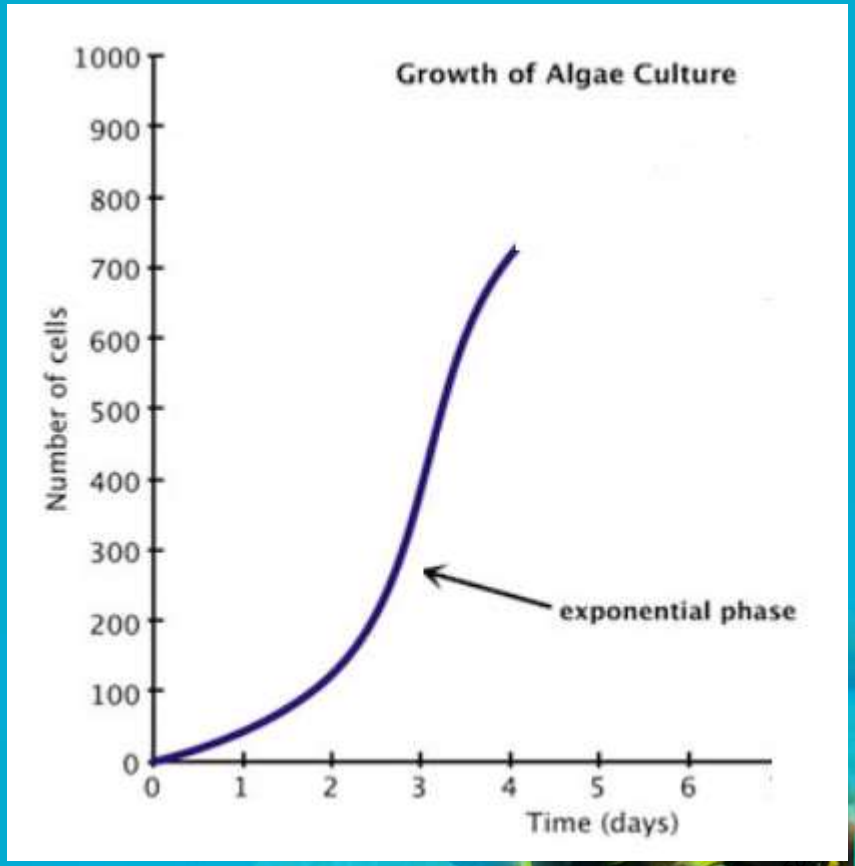
- **population** all the individuals of a species that occupy a particular geographic area at a specific time

- **exponential growth** accelerating growth that produces a J-shaped curve when the population is graphed against time



Exponential Growth

- exponential growth of a population in nature only occurs under certain conditions and for a short time. In some cases, it is seen when an organism comes to a new habitat that has a lot of resources, such as the first time that algae grows in a newly formed pond.



Limiting Factors and Exponential Growth

- **limiting factor** a factor that limits the growth, distribution, or amount of a population in an ecosystem

- As a population increases in size, each individual has access to fewer resources, limiting the growth of the population.

- The young perch, for example, require food for the nutrients and energy they need to survive, grow, and reproduce. Abiotic factors require the perch to live in parts of lakes and rivers that are the proper temperature and pH for growth and activity. The habitat must have enough dissolved oxygen, light, and hiding places, as well. In natural ecosystems, there are simply not enough places where 1 trillion or more yellow perch can have these needs satisfied. Additional biotic factors, such as symbiosis, predation, and competition, can also regulate population growth. There are two categories of limiting factors: density-independent factors and density-dependent factors.

- **Density-independent factors** Any factor in the environment whose impact on populations does not depend on the size of the population.
- These factors are usually abiotic and include natural phenomena, such as weather events—extreme storms, droughts, floods, fires, cold snaps, and heat waves.
- Pollution of air, land, and water as a result of human activities can also limit populations.
- Pollution reduces the available resources by making some of them toxic.

- **Density-dependent factors** Any factor in the environment whose impact on populations does depend on the size of the population.
- These factors are usually biotic factors such as disease, parasites, predation, and competition.
- Outbreaks of disease tend to occur when population size has increased and population numbers are high. When population numbers are high, disease is transmitted easily from one individual to another and spreads quickly throughout a population because contact between individuals occurs more often.
- This is true for human populations as it is for plants and other animal species.

- **carrying capacity** the size of a population that can be supported indefinitely by the available resources and services of an ecosystem

- Beyond this carrying capacity, no additional individuals can be supported, at least not for long.
- When a population is maintained at its carrying capacity, the size of the population is in equilibrium. there is a balance between the number of individuals that are added to the population and the number of individuals that leave or die.

- When one of the necessary resources is being used at a rate that exceeds the carrying capacity of the ecosystem, the population will eventually be reduced in size until it is once again in balance with the available resources of its ecosystem.
- The limiting factor might be food, but it could also be an abiotic factor.
- Newfoundland (pine) martens need mature boreal forest that supplies lots of cover.

- Polar bears need pack ice on which to hunt

- Brook trout need rocky lake bottoms on which to lay eggs

- A famous, well-studied example of the impact of limiting factors on exponential growth has been seen with the population of the northern fur seal.
- In the 1800s, the fur trade led to a drastic reduction in the northern fur seal population. Its decline prompted the first international treaty to conserve wildlife, signed in 1911.
- As you can see in the graph the fur seal population underwent exponential growth following protection, but eventually levelled out at the ecosystem's carrying capacity.

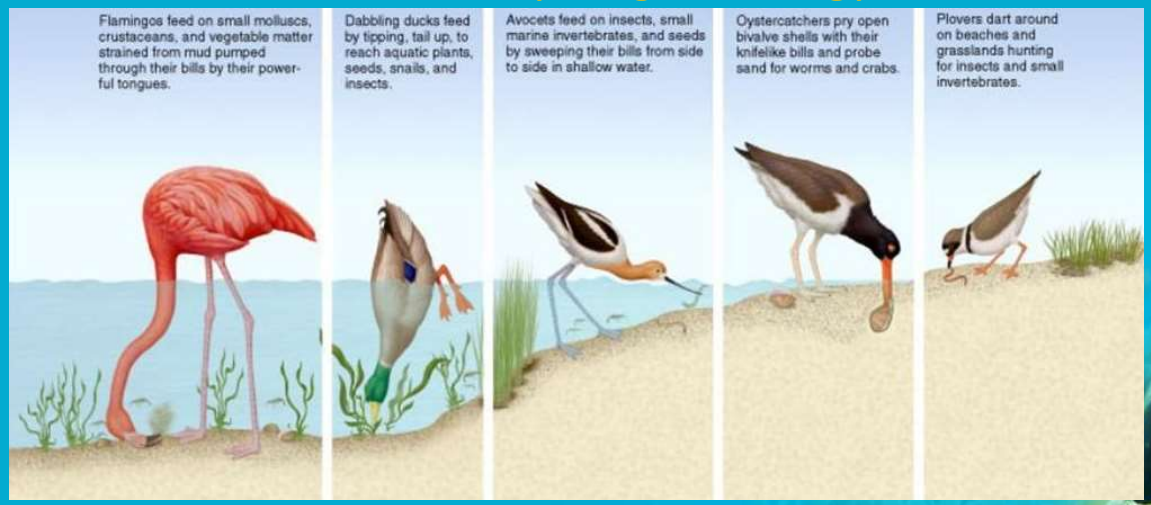
Activity – Graphing Population Change

Interactions Among Species

- All organisms interact with other species in multiple ways, and these interactions can have positive and negative effects on a population.
- Recall that predation, competition, and symbiosis are the major types of interactions among species.
- These interactions, along with other limiting factors, restrict populations to particular places, roles, and sizes in the ecosystems they occupy.

A Species' Ecological Niche

- **ecological niche** the way an organism occupies a position in an ecosystem, including all the necessary biotic and abiotic factors.
- Different species provide many different services to their ecosystems by occupying their ecological niches. These services may include the regulation of population sizes of other organisms, as well as specific services related to matter cycling or energy flow.



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- Predator-Prey Simulation
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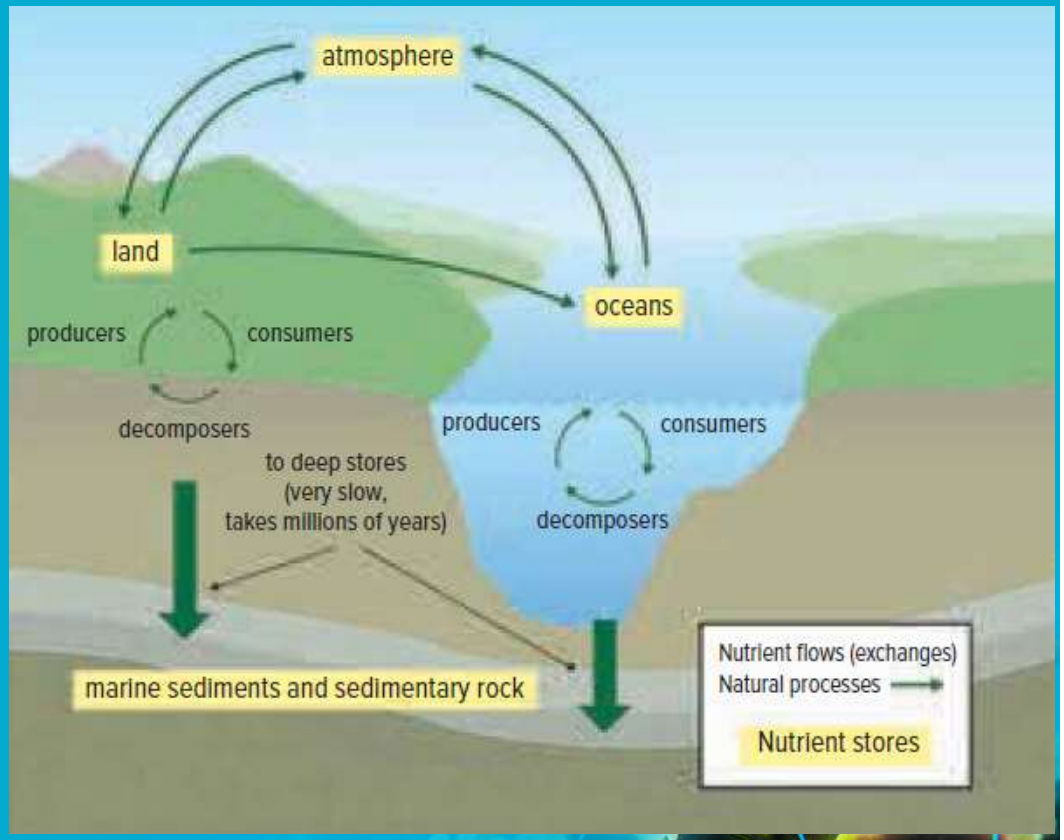
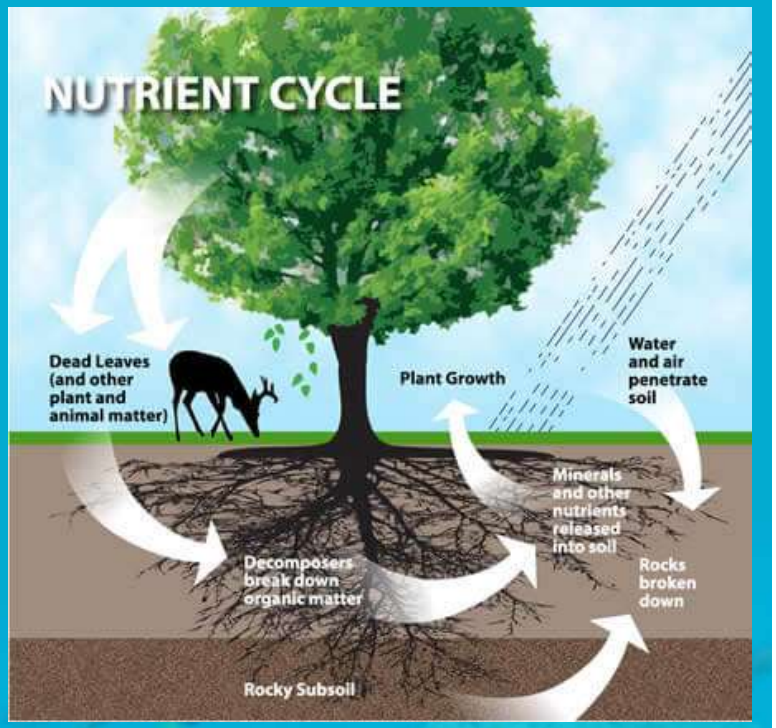
Cycles and Sustainability

- Nutrients are chemicals that living things need to carry out all their life processes. Nutrients are accumulated for short or long periods of time in the atmosphere, oceans, and land masses.
- These accumulations are called *stores*.



Cycles and Sustainability

- Biotic processes such as decomposition and abiotic processes such as river run-off cause nutrients to flow in and out of stores. Taken together, these continuous flows of nutrients in and out of stores are called *nutrient cycles*. Without human interference, nutrient cycles are usually balanced. That's because, over time, the amounts of nutrients flowing into the stores are about the same as the amounts of nutrients flowing out of the stores.



- Human activities such as urban development, farming, mining, power generation, manufacturing, and transportation can affect a nutrient cycle by increasing the amounts of nutrients in the cycle faster than natural biotic and abiotic processes can move them. Over time, increased amounts of nutrients in the atmosphere, oceans, and on land can have significant effects on ecosystems.

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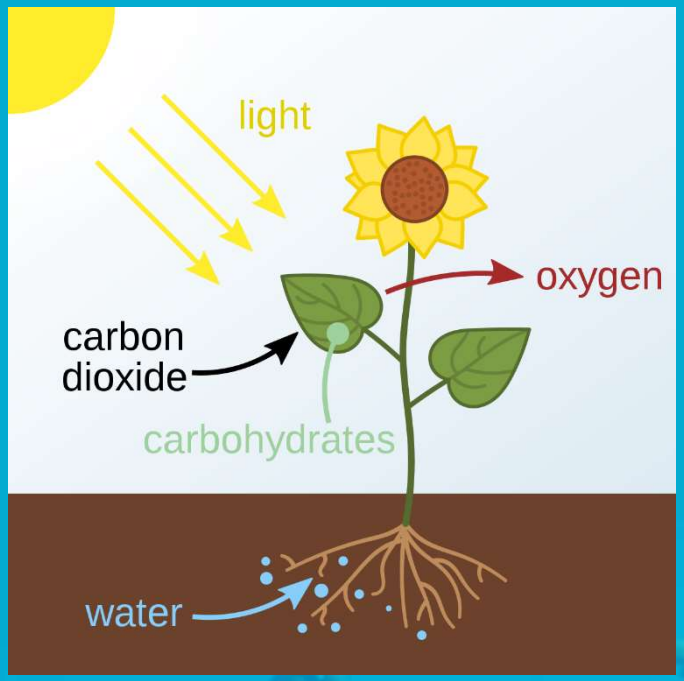
The Cycling of Oxygen and Carbon

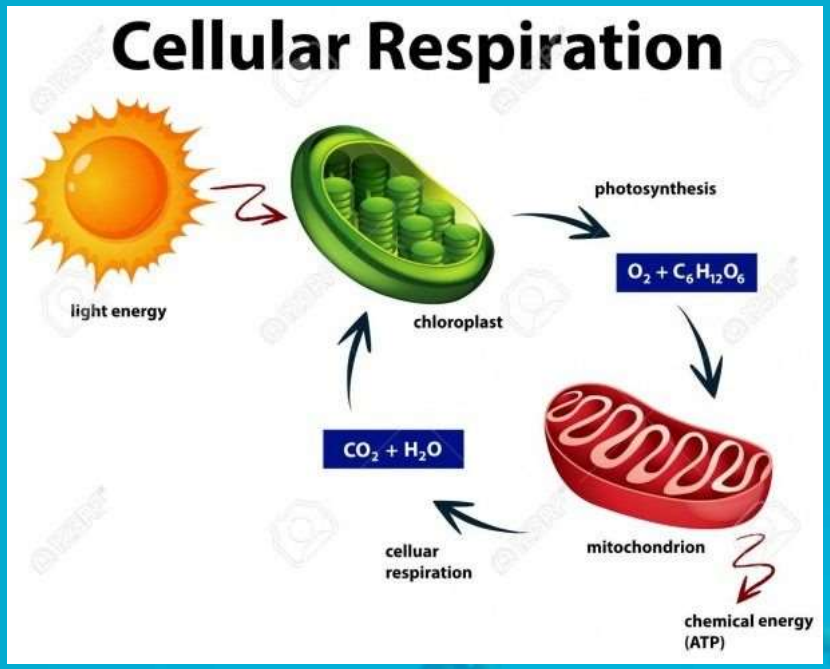
- **photosynthesis** a reaction in the cells of green plants and plant-like organisms that converts light energy into chemical energy, producing oxygen in the process



carbon dioxide + water + light energy → glucose + oxygen

$$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

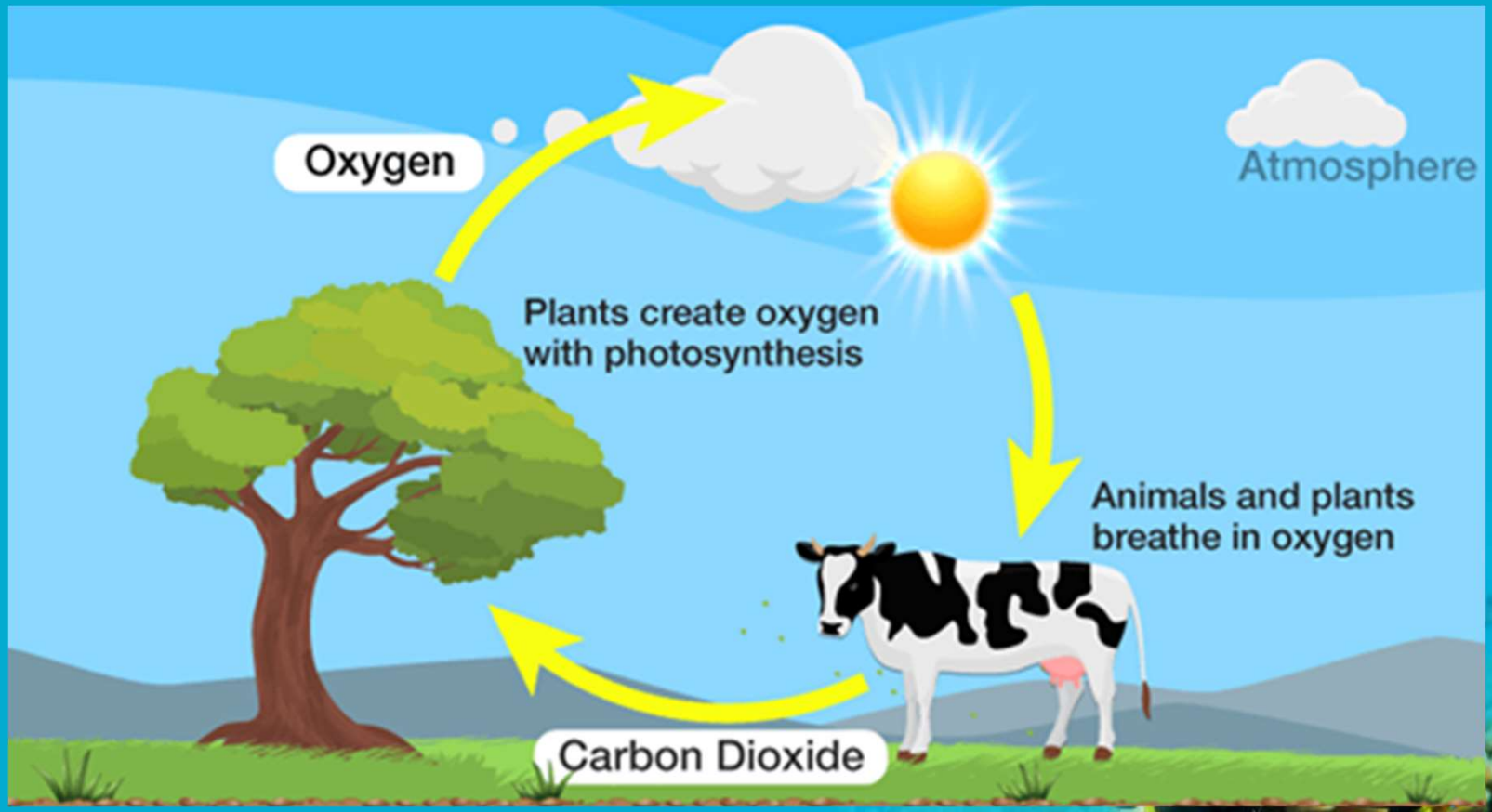
- **cellular respiration**
  a reaction in the cells of most organisms that releases stored energy, producing carbon dioxide in the process



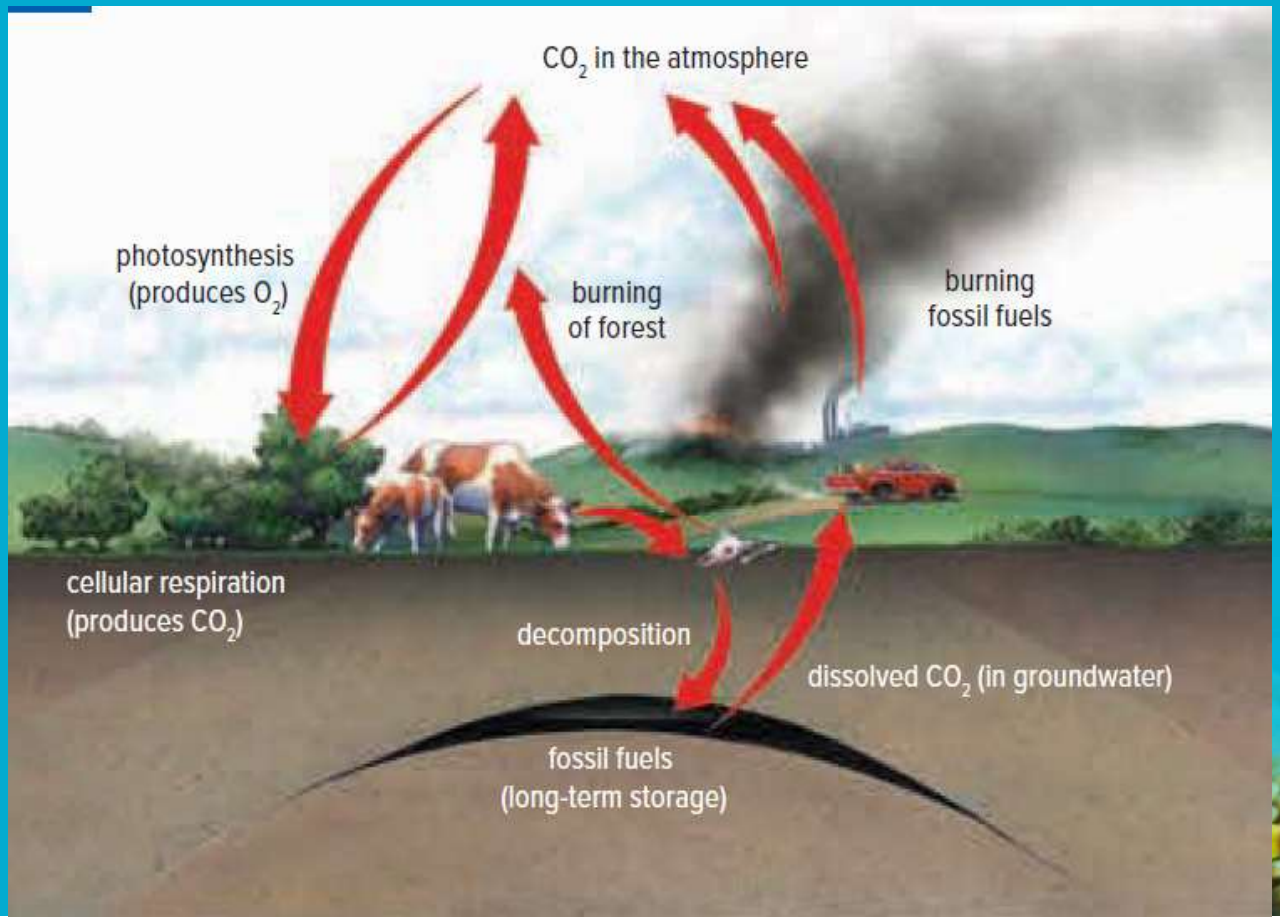
glucose + oxygen → carbon dioxide + water + usable energy

$$6C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{usable energy}$$

The Natural Carbon/Oxygen Cycle

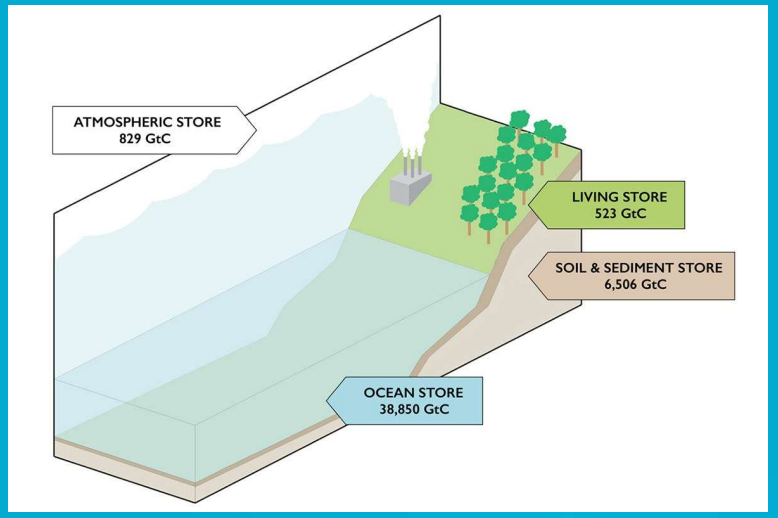


The Anthropogenic Carbon/Oxygen Cycle



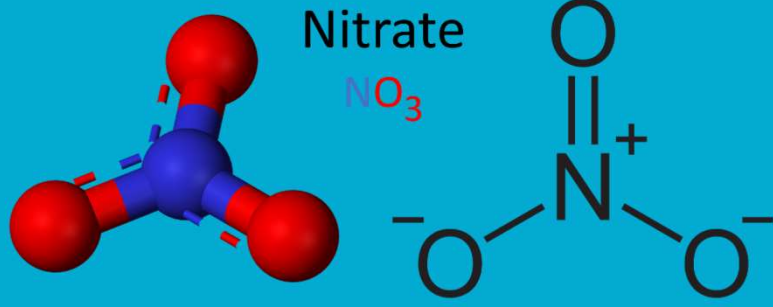
Carbon Stores

- Water, as part of oceans and freshwater bodies, contains dissolved oxygen and carbon dioxide through the interaction of numerous aquatic producers and consumers.
- Carbon is also bound up and stored in the shells of many aquatic organisms in the form of calcium carbonate. As well, carbon is stored in limestones and other carbon containing rocks below as well as above the surface.

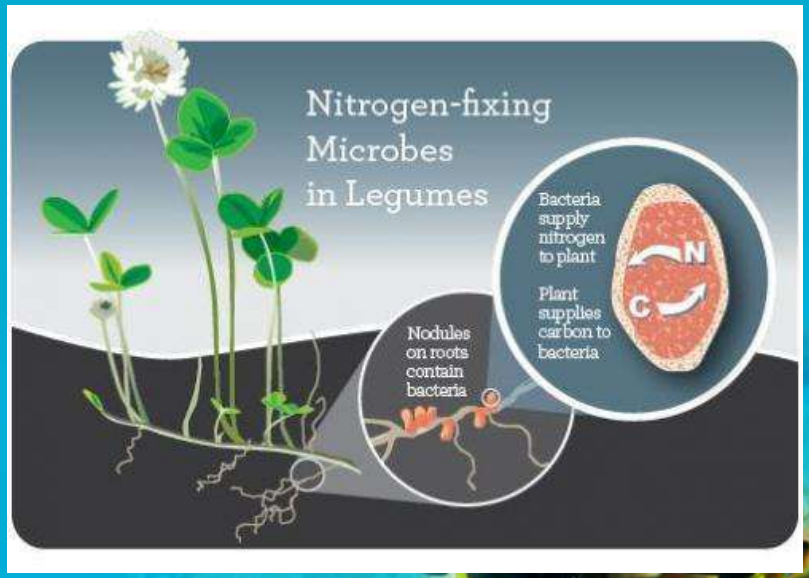


The Cycling of Nitrogen

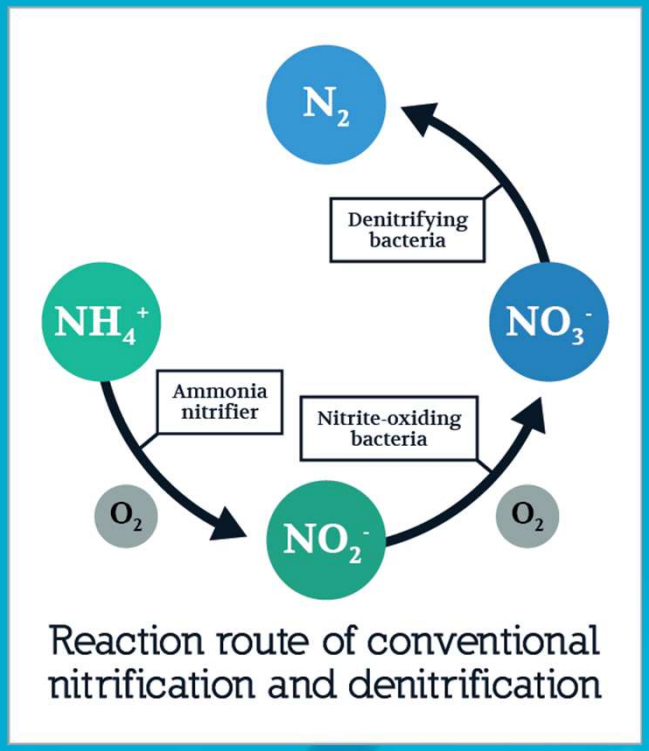
- Nitrogen makes up about 78% of air, but most living things cannot use it directly.
- Animals get nitrogen in the form of proteins from plant and animal tissues they eat.
- In order for plants to make proteins, they require nitrogen-containing compounds called nitrates.



- The nitrogen cycle forms nitrate in three ways.
- 1) One way involves lightning, which converts nitrogen and oxygen gas in air into nitrates.
- 2) Some types of soil bacteria that convert nitrogen gas into nitrates.
- 3) Bacteria that live among the roots of legumes, such as beans and clover convert nitrogen into nitrates.



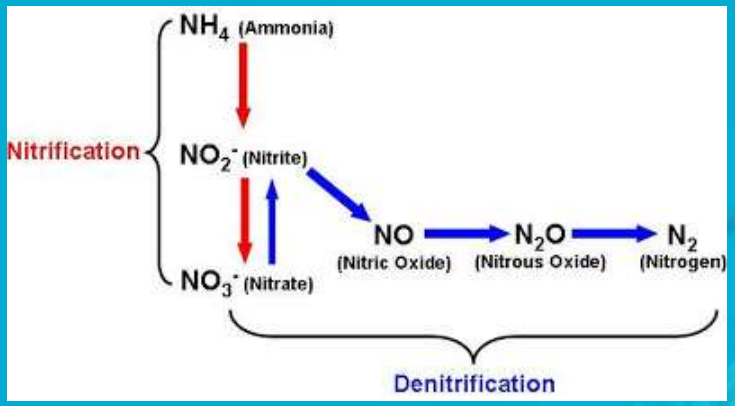
- **denitrification** the process of converting nitrates to nitrogen gas
- **nitrification** the process of converting ammonia to nitrate, which may be converted to nitrogen gas

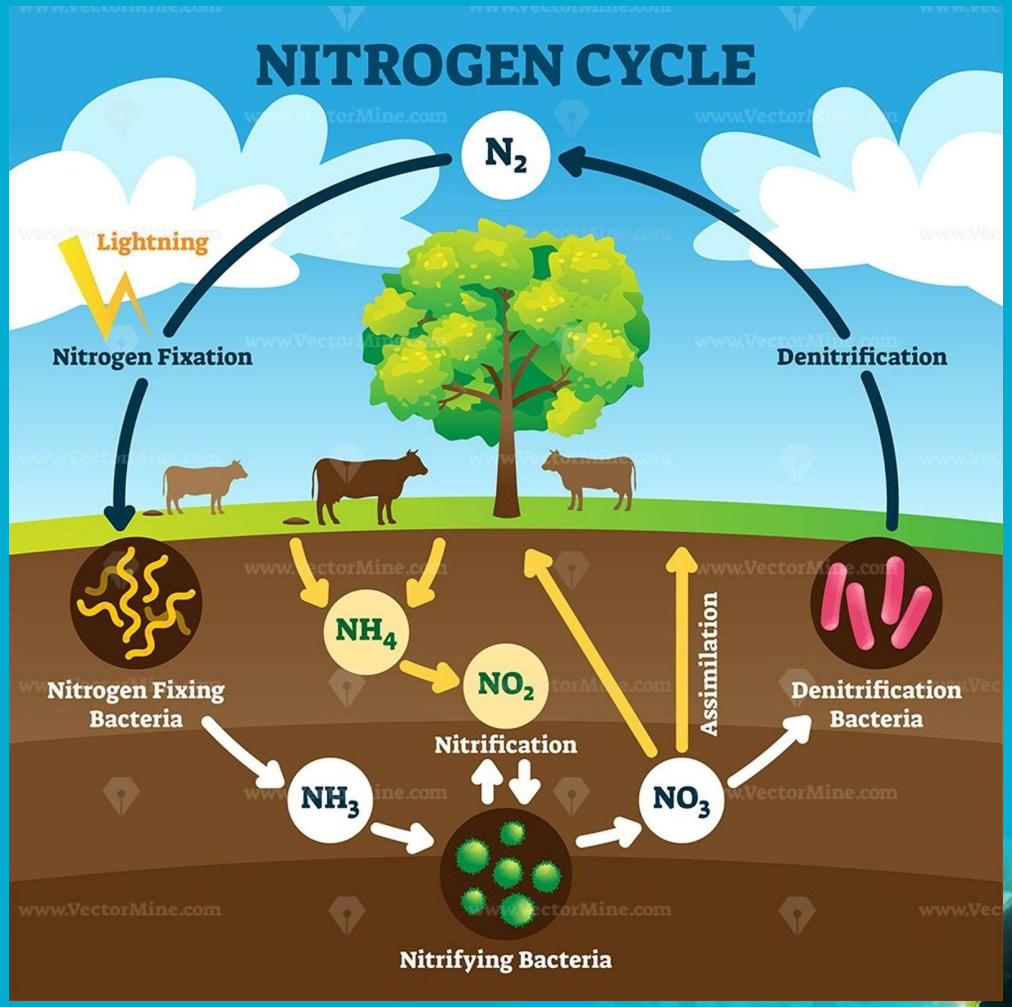


Reaction route of conventional nitrification and denitrification

Nitrification

- As animal wastes and dead bodies decompose, they release a nitrogen containing compound called ammonia.
- Certain types of bacteria convert ammonia into other nitrogen containing substances called nitrites.
- Other types of bacteria convert nitrites into nitrates, which may then decomposed to release nitrogen gas. Nitrates produced in this way also may be taken up and used by plants.

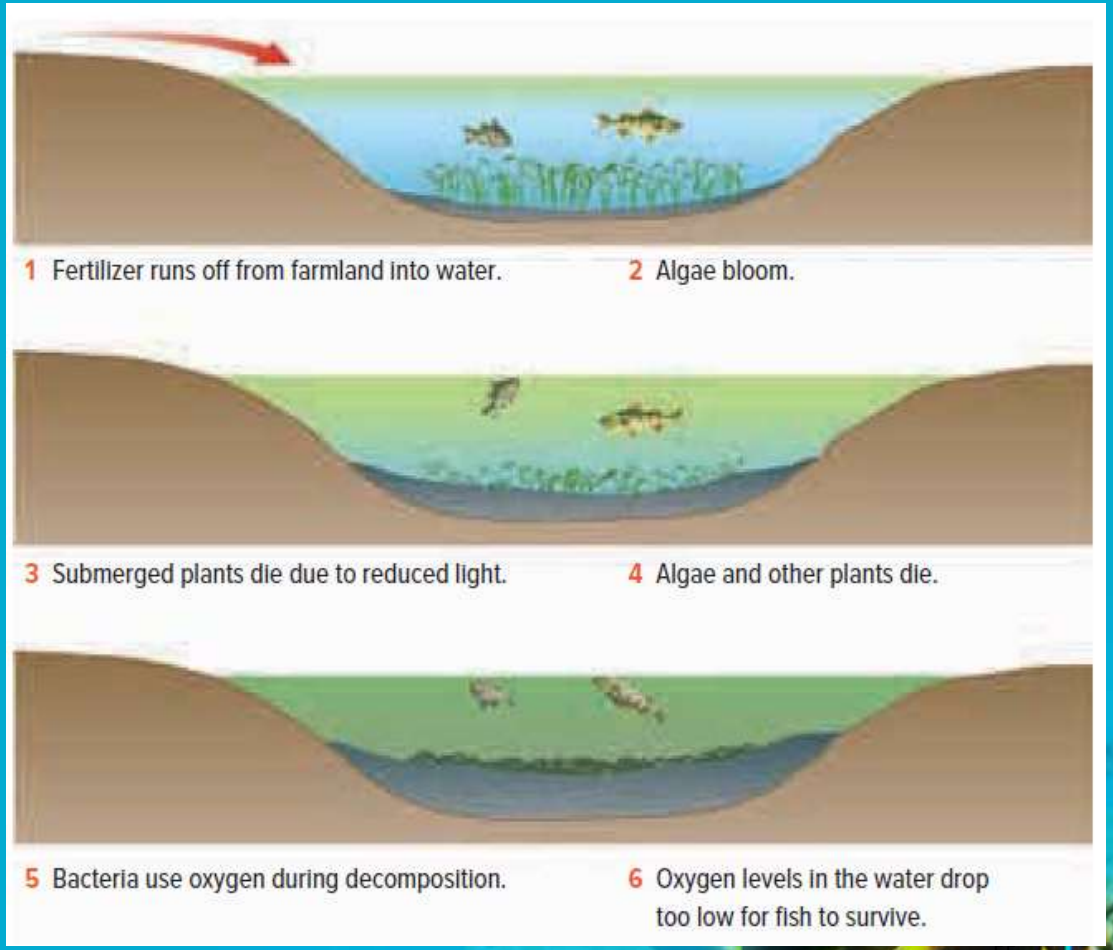



NITROGEN CYCLE
N_2
Lightning
Nitrogen Fixation
Denitrification
NH_4
NO_2
Nitrification
Assimilation
Nitrogen Fixing Bacteria
Denitrification Bacteria
NH_3
NO_3
Nitrifying Bacteria

Nutrient Cycles and Aquatic Ecosystems

- Many human activities affect the nitrogen cycle.
- Nitrogen is a key part of fertilizers. Farmers and gardeners use fertilizers to enhance the growth of their plants.
- However, not all the nitrogen in the fertilizers is used by the plants. Some stays in the soil.
- When it rains, or when fields are watered, some of the nitrogen is carried into aquatic ecosystems where it can cause an overgrowth of algae called an algal bloom.

- **eutrophication** a buildup of nutrients in aquatic ecosystems that leads to an increase in populations of primary producers



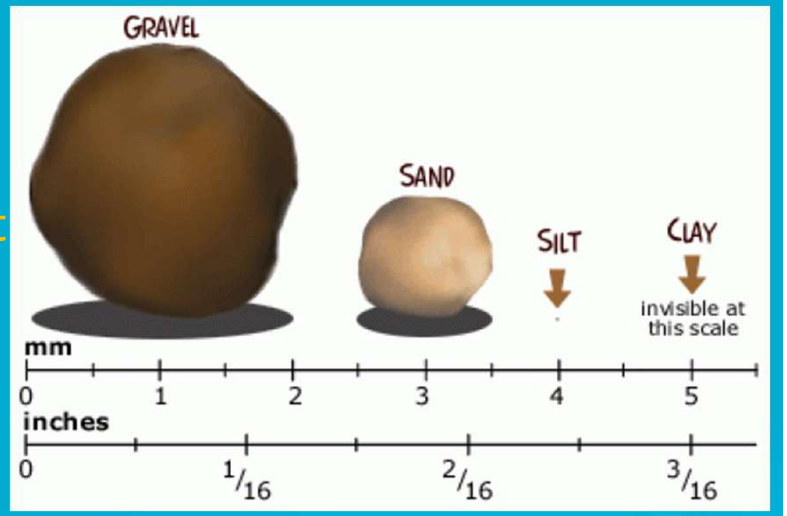
Soil Alteration

- A soil amendment is any material added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration and structure. The goal is to provide a better environment for roots.

Soil Amendments

- Sand a loose granular substance, typically pale yellowish brown, resulting from the erosion of siliceous and other rocks.
- Sand is, among the three types of soil (sand, silt, and clay), it has the coarsest (roughest) particles.
- If sand is added to a medium (like regular potting soil), it will increase its drainage ability.
- Sand does not store nutrients

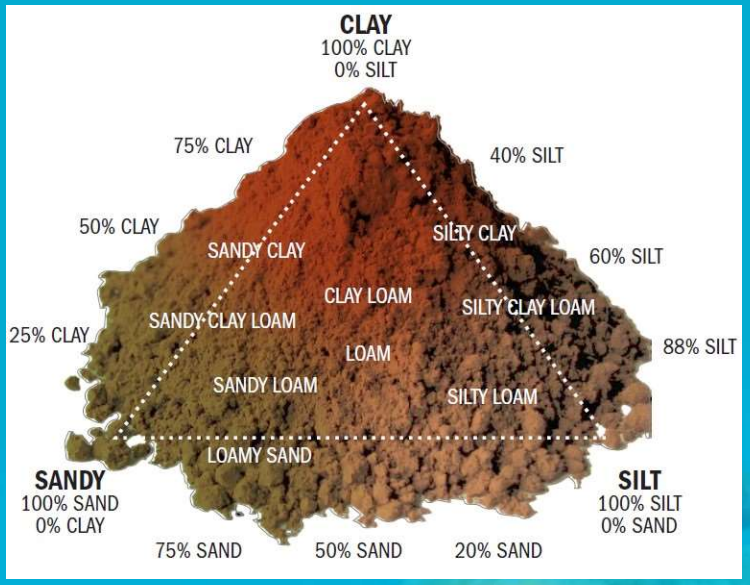
- Silt is a solid, dust-like sediment that water, ice, and wind transport and deposit.
- Silt is made up of rock and mineral particles that are larger than clay but smaller than sand.
- Silty soil is slippery when wet, not grainy or rocky.
- Silty soil is usually more fertile than sand, meaning it is good for growing crops. Silt promotes water retention and air circulation.



- Clay, because of its density, retains moisture well. It also tends to be more nutrient-rich than other soil types.
- The reason for this is that the particles that make up clay soil are negatively charged, which means they attract and hold positively charged particles, such as calcium, potassium, and magnesium.

- Disadvantages of Clay Soil
- Slow draining
- Slow to warm in the spring
- Compacts easily, making it difficult for plant roots to grow
- Tendency to heave in winter
- Tendency to be alkaline in pH


Clay
Loam
Sand
Silt


CLAY
100% CLAY
0% SILT
75% CLAY
40% SILT
50% CLAY
60% SILT
25% CLAY
88% SILT
SANDY CLAY
SILTY CLAY
CLAY LOAM
SANDY CLAY LOAM
SILTY CLAY LOAM
LOAM
SANDY LOAM
SILTY LOAM
LOAMY SAND
SANDY
100% SAND
0% CLAY
SILT
100% SILT
0% SAND
75% SAND
50% SAND
20% SAND

- Peat a brown deposit resembling soil, formed by the partial decomposition of vegetable matter in the wet acidic conditions of bogs and fens, and often cut out and dried for in gardening.
- Peat moss helps the soil hold nutrients by increasing what is called the CEC or "cation exchange capacity."
- Peat moss has a low pH, so if you use much, lime should be added as well.
- Plants that do well in acidic soils, such as blueberries benefit from peat moss.

Manure

- Manure animal dung used for fertilizing land.
- Manure from animals is a valuable soil amendment for home gardens. It supplies primary nutrients (nitrogen, phosphorus and potassium) and micronutrients for plant growth, but also is a source of organic matter.

Micronutrient Content of Dairy Manure

Nutrient	Lb per ton	Lb per 1000 gal
Calcium	5	14
Magnesium	2	6
Sulfur	1.5	4.2
Iron	0.1	0.3
Boron	.01	.03
Copper	.01	.03
Manganese	.03	.08
Zinc	.04	.11

Composting

- Compost is decayed organic material used as a plant fertilizer.
- Compost contains macro and micronutrients often absent in synthetic fertilizers.
- Compost releases nutrients slowly—over months or years, unlike synthetic fertilizers
- Compost enriched soil retains fertilizers better. Less fertilizer runs off to pollute waterways.
- Compost buffers the soil, neutralizing both acid & alkaline soils, bringing pH levels to the optimum range for nutrient availability to plants.

- Compost helps sandy soil retain water and nutrients.
- Compost loosens tightly bound particles in clay or silt soil so roots can spread, water drain & air penetrate.
- Compost alters soil structure, making it less likely to erode, and prevents soil spattering on plants—spreading disease.
- Compost can hold nutrients tight enough to prevent them from washing out, but loosely enough so plants can take them up as needed.

- Compost brings and feeds diverse life in the soil. These bacteria, fungi, insects, worms and more support healthy plant growth.
- Compost bacteria break down organics into plant available nutrients. Some bacteria convert nitrogen from the air into a plant available nutrient.
- Compost enriched soil have lots of beneficial insects, worms and other organisms that burrow through soil keeping it well aerated.

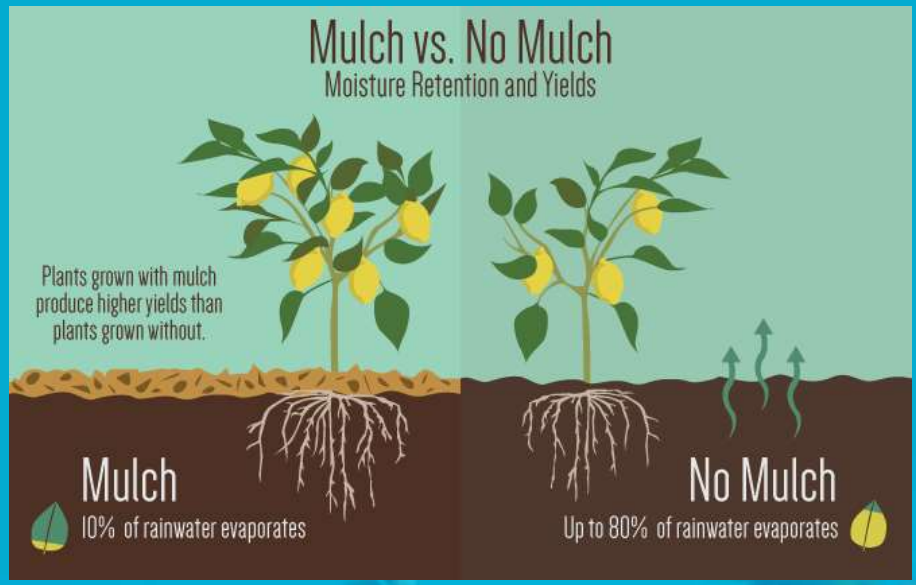
Irrigation

- Irrigation is the supply of water to land or crops to help growth, typically by means of channels.

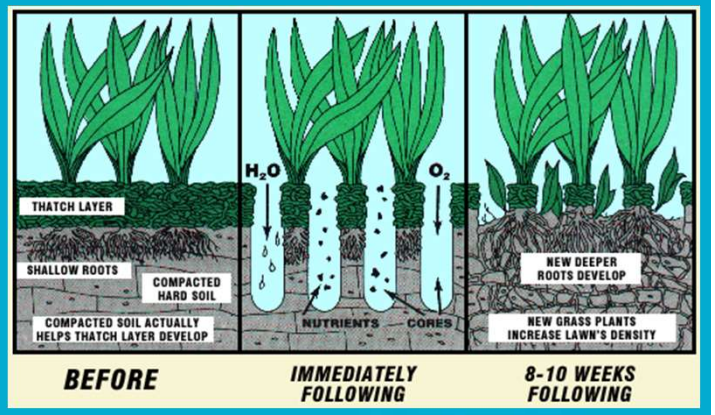
- Soil can be over-irrigated because of poor management of waste water and chemicals may lead to water pollution.

- If soil is under irrigated, it gives poor soil salinity control which leads to increased soil salinity with consequent buildup of toxic salts.

- Mulching is the placement of any organic or inorganic material over the top of a soil surface to protect it
- Some of the benefits include:
- reduced soil erosion
- less compaction
- moisture conservation, increased control of soil temperature
- reduction in weed growth.



- Compacted soils don't leave much space for roots to grow.
- Humans cause soil compaction by driving heavy machinery over the soil during harvest.
- Soil aeration is defined as the exchange of gases between the soil and the atmosphere.
- Since plant roots and soil microorganisms absorb O2 and release CO2 during respiration in the soil, soil aeration is one of the most important things affecting soil productivity



Tilling

- Tilling is a form of deep cultivation that is necessary when preparing a new garden bed or when adding large amounts of organic material.

Types of Tillage

- **Primary and secondary tillage**
- The objective of primary tillage is to attain a reasonable depth of soft soil, incorporate crop residues, kill weeds, and to aerate the soil. Secondary tillage is any subsequent tillage, in order to incorporate fertilizers, reduce the soil to a finer tilth, level the surface, or control weeds.

- **Reduced tillage**
- Reduced tillage leaves between 15 and 30% crop residue cover on the soil during the critical erosion period.

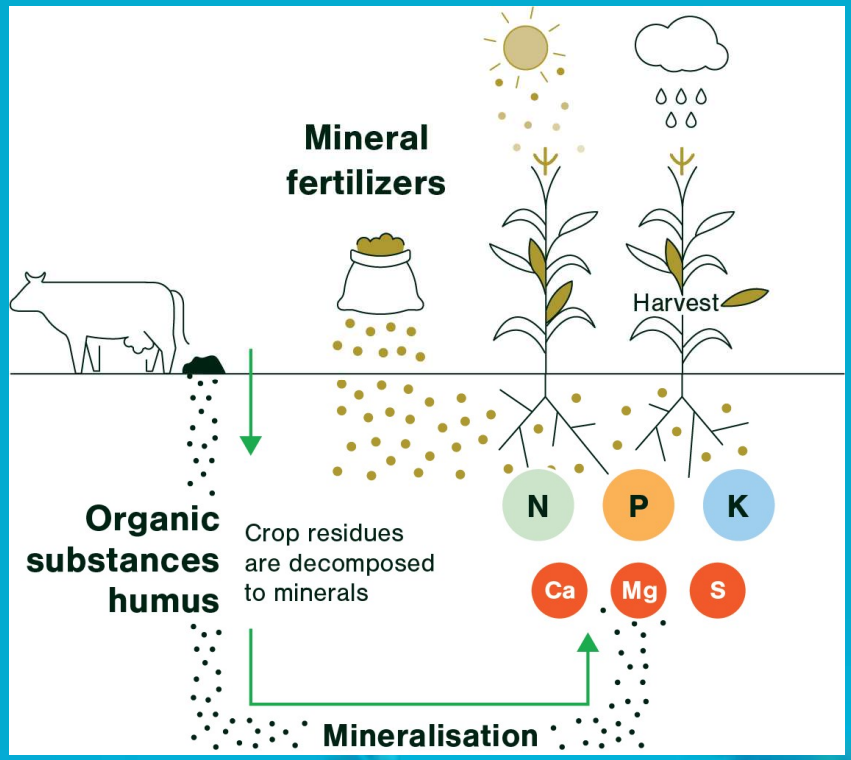
ADVANTAGES OF REDUCED TILLAGE

- 1. Reduces soil erosion by up to 90 percent
- 2. Improves water quality by retaining soil and associated nutrients (especially phosphorus) in the field, lessening runoff into waterbodies.
- 3. Enhances soil health and increases organic matter.
- 4. Decreases the amount of compaction.
- 5. More water held in the soil profile due to residues capturing moisture and shading the soil.
- 6. Reduces soil erosion and runoff due to buffering energy from raindrops.
- 7. Improves air quality through less wind erosion, tying up carbon in the soil and reducing the release of carbon dioxide into the air.

- **Intensive tillage**
- leaves less than 15% crop residue on top of the soil. Intensive Tillage has all along been contributing negatively to soil quality. Since tillage fractures the soil, it disrupts soil structure, accelerating surface runoff and soil erosion. Tillage also reduces crop residue, which help cushion the force of pounding raindrops.

Fertilizer

- Fertilizers provide the major nutrients (nitrogen, phosphorus and potassium and important secondary elements) that plants need. Unless the nutrients are replenished, the soil's productive capacity declines with every harvest.



Nitrogen fertilizers

- Nitrogen is so vital because it is a major component of chlorophyll, the compound by which plants use sunlight energy to produce sugars from water and carbon dioxide (i.e., photosynthesis). It is also a major component of amino acids, the building blocks of proteins.
- ammonium nitrate, calcium ammonium nitrate, ammonium sulphate, ammonium sulphate nitrate, calcium nitrate, sodium nitrate, and anhydrous ammonia.

Phosphorus fertilizers

- Phosphorus (P) is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next.

- Potassium fertilizers
- Potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. It's involved with enzyme activation within the plant, which affects protein, starch and adenosine triphosphate (ATP) production.

- Potassium chloride (KCl), Potassium sulphate (K2SO4) or potash, Potassium nitrate (KNO3).

- Calcium, magnesium and sulphur Fertilizers
- Calcium (Ca), magnesium (Mg) and Sulphur (S) are essential secondary plant nutrients.
- They are all used in the creation of chlorophyll

Cover Crops

- cover crops are plants that are planted to cover the soil rather than for the purpose of being harvested.
- Cover crops manage soil erosion, soil fertility, soil quality, water, weeds, pests, diseases, biodiversity and wildlife in an agroecosystem
- agroecosystem—an ecological system managed and shaped by humans. Cover crops may be an off-season crop planted after harvesting the cash crop.

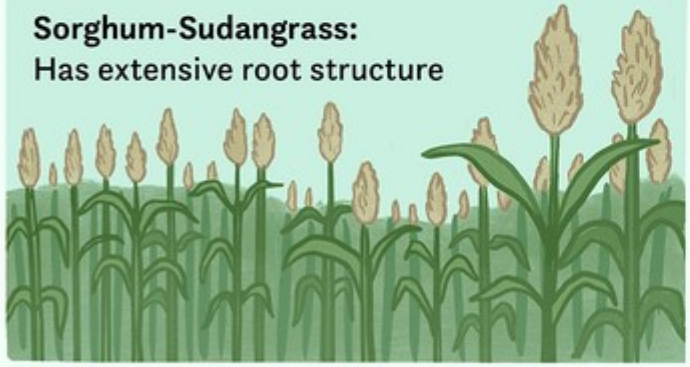
5 Cover Crops for Your Small Farm

Winter and cereal rye:
Plant in fall or early winter

Buckwheat:
Grows very quickly

Clover:
Varieties all have different purposes

Sorghum-Sudangrass:
Has extensive root structure



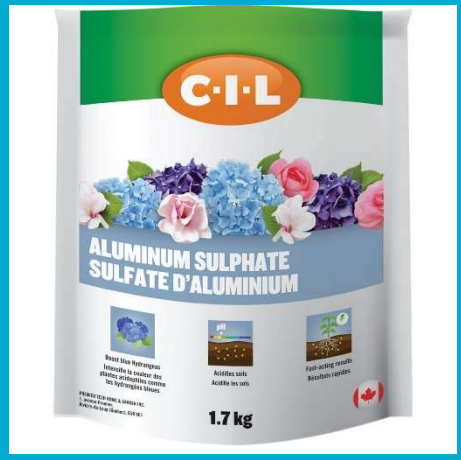
Hairy vetch:
Perfect for northern climates

Treehugger

pH (potential of Hydrogen)

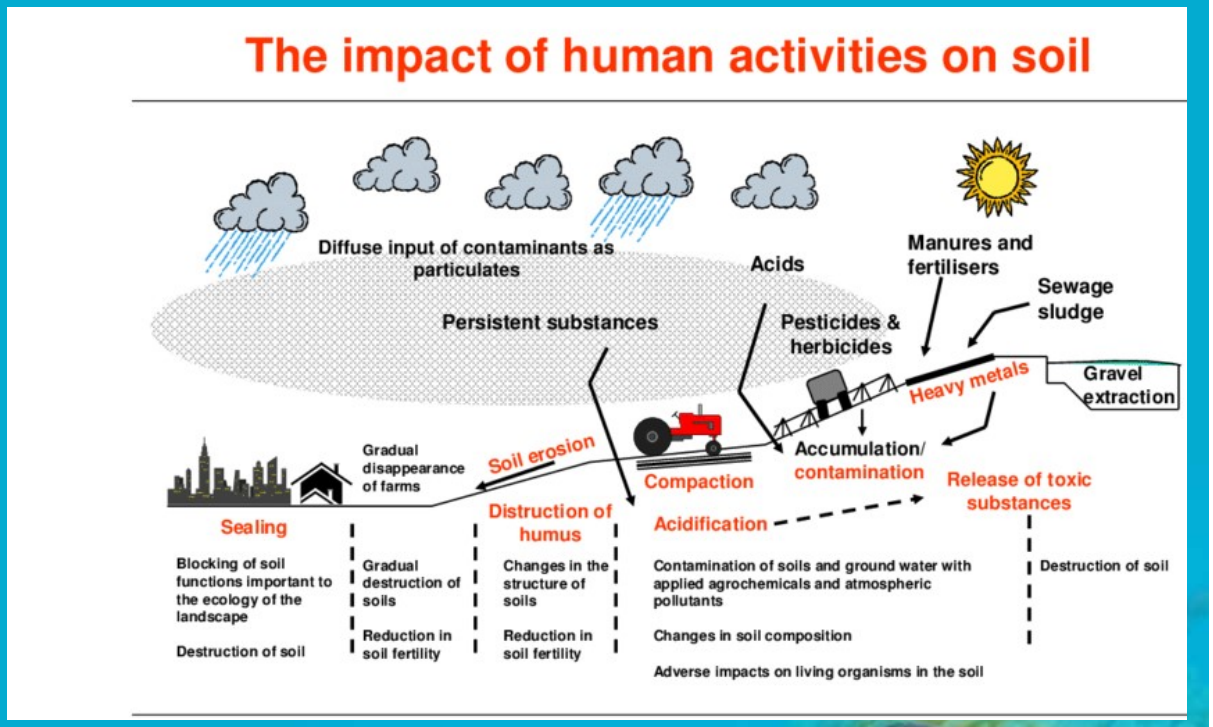
- Two materials commonly used for lowering the soil pH are aluminum sulfate and sulfur. These can be found at a garden supply center. Aluminum sulfate lowers soil pH instantly because the aluminum produces acid as soon as it dissolves in the soil.

- To make soils less acidic, the common practice is to apply a material that contains some form of lime. Ground agricultural limestone is most frequently used. The finer the limestone particles, the more rapidly it becomes effective.



How Human Activities Affect Soil

- Human activities, related to agriculture, may also result in unintended consequences
- soil erosion
- soil compaction
- nutrient depletion
- toxicity
- eutrophication



- Design and conduct an experiment to investigate the effects of altering a personally-selected aspect of soil composition or fertility.
- fertilizer type (i.e., percentages of primary nutrients) or amount on plant growth
- fertilizer amount on the growth of algae in water
- pH on plant growth
- growing legumes on nitrogen levels in soils
- mulch type or amount on soil water retention
- sand percentage in soils on drainage.

Trophic Levels

- A *trophic level* is a category of organisms that is defined by how the organisms gain energy in a food chain or web.
- *Primary producers* are organisms, such as plants, that can make their own food.
- Consumers are organisms that cannot make their own food. *Consumers* must eat other organisms to get the matter and energy they need to survive.

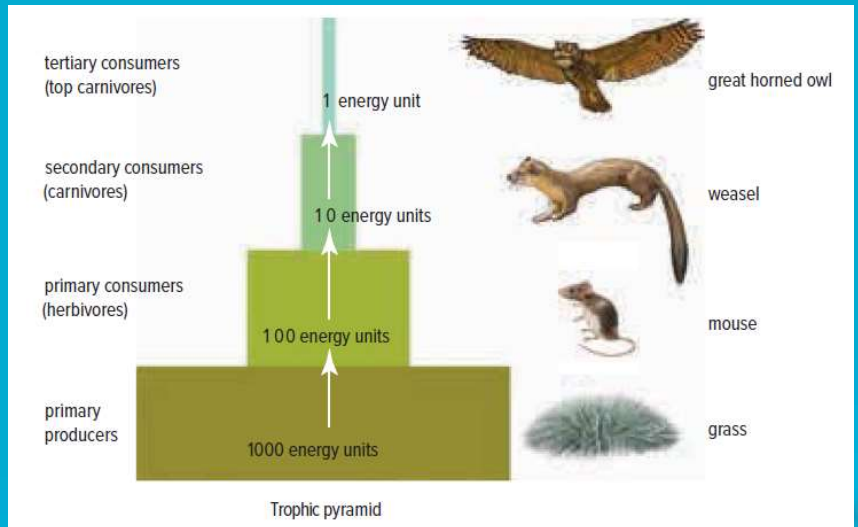
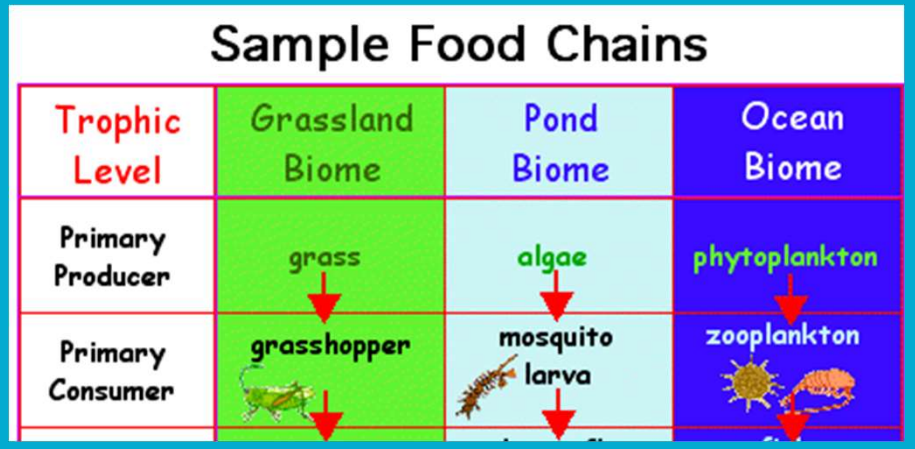


Figure 7.19 Energy that is stored in biomass at one trophic level moves to the next trophic level through a food chain.

- **Primary consumers** are herbivores, feeding on plants. Caterpillars, insects, grasshoppers, termites and hummingbirds are all examples of primary consumers because they only eat autotrophs (plants).



- **Secondary consumers** are any organism that consumes or feeds largely on primary consumers, as well as autotrophs.

Sample Food Chains

Trophic Level	Grassland Biome	Pond Biome	Ocean Biome
Primary Producer	grass	algae	phytoplankton
Primary Consumer	grasshopper	mosquito larva	zooplankton
Secondary Consumer	rat	dragonfly larva	fish

- Tertiary consumers are usually at the top of food chains.
- They are capable of feeding on secondary consumers and primary consumers.
- Tertiary consumers can be either fully carnivorous or omnivorous.

Sample Food Chains

Trophic Level	Grassland Biome	Pond Biome	Ocean Biome
Primary Producer	grass	algae	phytoplankton
Primary Consumer	grasshopper	mosquito larva	zooplankton
Secondary Consumer	rat	dragonfly larva	fish
Tertiary Consumer	snake	fish	seal

- A quaternary consumer is simply consumer which preys upon a tertiary consumer. To be classed a quaternary consumer within a food chain or food web, there must be a tertiary consumer available for the quaternary consumer to prey upon.

- Examples of quaternary consumers include lions, wolves, polar bears, humans, and hawks.

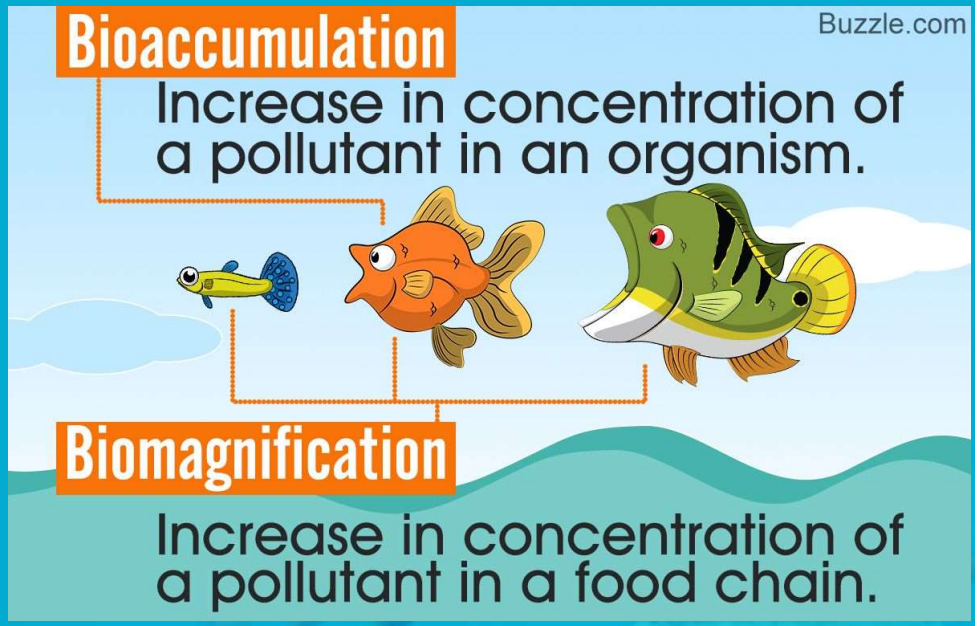
Sample Food Chains

Trophic Level	Grassland Biome	Pond Biome	Ocean Biome
Primary Producer	grass	algae	phytoplankton
Primary Consumer	grasshopper	mosquito larva	zooplankton
Secondary Consumer	rat	dragonfly larva	fish
Tertiary Consumer	snake	fish	seal
Quaternary Consumer	hawk	raccoon	white shark

Bioaccumulation vs Biomagnification

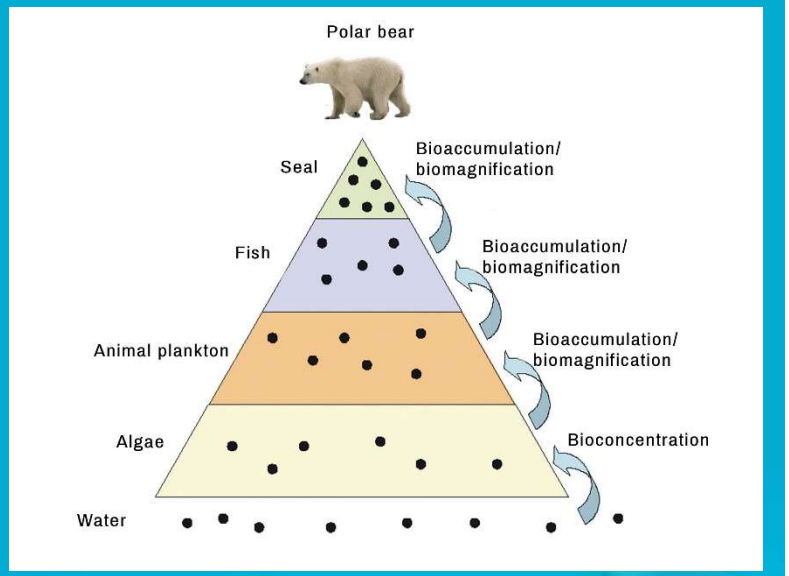
- **bioaccumulation** a process in which matter, especially toxins, is ingested by an organism at a rate greater than it is eliminated when it enters a food chain

- **biomagnification** the increase in the concentration of a toxin as it moves from one trophic level to the next



Effects on Trophic Levels

- Bioaccumulation for a polar bear (a carnivore) would result if the polar bear consumes multiple seals that have a pollutant. The pollutant would build up in the polar bear the more seals the animal consumed. The same is true for a herbivore. If a giraffe consumes multiples leaves that have been sprayed with a pollutant, the more leaves the giraffe consumes, the more of the pollutant will build up in the giraffe.
- The amount of biomagnification that occurs is going to depend in part on how many trophic levels are involved.



DDT

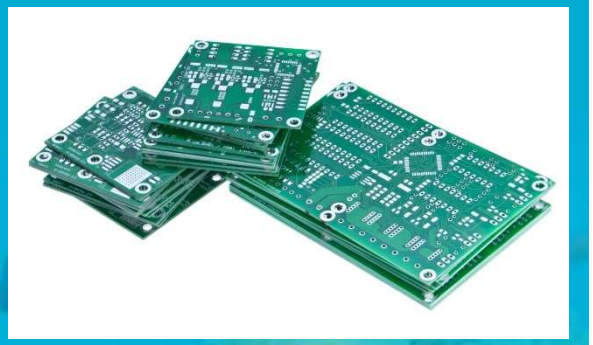
- DDT (dichlorodiphenyltrichloroethane) is an agricultural insecticide that was once used in North America. When DDT entered aquatic ecosystems in run-off from land, it was absorbed by algae. Microscopic animals ate the algae, and small fish ate the microscopic animals.
- At each trophic level, the concentration of DDT in the tissues of the organisms was magnified.
- At high concentrations, the DDT affected reproduction in fish-eating birds by causing egg shells to be thin and crack.
- Following the ban on DDT in the 1970s, populations of DDT-vulnerable birds slowly increased in numbers in Canada.

Normal Egg

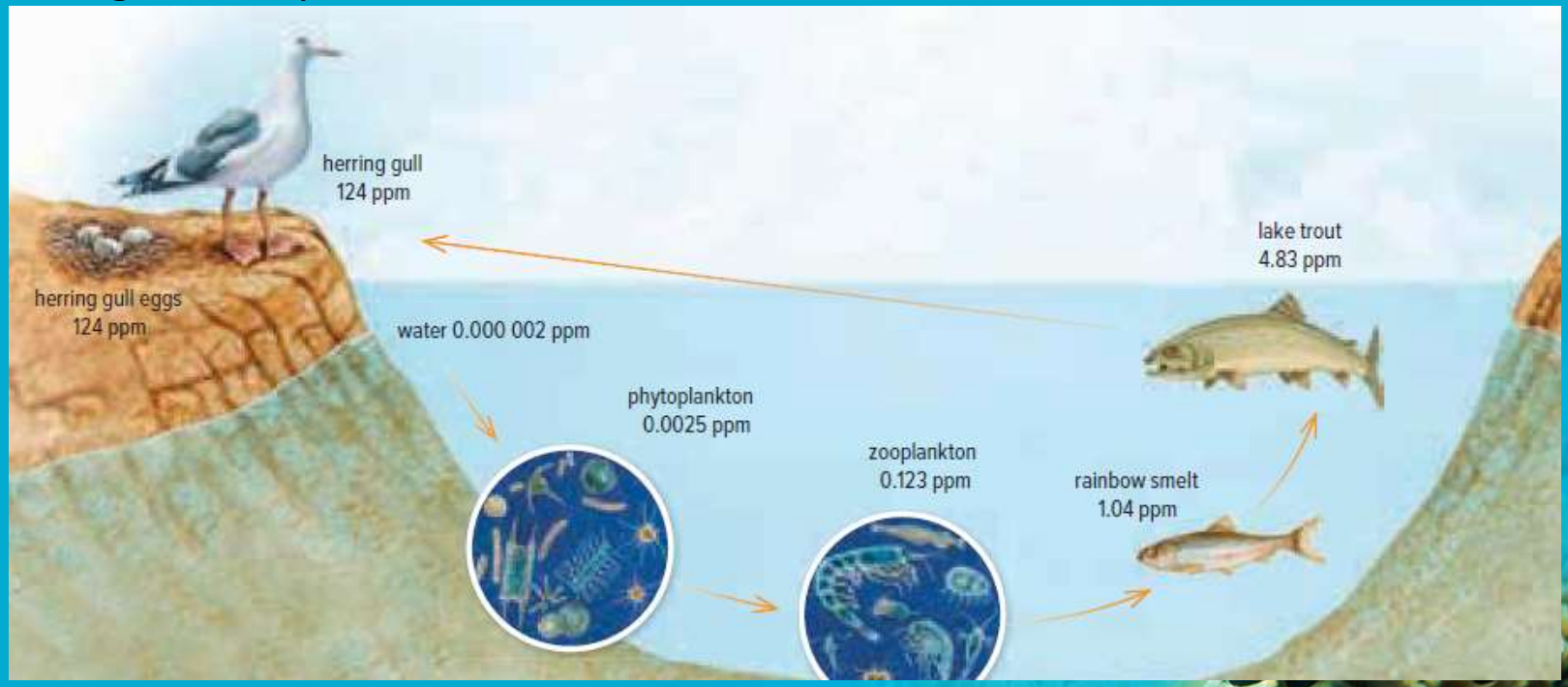
DDT Exposure

PCBs

- PCBs (polychlorinated biphenyls) are industrial chemicals that entered water, air, and soil while they were being used and disposed of. They were once widely deployed as coolant fluids in electrical apparatus, carbonless copy paper and in heat transfer fluids.
- Peregrine falcons were affected by both DDT and PCBs. Peregrine falcons were brought back from the brink of extinction by having captive birds produce young.
- There are 60 to 70 nest sites in the province, located along the coasts and major rivers of Labrador. More than 500 nesting pairs have been observed throughout Canada since the PCB ban.

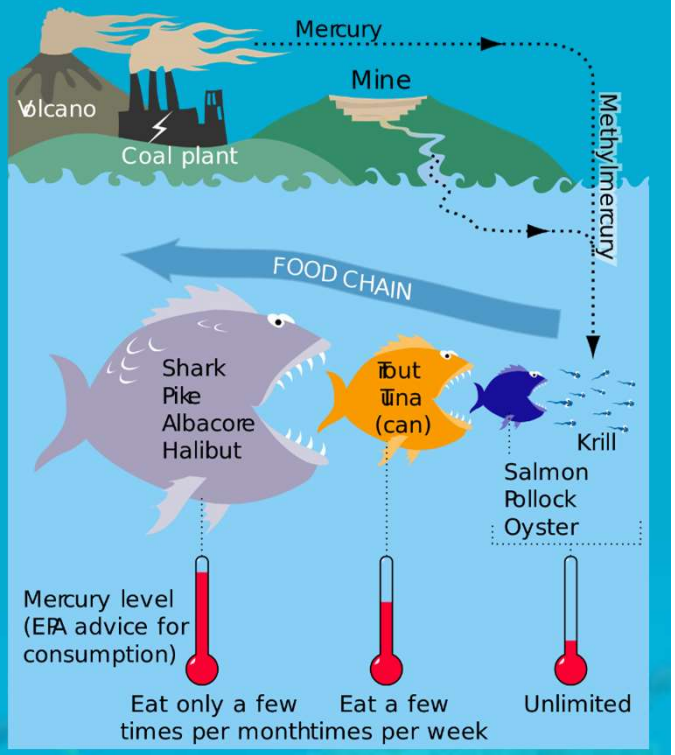


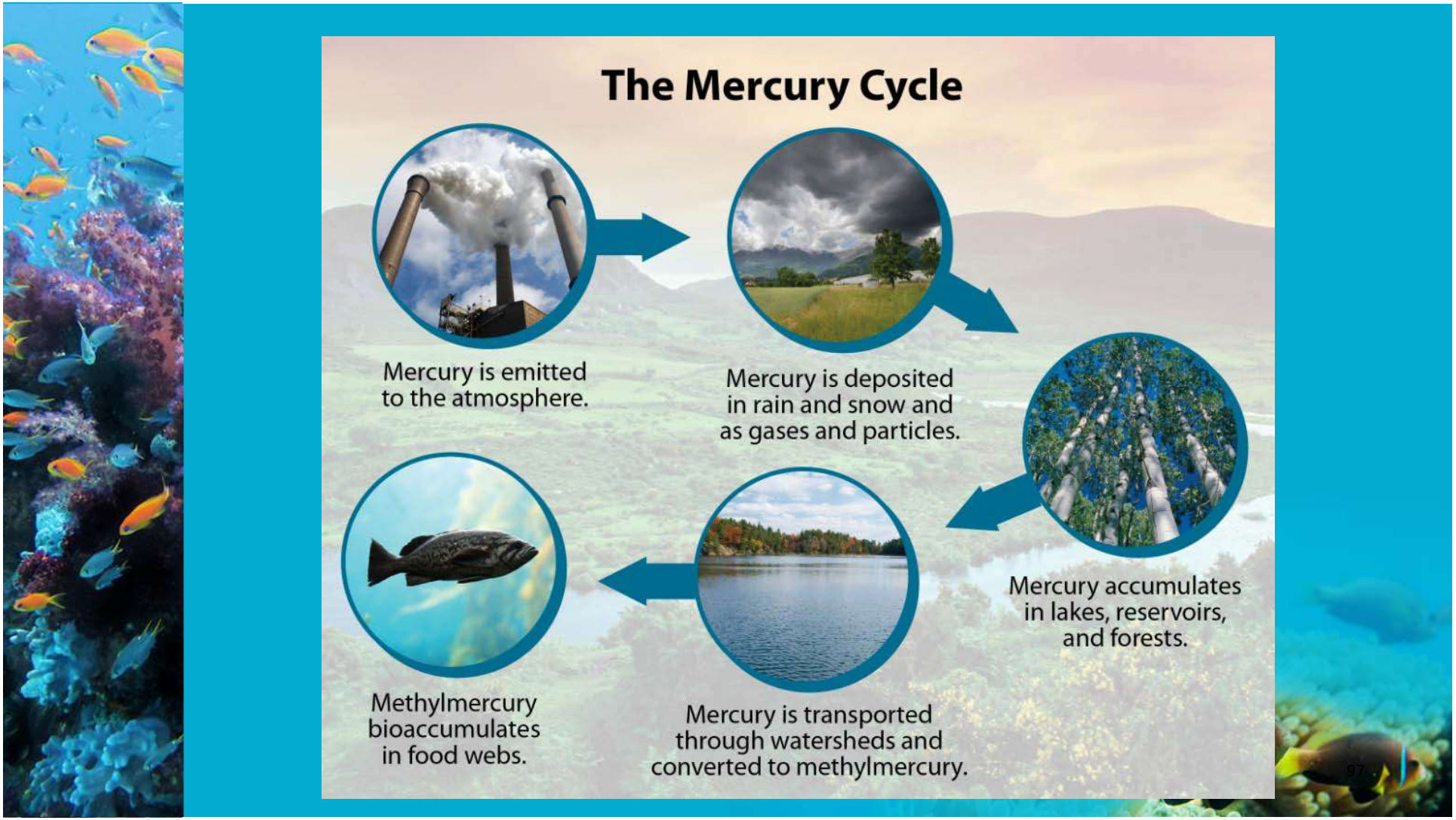
- The concentration of PCBs in the tissues of organisms magnifies at each trophic level. The greatest health problems show up at the highest trophic levels.



Mercury

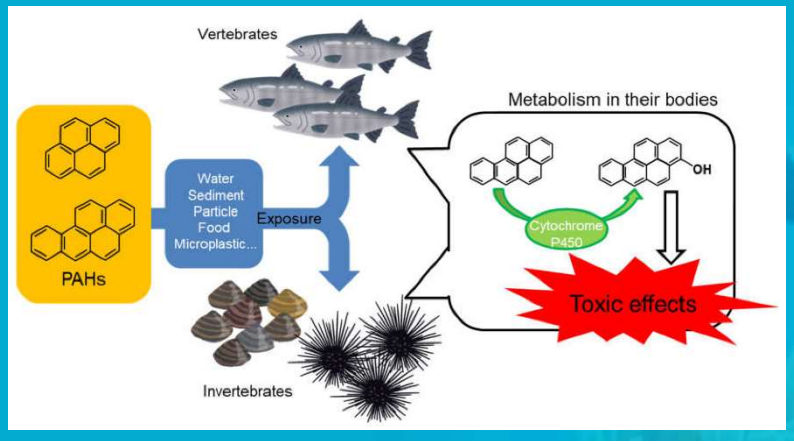
- When released into the environment, it accumulates in water laid sediments where it converts into toxic methylmercury and enters the food chain.
- Mercury, which can adversely alter the neurological and reproductive systems of humans and wildlife, has long been known to contaminate fresh-water lakes, fish and fish-eating birds, including loons and eagles.
- Levels of mercury in the environment are increasing due to discharge from burning fossil fuels, hydroelectric dams, mining, pulp, and paper industries.




The Mercury Cycle
Mercury is emitted to the atmosphere.
Mercury is deposited in rain and snow and as gases and particles.
Mercury accumulates in lakes, reservoirs, and forests.
Mercury is transported through watersheds and converted to methylmercury.
Methylmercury bioaccumulates in food webs.

PAHs

- **Polycyclic aromatic hydrocarbons (PAHs)** are a class of chemicals that occur naturally in coal, crude oil, and gasoline. They also are produced when coal, oil, gas, wood, garbage, and tobacco are burned.
- Long-term health effects of exposure to PAHs may include cataracts, kidney and liver damage, and jaundice. Repeated skin contact to the PAH naphthalene can result in redness and inflammation of the skin. Breathing or swallowing large amounts of naphthalene can cause the breakdown of red blood cells.



- Science Watch Pollution in the North

Research Project

- Investigate and analyze the impact of external factors
- changing climate, human activities [deforestation, draining wetlands, industry, introduction of non-native species, overexploitation, pollution]) on the sustainability of local ecosystems
- Select a local ecosystem
  - Arctic, freshwater, forests, or oceans.
- identify external factors affecting the ecosystem
- collect and analyze information on their topic
- compile and display their information, in an appropriate format, to communicate how their selected ecosystem is impacted by external factors

Ecosystem Services

- **ecosystem services** the benefits sustainable ecosystems provide that are experienced by living organisms, including humans

Ecosystem Services

Supporting

-Soil formation
-Biodiversity
-Primary production
-Habitat

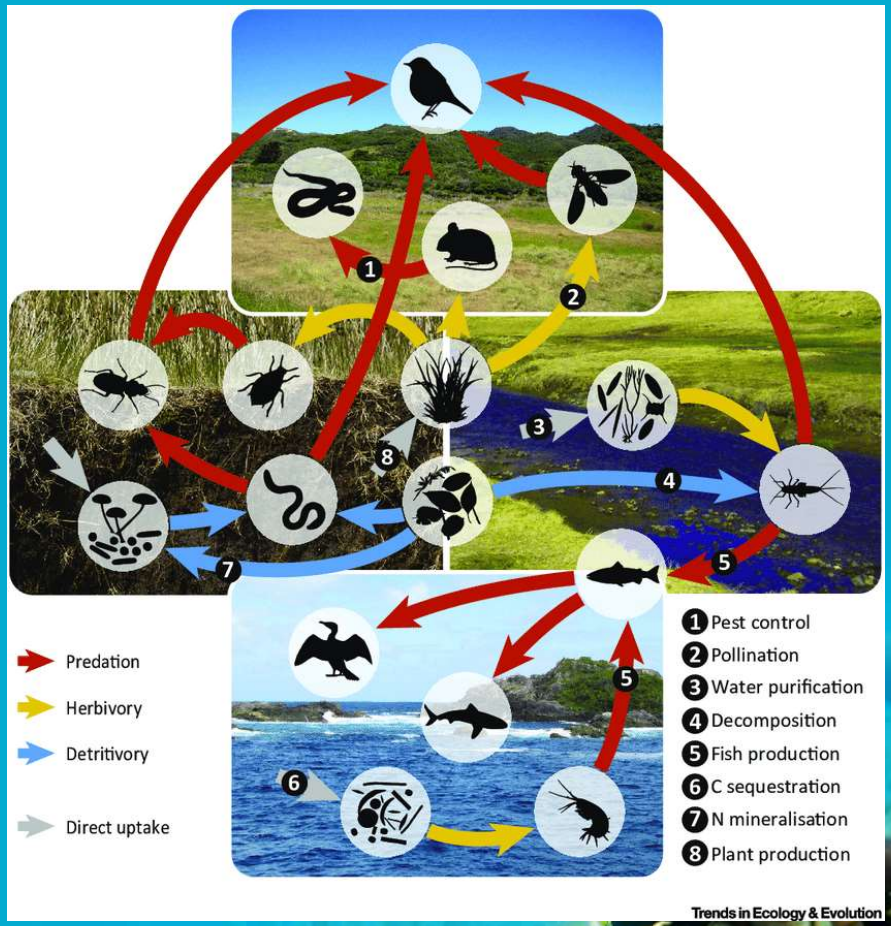
Provisioning
-Food and fiber
-Wood
-Clean Water
-Medicinals

Regulating
-Climate Regulation
-Pollination of crops
-Store carbon
-Control flooding

Cultural
-Inspiration
-Recreation
-Education
-Aesthetic

Ecosystem Services Provided by Forests

- Forests take up carbon dioxide, release oxygen, and maintain soil fertility.
- Forests also perform many other ecosystem services, such as influencing climate, acting as stores for carbon dioxide, reducing erosion in watersheds, and providing a habitat for thousands of species.



Ecosystem Services Provided by Wetlands

- Wetlands store water, reducing risk of floods, and provide habitat for commercially important species of fish and shellfish.
- Wetlands are protected spaces for juvenile animals to develop. Each spring and fall, migrating birds use wetlands to feed and rest. bout one-third of North American birds stop in Canada's wetlands.
- Wetland plants filter sediment and pollution from water.

Ecosystem Services Provided by Insects

- Insects break down dead wood, animal carcasses, and feces. This releases and helps cycle nutrients in ecosystems.
- Insects are a protein-rich food source for many organisms (including humans).
- Insects disperse seeds in and among ecosystems.
- Insects play an essential role in plant reproduction through their role as pollinators.

- Activity 8-1A: A land Development Proposal for Barry's Bog

Biodiversity and Sustainability

- **biodiversity** the variety of species and ecosystems in a region

- **resilience** the ability of an ecosystem to remain functional and stable in the presence of disturbances to its parts

Evidence of Relationship Between Biodiversity and Resilience

- Scientists conducted long-term experiments using many growing plots, each with a specific number of native plant species, ranging from 1 to 24
- In all cases, the more species present in the plot, the more efficient the ecosystem.
- The more diverse plots were better able to resist the invasion of non-native species and exhibited reduced disease.

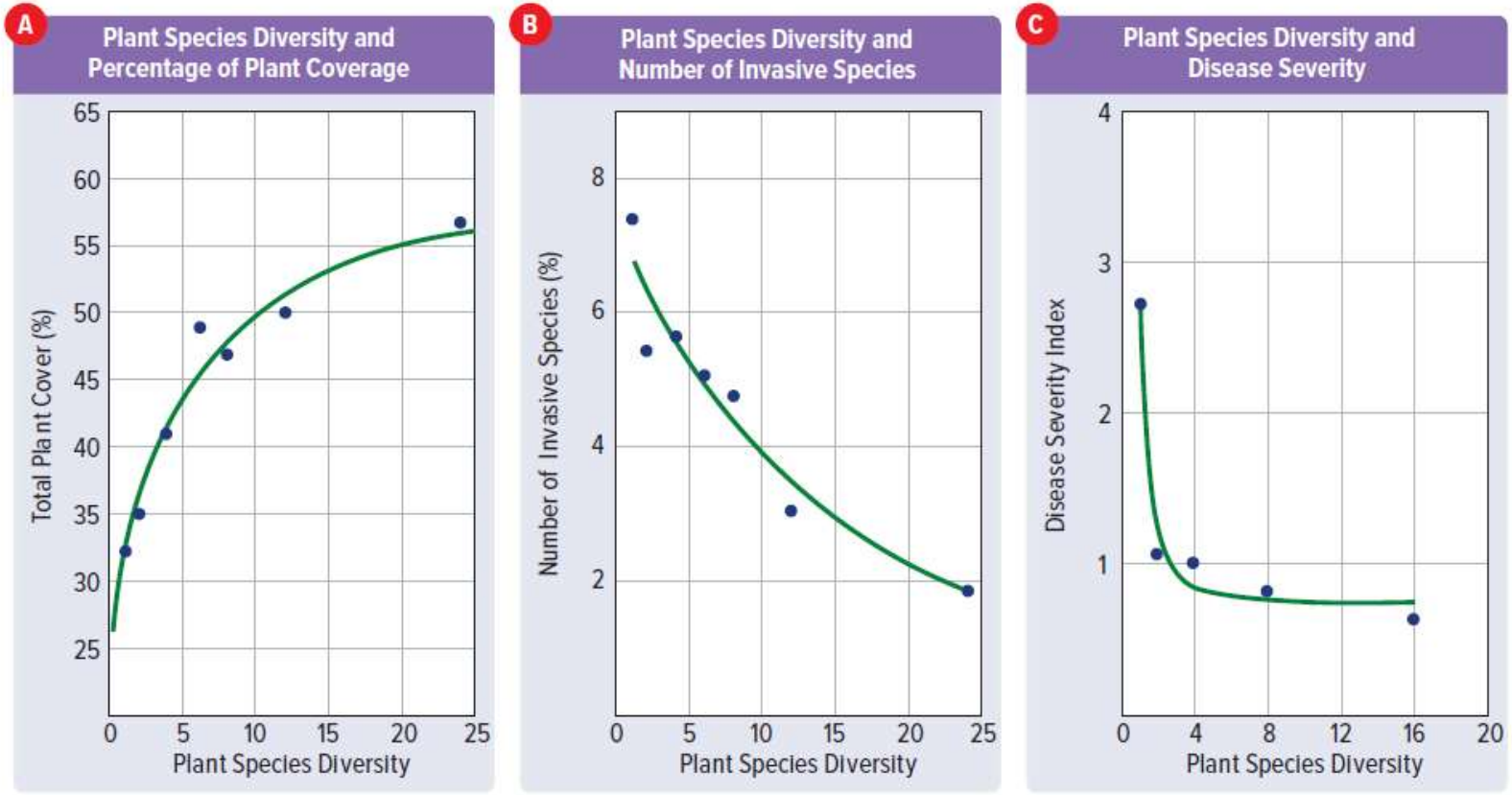


Figure 8.8 In experiments conducted at the University of Minnesota from 1982 to 1993, researchers concluded that greater biodiversity in an ecosystem results in at least three beneficial patterns: increased plant cover, more resistance to invasive species, and more disease resistance.

Ecosystem Stresses

- Ecosystems became "stressed" when their natural structure and processes are changed.
- Stressors may be physical, chemical or biological.
- Stress is common when resources and organisms are removed from or added to ecosystems, and when essential processes are changed.
- Sometimes they are unable to fully recover from imposed stresses.

Types of Stress

- Physical
- This is a type of ecological disturbance because of its acute, episodic nature. Examples include volcanic eruptions, windstorms, and explosions.
- Can be long term or short term

- Wildfire is a disturbance, during which much of the biomass of an ecosystem is combusted, and the dominant species may be killed.
- Can be long term or short term

- Pollution
- Toxic pollution in concentrations large enough to affect organisms and thereby cause ecological changes.
- Phosphate and nitrate can influence productivity and other ecological processes, causing a type of pollution known as eutrophication.
- Usually causes long term changes

- Exotic species, alien, nonnative or non-indigenous species - Species introduced to new habitats from places outside of where they are naturally found

- Invasive species a species that can take over the habitat of native species.
- threaten the sustainability of ecosystems and their services.

Table 8.1 Examples of Invasive Species in Newfoundland and Labrador

Some Invasive Species in both Newfoundland and Labrador	Invasive Species in Labrador	Some Invasive Species in Newfoundland
cabbage white butterfly	muskox	black knapweed
Canada thistle		fir coneworm
European green crab		mink
house sparrow		moose
Japanese knotweed		golden star tunicate
purple loosestrife		water scavenger beetle
rock dove		wood frog

- Activity 8-1c Newfoundland and Labradors Most Wanted

Overexploitation

- **overexploitation** the use or extraction of a resource until it is depleted

- Overexploitation can lead to dangerously low population numbers, if not the complete disappearance of a species.

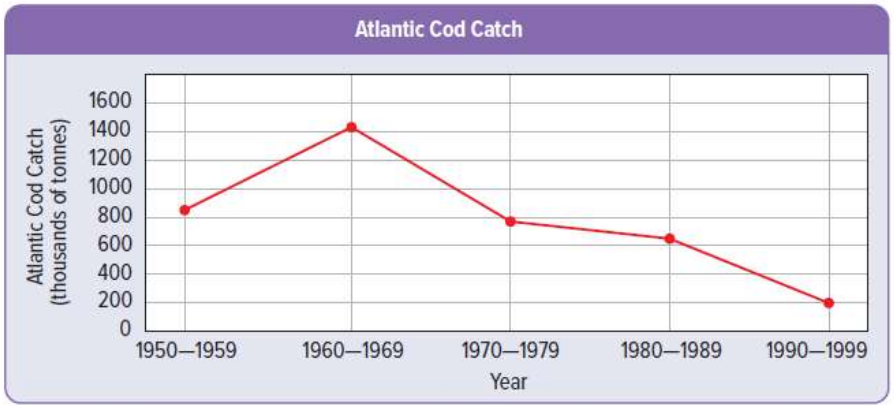


Figure 8.10 The reduced catch of Atlantic cod reflects a decrease in population as a result of overexploitation.

- **Threatened Species**
- The term "threatened" is not a category in itself but an umbrella term to encompass all three of their levels of most concern:
- Vulnerable
- Endangered
- Critically endangered

- Vulnerable Species
- A species classified as vulnerable faces threats, like loss of habitat and poaching, in the wild that may cause it to go extinct.

- Polar Bear

- Endangered Species
- populations are in severe decline and are at risk for extinctions based on several factors, such as pollution, deforestation and hunting.

- Woodland Caribou

- Critically endangered species are those that are almost extinct in the wild. Their numbers have become so few that they may have trouble breeding to keep the entire species viable without help from conservationists. In other words, they cannot find mates to produce young, or they take such a long time to mature that they often die before they can reproduce.
- Blue Whale

Recovery in Ecosystems

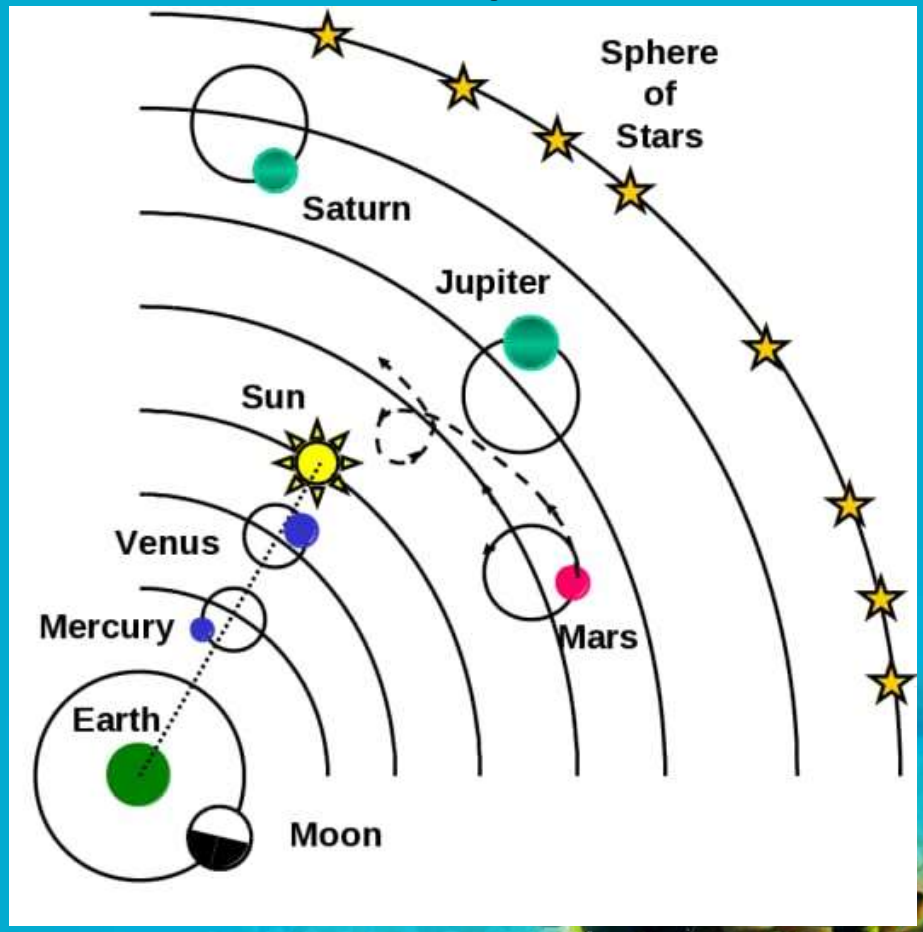
- The first priority is to identify the stressors and then reduce them to levels at which the ecosystem can recover.
- This may occur naturally ever an extended time frame, perhaps hundreds or thousands of years, or more rapidly through human intervention.
- An important aim should be to help the establishment of a self-renewing, self-regulating, productive ecosystem that satisfies human needs but not human greed's.

- Science Watch – Restoration Ecology page 331

The Shift Is On—Attitude, Actions, and Empowerment

- **paradigm** a view of the world or a way of thinking about how the world works

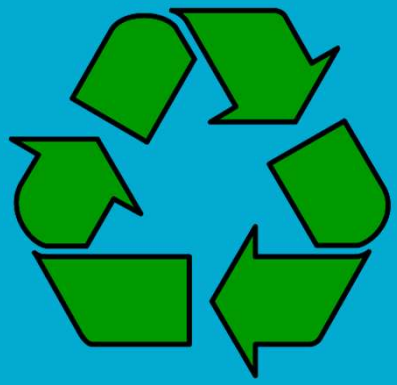
- **paradigm shift** a significant change in the way humans view the world



- How did pictures from space change this way of thinking?
- Saudi astronaut Sultan bin Salman bin Abdulaziz Al Saud put it this way, as the Space Shuttle *Discovery* carried him and six others away from Earth in 1985: "The first day or so we all pointed to our countries. The third or fourth day we were pointing to our continents. By the fifth day, we were aware of only one Earth." We began to see an Earth where everything is connected.

Current Paradigm Shift

- The shift involves the way people view the sustainability of ecosystems and the use of resources on Earth.



- The shift involves the way people think about the consequences of our actions and how our actions affect our ecosystems and all of Earth's systems

- People are starting to see that ecosystems and Earth's systems are connected and that a change made to one system can have effects, sometimes far-reaching, in another system.

Evidence of Paradigm Shift

- **Millennium Ecosystem Assessment (MA)**

- This international effort began in 2001, when more than 1300 scientists worldwide collected data to assess the conditions and trends in ecosystems and ecosystem services, and to report on ways to conserve or increase sustainable use of ecosystems.

- **Amending Phosphorus Concentration Regulations**
- Environment Canada adopted a national standard to ban phosphorus from household cleaners and household dishwashing and laundry detergents in 2010.
- Scientists estimate that a 10 percent reduction of phosphorus run-off into lakes and other aquatic ecosystems can result by removing phosphorus from dishwasher detergents alone.
- With the ban in place, the reduced phosphorus run-off could result in fewer harmful algal blooms in aquatic ecosystems.

- **Climate Change Action Plan**
- Implemented in 2011, The province of Newfoundland and Labrador's Climate Change Action Plan.
- Reduce greenhouse gas emissions by at least 10 percent from 1990 levels by 2020 by promoting greater energy efficiency, generating even more electricity from renewable resources, and embracing a green economy, which includes cleaner transportation, increasing recycling, and conducting energy audits, and promoting public transit and bicycling in areas where it is feasible.
- Prepare for changes in temperature and precipitation trends, changes in weather events, and sea-level rise due to global climate change.

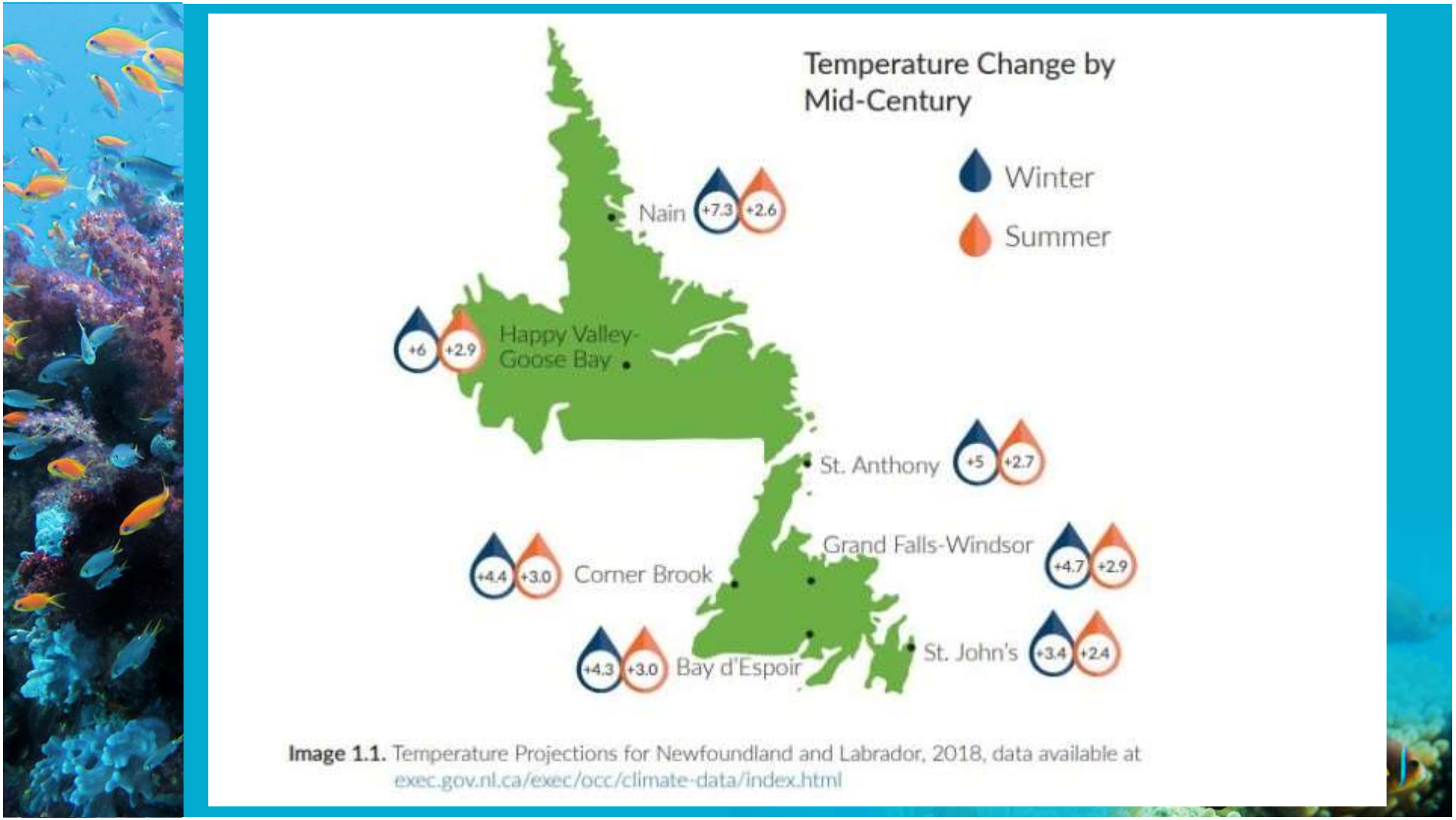


Image 1.1. Temperature Projections for Newfoundland and Labrador, 2018, data available at exec.gov.nl.ca/exec/occ/climate-data/index.html

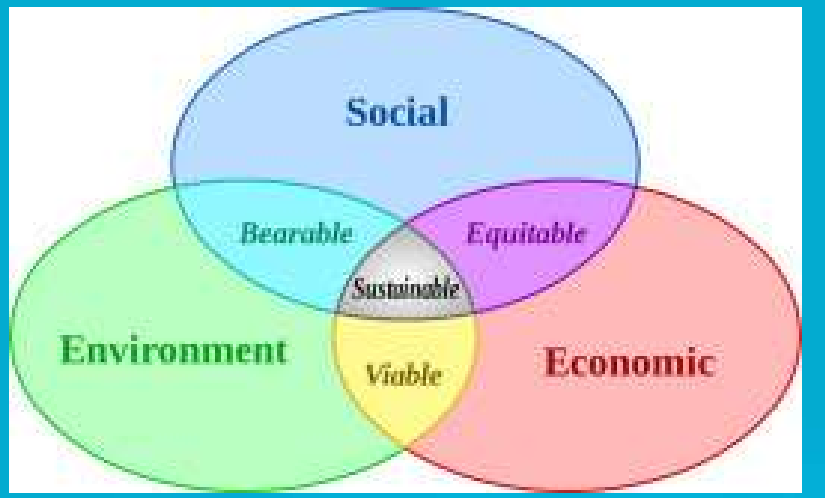
- **Qalipu Natural Resources Division**
- researches and monitors species such as woodland caribou, eels, Atlantic salmon, and green crabs, runs a Fisheries Enforcement Program, and has local Community/Youth Engagement programs in an effort to promote the sustainable use of resources.

Qalipu
FIRST NATION

- 8-2A Funding Canadian Research Projects 338

Risk vs Benefit of Technology

- Aquaculture
- Antibiotic use in livestock farming
- Herbicides or pesticides
- Hydroelectric power generation
- Microbead (plastic) use in hygiene products
- Sonar and seismic testing.



Aquaculture Benefits

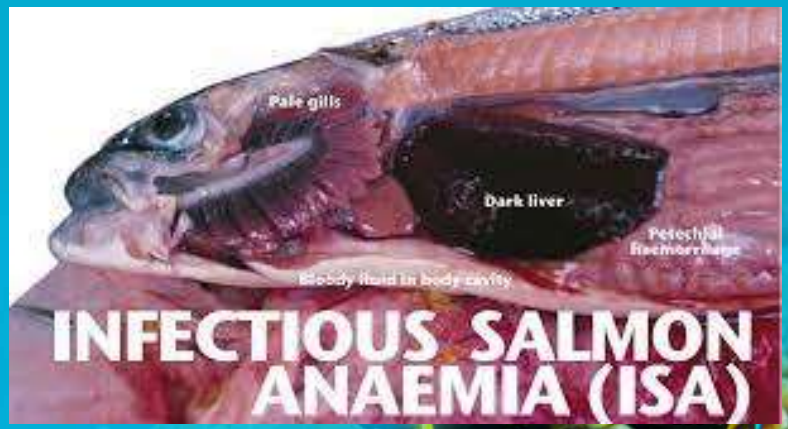
- Economic: US aquaculture production is near $900 million annually, the US Department of Commerce hopes to increase this to $5 billion by 2025.
- Social: Aquaculture has the potential to provide those fishermen put out of work as well as new recruits with a job in aquaculture.
- Dietary needs: Cheaper for many Americans to obtain the health benefits of a diet with a sufficient fish component.

Aquaculture Benefits Cont

- Environmental: decrease the pressure on wild fish stocks, provided that market demand for famed fish is as great as the demand for wild fish.
- A potentially less harmful fishing technique: There has been some suggestion that fish farming may have less harmful impact on the ecosystem than some particularly deleterious fishing techniques, such as ocean trawling that damages the ocean substrate and has high rates of bycatch.

Aquaculture Risks

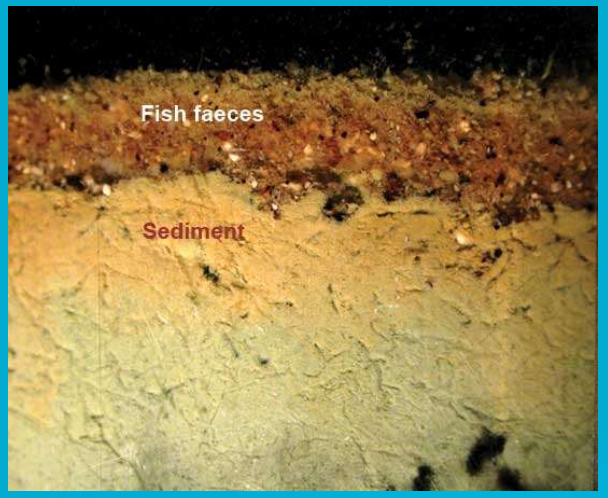
- **Disease and Sea Lice:** When any type of organism is confined in high density the spread of disease and parasites can become more rapid.



Aquaculture Risks cont

- **Pollution from Aquaculture:** Sedimentation of feces and uneaten fish feed can add large quantities of nutrient-rich organic matter into the sea (marine or coastal pens), rivers (raceways) or soil (inland ponds).

- **Increased Fishing Pressure on Wild Stocks:** Many farmed fish are carnivorous species that require more feed products than can be supported from natural food sources either growing within or passing through fish ponds or pens.



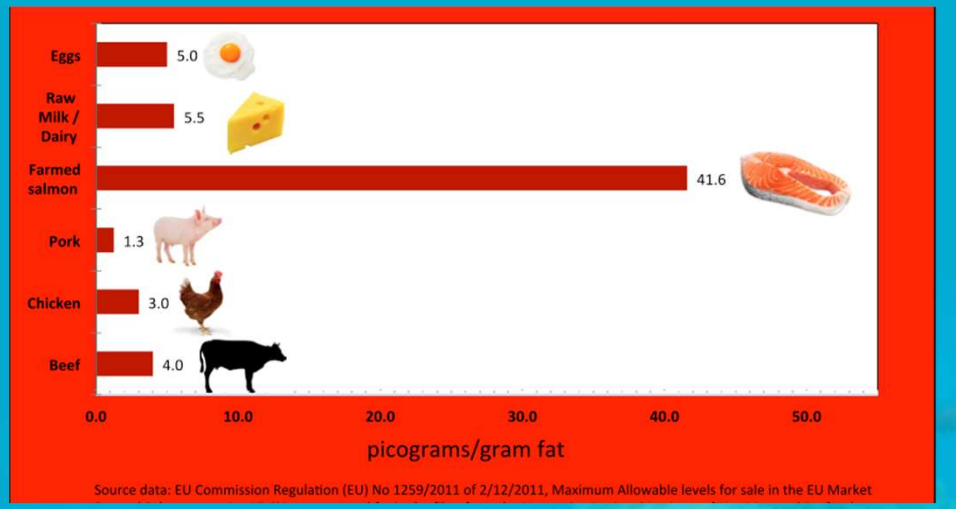
- **Escaped Farmed Fish = Invasive Species:** In the United States and abroad, aquaculture has become a leading vector of aquatic invasive species worldwide introducing unwanted seaweeds, fish, invertebrates, parasites, and pathogens.

- **Spread of Sea Lice to Wild Fish:** A growing number of scientific studies are reporting on the movement of sea lice from farmed salmon stocks to wild salmon stocks.

Aquaculture Risks cont

- **Health effects from farmed fish consumption:**
- Bioaccumulation of toxins in Salmon: Not only are farmed salmon artificially colored, higher in fat and lower on Omega-3 fatty acids than their wild counterparts, but a new report showed elevated levels of PCBs and other toxins in farmed stocks.

- EU graphic of the concentration of dioxins, PCBs, etc. in farmed fish:



Benefits of Antibiotic Use in Livestock Farming

- Animals receiving antibiotics in their feed gain 4% to 5% more body weight than animals that do not receive antibiotics.
- Antibiotics are used for treatment of animal disease and/or disease prevention.
- Livestock treated with antibiotics live longer than those who are not treated.
- The shelf life is extended for meat, poultry, eggs, and dairy products when treated with antibiotics.

Risks of Antibiotic Use in Livestock Farming

- Using antibiotics in animals may increase the risk of transmitting drug-resistant bacteria to humans either by direct infection or by transferring resistant genes from agriculture into human pathogens.

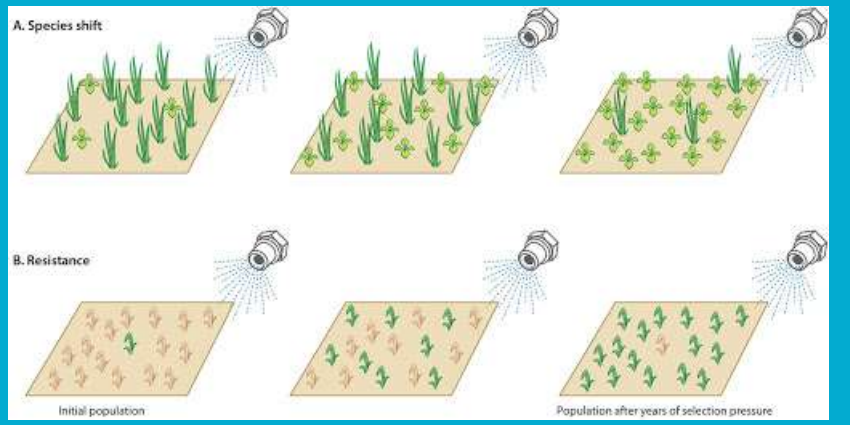
Benefits of Herbicides or Pesticides

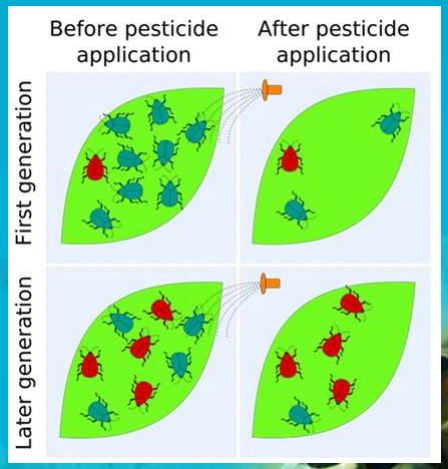
- Crop Yield: weeds compete with crops for water, sunlight and nutrients in the soil. Using herbicides eliminate this competition to allow for greater crop yield, fewer food shortages and lower food prices. Pesticides kill pests that eat the crops.
- Economic Benefits: use of herbicides provides a $16 billion boost to farmers in the United States each year. Herbicides cut weed control costs by $10 billion, including more than $1 billion in savings in hand weeding alone.
- Beautiful Landscaping: While it's tough to put a price on a well-manicured golf course or a blooming garden, these types of beautiful landscapes offer benefits of their own.

Risks of Herbicides or Pesticides

- Health Effects: Chemical herbicides and pesticides pose health dangers for everyone from field workers to people who buy food grown using these chemicals. Exposure to herbicides/pesticides causes skin irritation, while inhaling these chemicals irritates the throat and nasal passages. Herbicide/pesticide exposure is also linked to non-Hodgkin lymphoma, and even birth defects in unborn babies.

- Increased Resistance: Farmers find that they have to keep using more and more of these chemicals to keep weeds and pests at bay. Weeds/pests demonstrate a remarkable ability to adapt to these chemicals and resist their effects. This resistance increases herbicide/pesticide costs for farmers and results in a larger quantity of herbicides/pesticides in the soil.

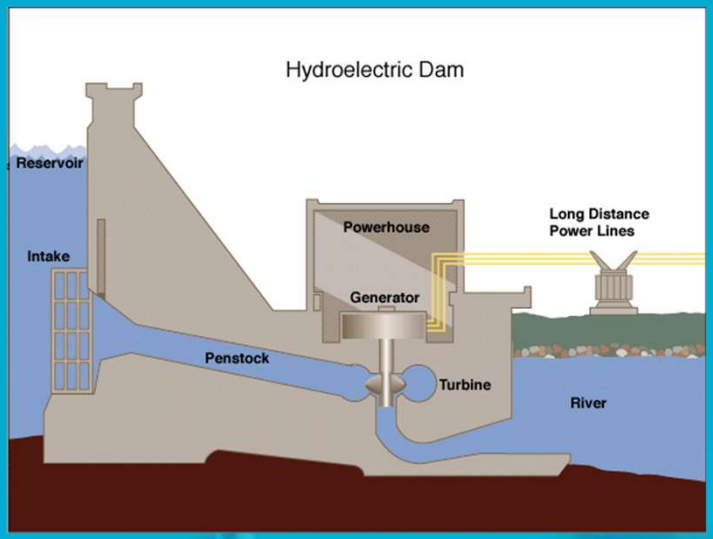




- Pollution: Chemical herbicides contribute to air, water and soil pollution. Not only do they pollute the soil where they have been applied, but rainwater can carry these chemicals to other areas. Some chemical herbicides end up in waterways, where they kill fish and other aquatic life. Chemical herbicides can also evaporate into the air, resulting in air pollution and reduced air quality.

Benefits of Hydroelectric Power Generation

- Hydropower is clean and renewable
- Unlike traditional fossil fuel energy sources, using water to generate electricity doesn't release harmful pollutants into the air or water. While there are some environmental considerations that come with building large hydropower facilities like dams and reservoirs, once operational, hydropower plants themselves don't require burning any fossil fuels.



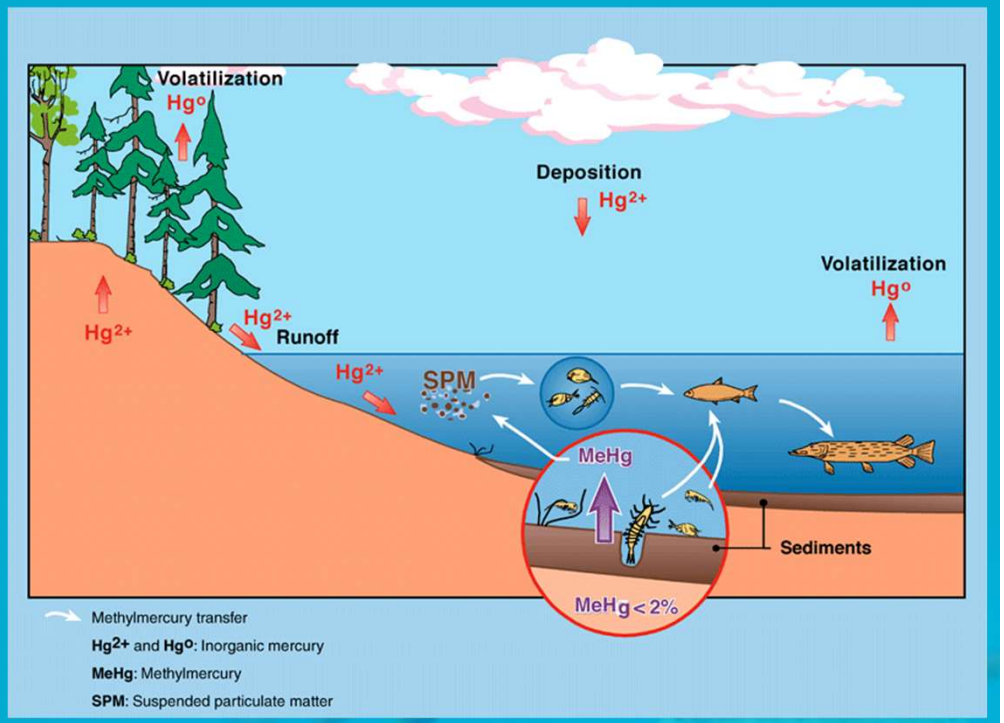
Risks of Hydroelectric Power Generation

- Hydropower plants can adversely affect surrounding environments
- Storage hydropower or pumped storage hydropower systems interrupt the natural flow of a river system. This leads to disrupted animal migration paths, issues with water quality, and human or wildlife displacement.

- Building hydropower facilities is expensive up-front
- Many hydropower plants are large infrastructure projects that involve building a dam, a reservoir, and power-generating turbines. requiring a significant monetary investment. While a large hydropower facility can often provide low-cost electricity for 50 to 100 years after being built, the upfront construction costs can be large.

- Hydropower facilities rely on local hydrology
- Hydropower is a reliable energy source, but it is still ultimately controlled by weather and precipitation trends. Because most hydropower generation relies on river water, droughts that cause lower water flow impact hydroelectric generation capacity.

- Methylmercury: Microbes convert naturally occurring mercury in soils into potent methylmercury when land is flooded, such as when dams are built for hydroelectric projects. The methylmercury moves into the water and animals, magnifying as it moves up the food chain.



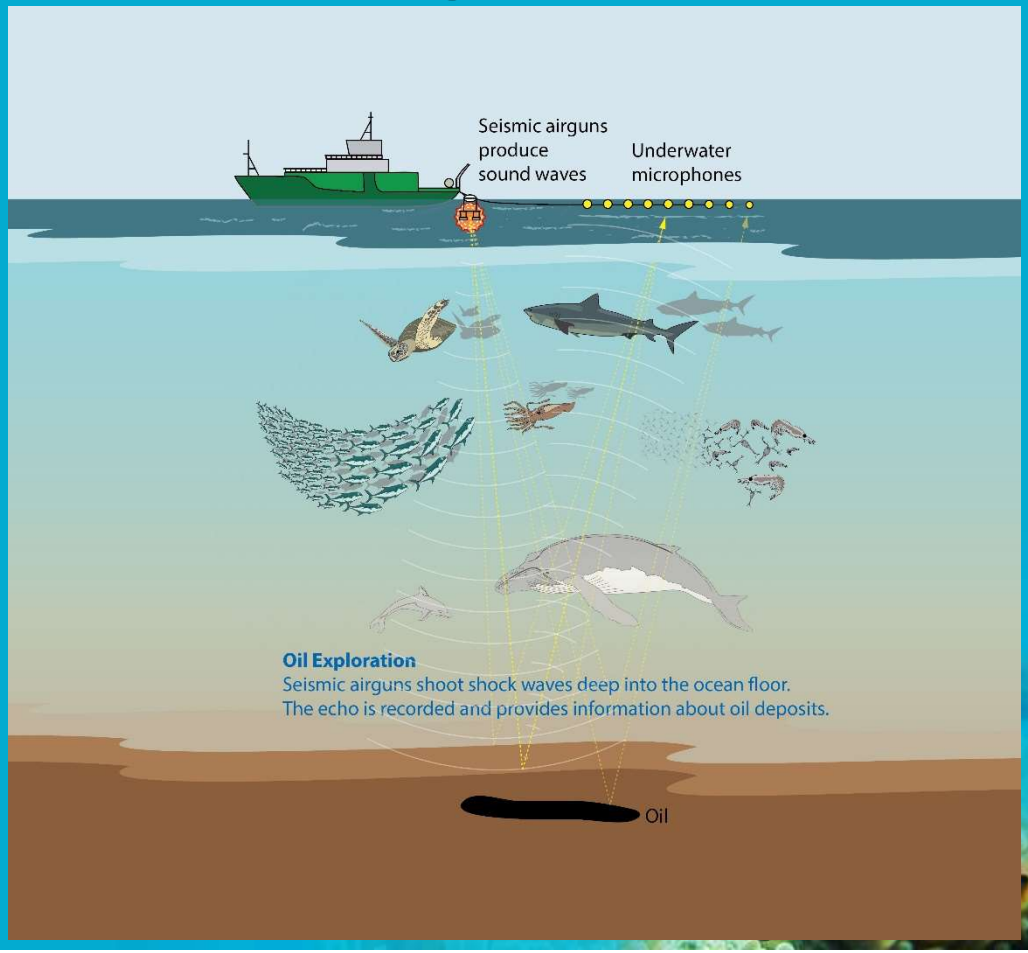
Microbead (plastic) Use in Hygiene Products

- Microbeads are small, solid, manufactured plastic particles that are less than 5mm in diameter and do not degrade or dissolve in water.
- They may be added to a range of products, including rinse-off cosmetic, personal care and cleaning products.
- Microbeads are a relatively cheap ingredient and are used in these products as an abrasive or exfoliant, a bulking agent, to prolong shelf-life, or for the controlled release of active ingredients.

- These tiny plastics persist in the environment and have a damaging effect on marine life, the environment and human health. This is due to their composition, ability to adsorb toxins and potential to transfer up the marine food chain. The best way to reduce the impact of microbeads is to prevent them from entering the environment in the first place.

Sonar and Seismic Testing

- **Seismic Testing**
- According to government estimates, 138,500 whales and dolphins will soon be injured and possibly killed along the east coast of the U.S. if exploration companies are allowed to use dangerous blasts of noise to search for offshore oil and gas.



Sonar and Seismic Testing

- **Sonar Testing**
- Along the entire east coast as well as in Hawaii, Southern California, and the Gulf of Mexico, the Navy plans to test sonar and explosive devices so deafening they cause whales to abandon their normal feeding grounds and migration patterns. The Navy's own report states that more than 40 marine mammal species will be impacted, including the endangered humpback whale and the blue whale.