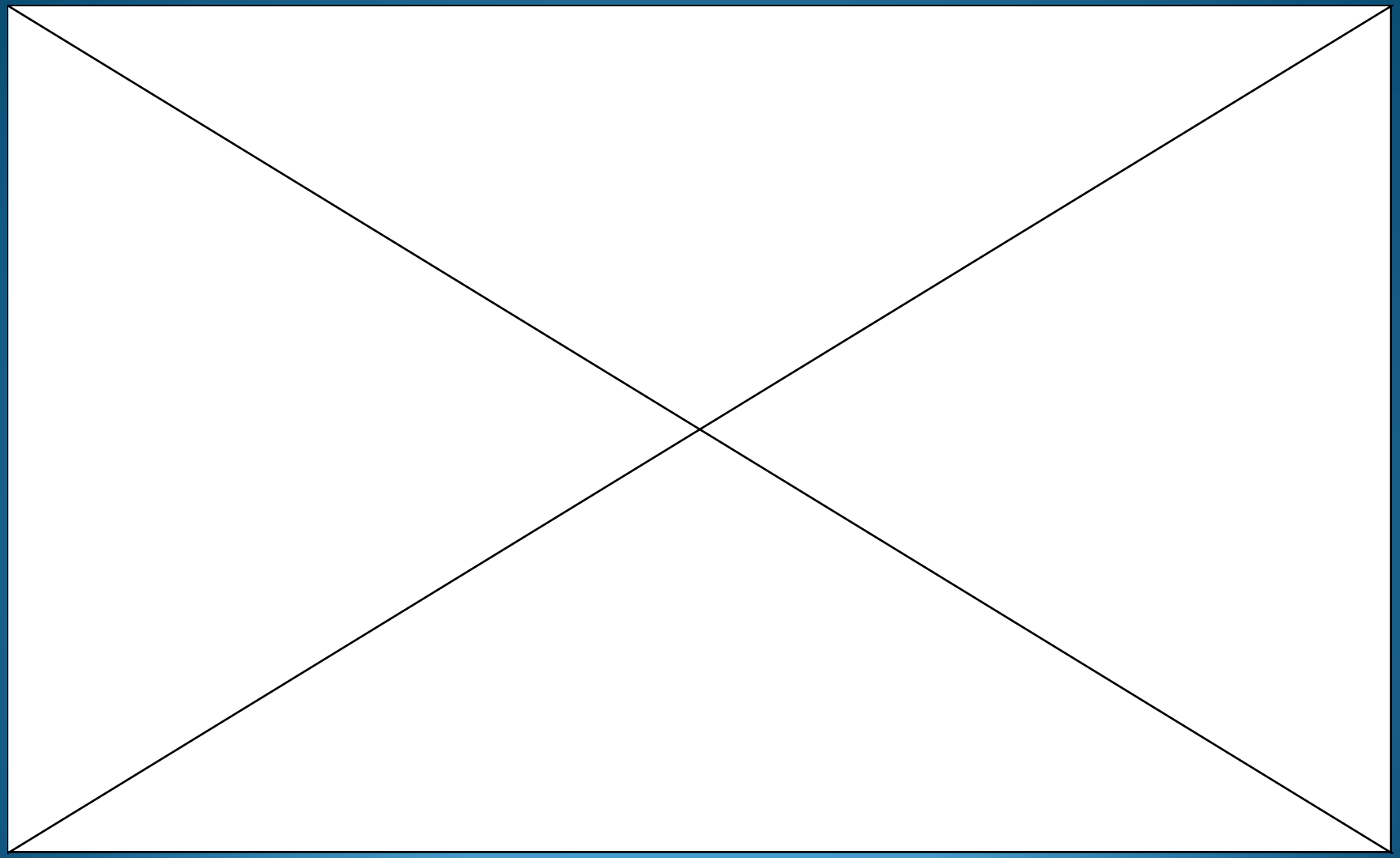
Unit 3: Ecosystems

Photograph by Robert Quinn, 2008 International Photo Contest



What is an Ecosystem?

- **Ecosystem**: The network of relationships formed among plants, animals, and the non-living elements in an environment.

3 types of organisms in an ecosystem

- **Producers**: *Plants* 
  - produce their own food from solar energy (photosynthesis) and from compounds in the soil and atmosphere.
- **Consumers**: *Animals* 
  - must eat plants or other animals for energy to survive.
- **Decomposers:** *Bacteria, fungi, and moulds* 
  - break down wastes into basic chemical compounds and nutrients that can be absorbed by producers.

Food chain

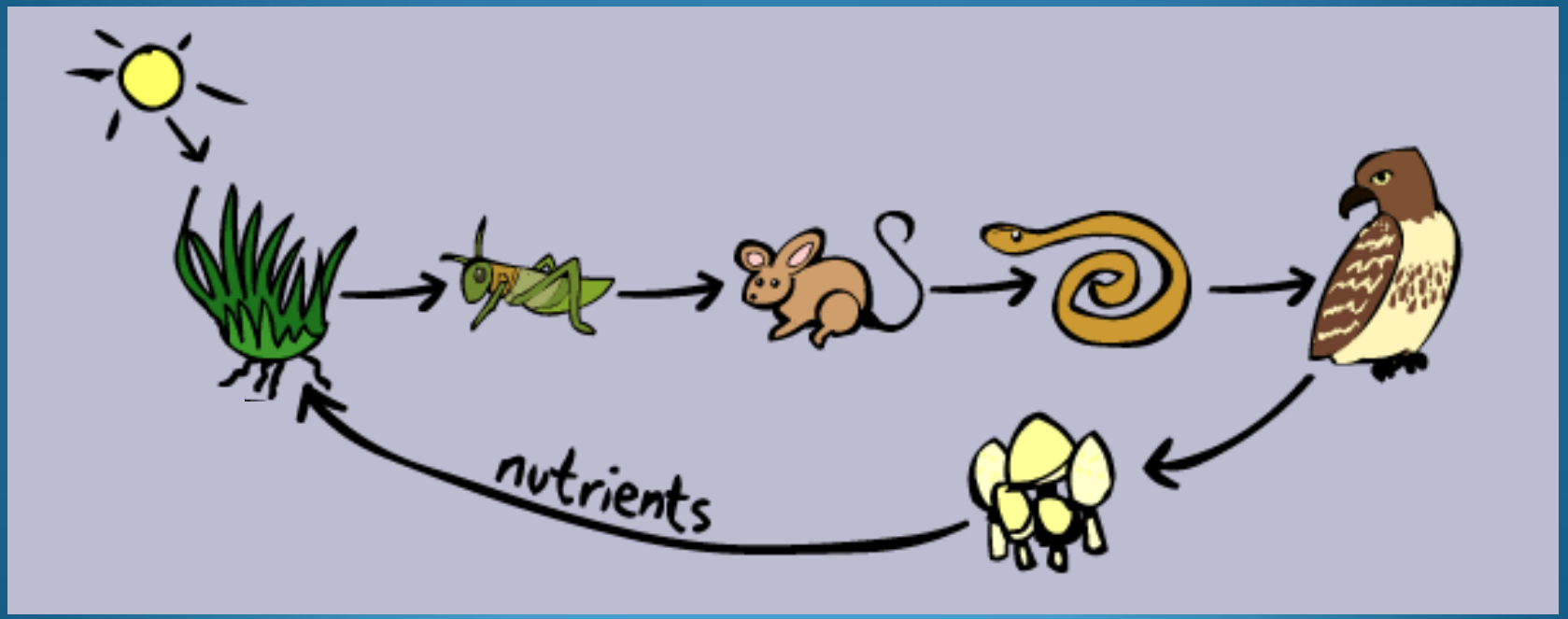
vs.

Food web

- Starting with the Sun sending solar energy to plant producers, and continuing on through every instance of one organism eating another, energy is constantly being transferred (or passed on) through life forms.

Food Chain

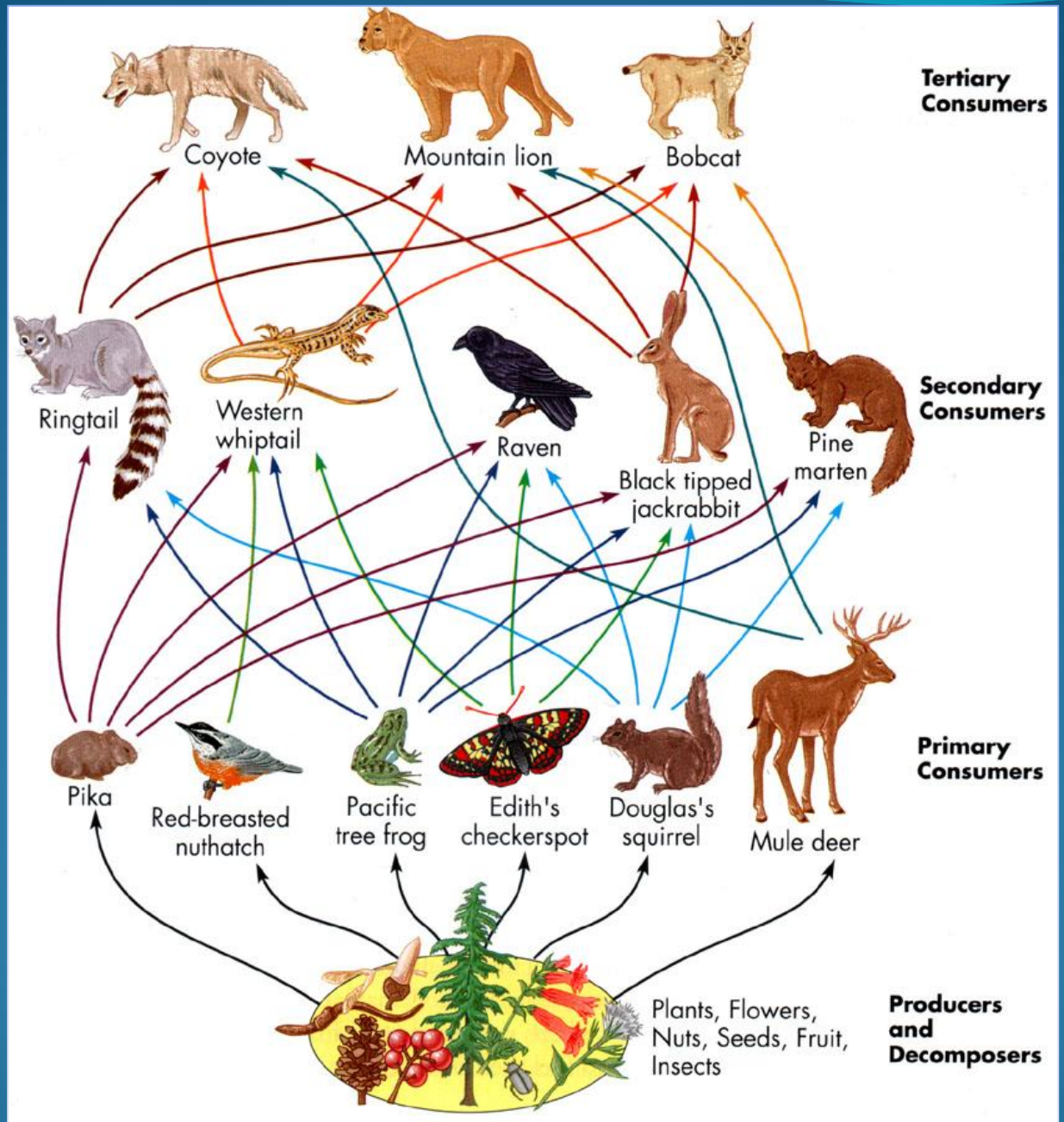
- A **food chain** follows *the specific* link of the transfer of energy from one organism being consumed by another.



Food Web

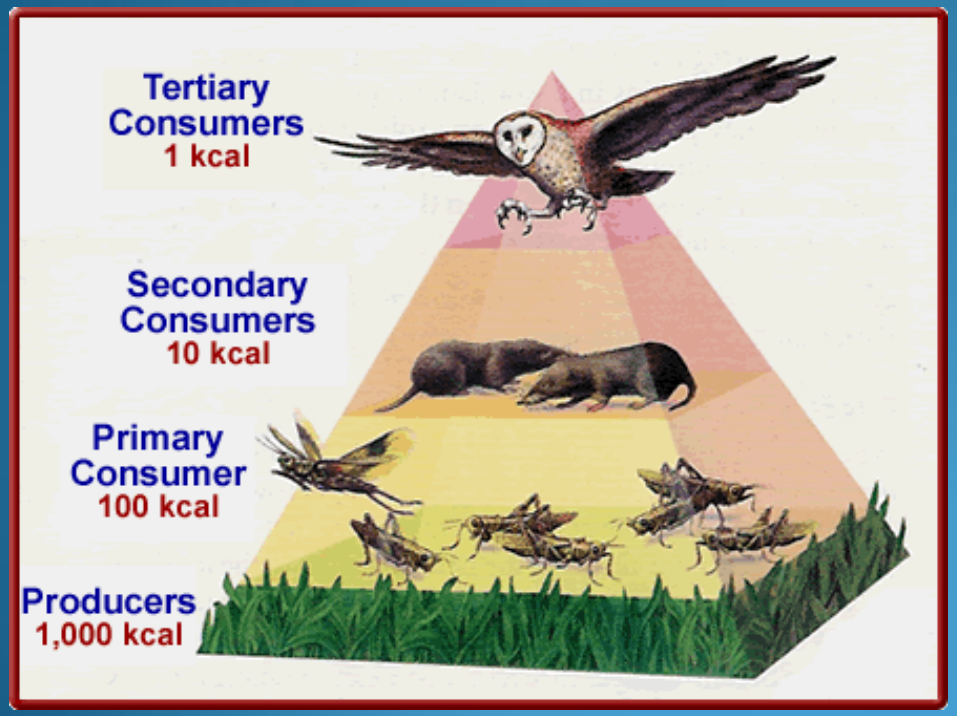
- In most ecosystems, there are many overlapping food chains because organisms draw from multiple food sources.
- Organisms participate in the food chain of each separate plant or animal that they consume.
- **Food Web:** the interconnected chains of energy transfer that combine to form a “web”.

Food web

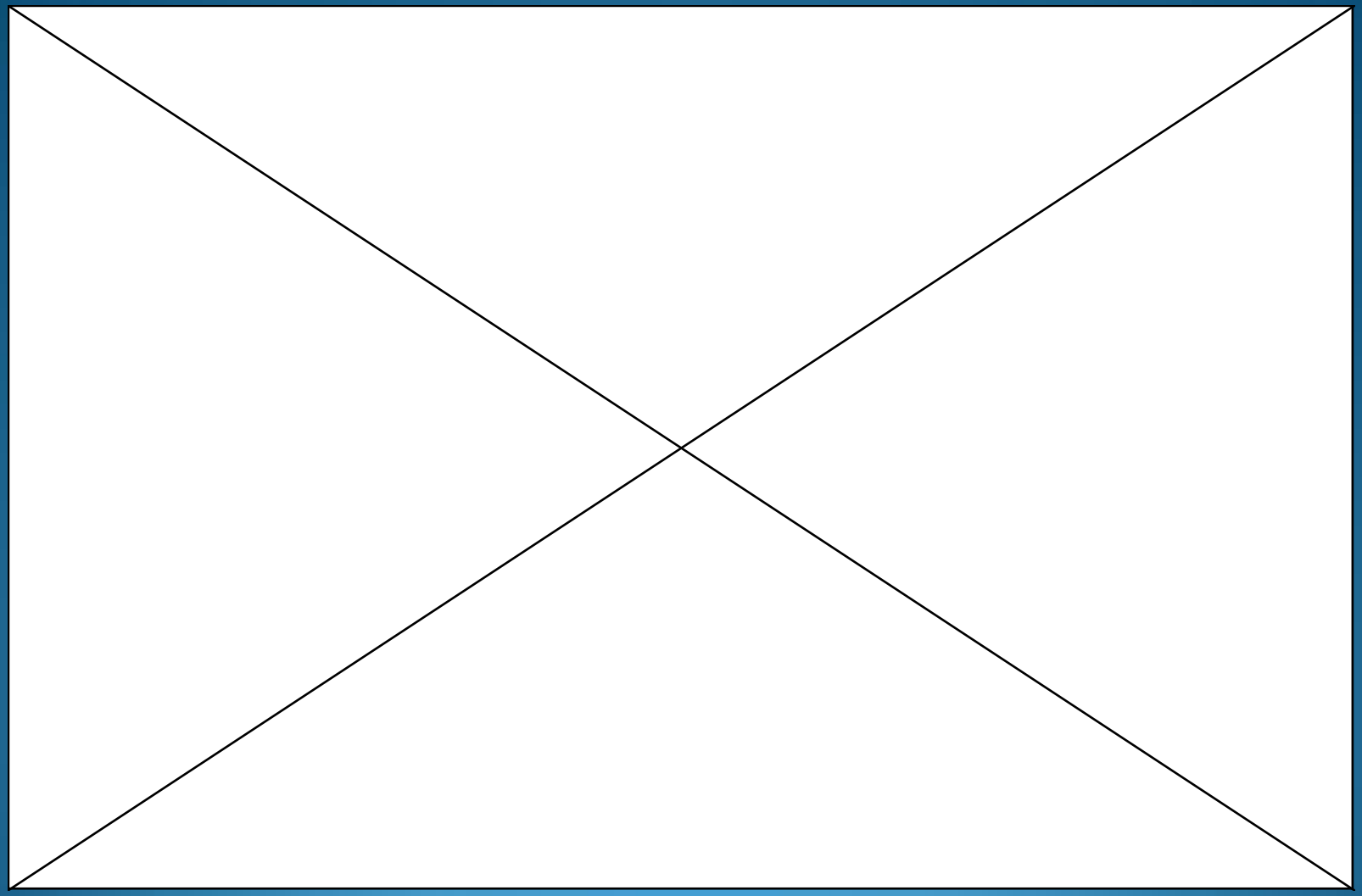

Tertiary Consumers
Coyote
Mountain lion
Bobcat
Secondary Consumers
Ringtail
Western whiptail
Raven
Black tipped jackrabbit
Pine marten
Primary Consumers
Pika
Red-breasted nuthatch
Pacific tree frog
Edith's checkerspot
Douglas's squirrel
Mule deer
Producers and Decomposers
Plants, Flowers, Nuts, Seeds, Fruit, Insects

Trophic Levels

- The **trophic level** of an organism is the position it occupies in a food chain, a food pyramid, etc.



Each **trophic level** simply illustrates the level of energy resulting after an energy transfer between organisms.



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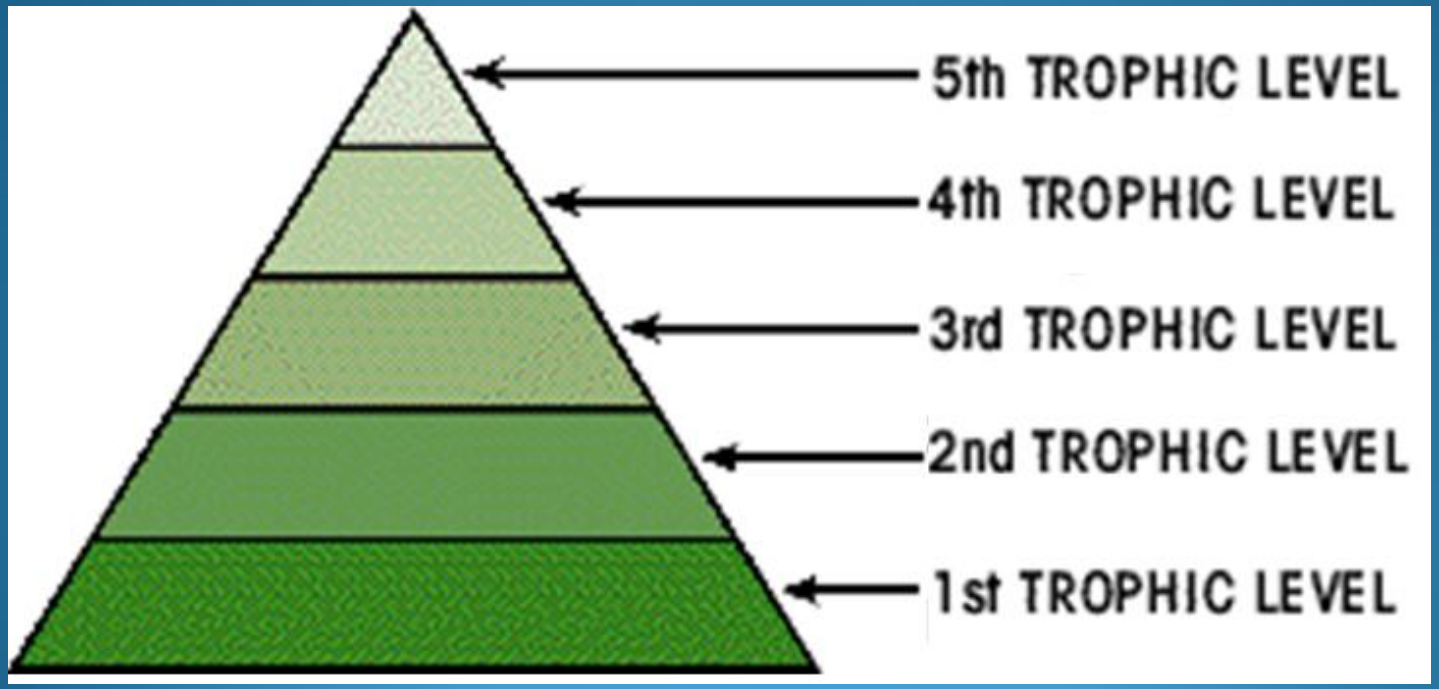
- The number of levels can vary depending on the number of organisms in the food chain.



Level 1

- Plants and algae produce their own food (*producers*)

Level 2

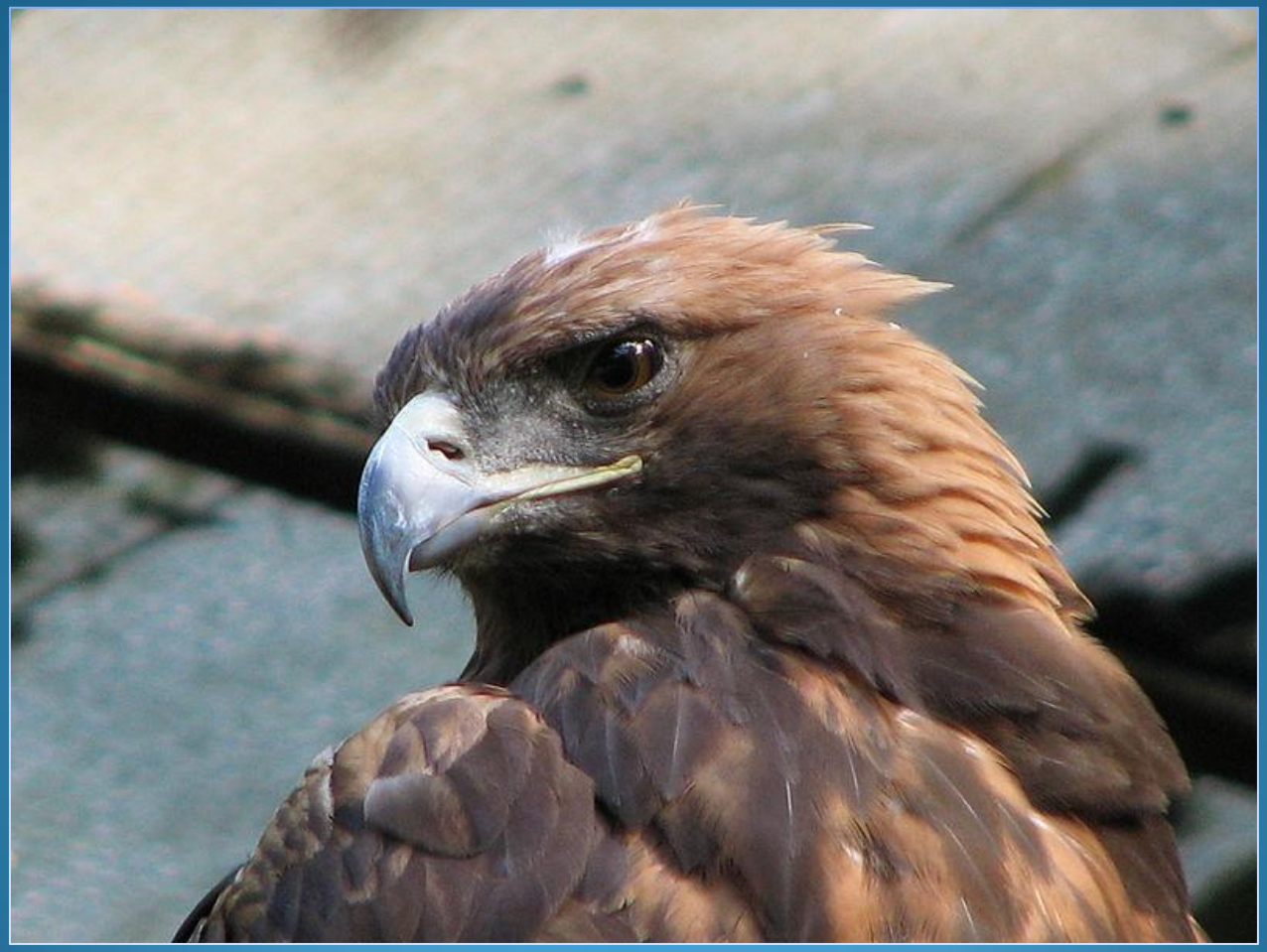
- Herbivores eat plants (*primary consumers*)

Level 3

- Carnivores eat herbivores (*secondary consumers*)

Level 4

- Carnivores eat other carnivores (*tertiary consumers*)

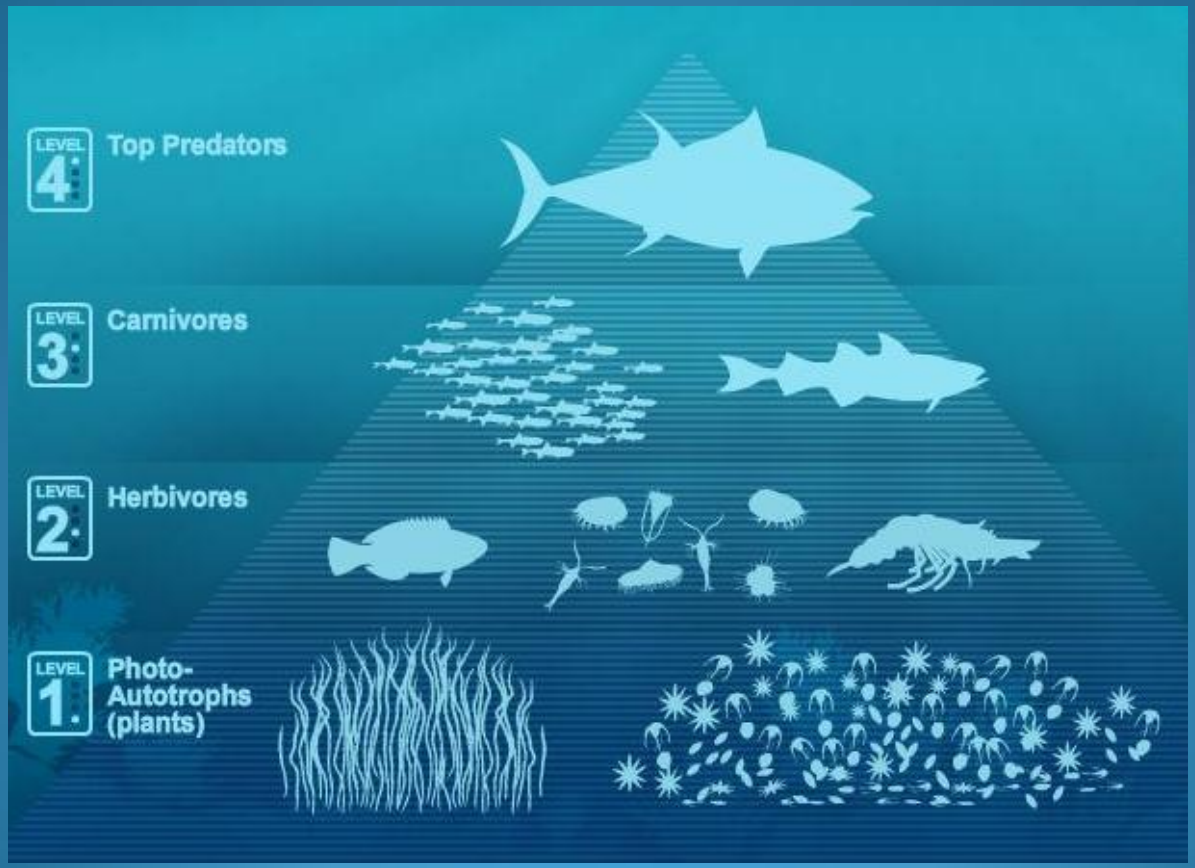


Level 5

- Predators which are not preyed upon are at the highest trophic level (*quaternary predators / apex predators*).

Food Pyramids

- Food pyramids can also be used to illustrate energy transfer and trophic levels in an ecosystem.



Energy Flow

- Solar radiation provides energy to producers (plants).
- Much of the solar energy is lost by the plant as heat and in maintaining its life processes (90% energy loss).
- These plants either decompose or are eaten by herbivores, which also expel much of that energy as heat.

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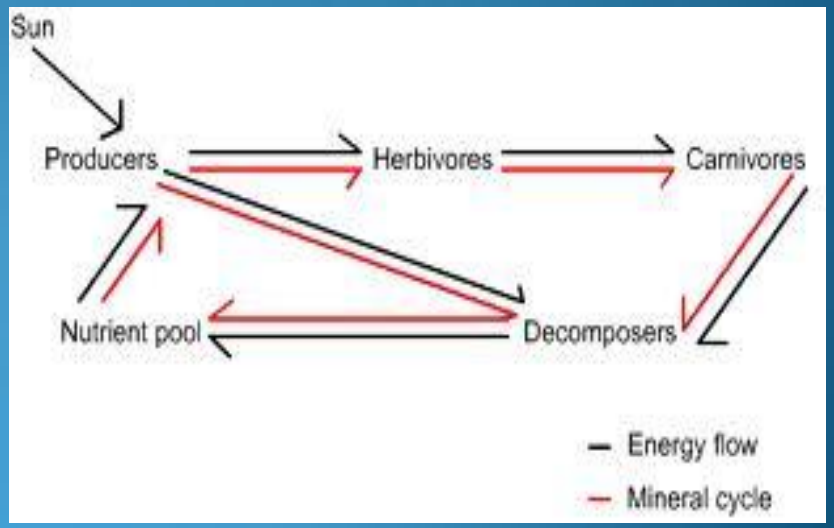
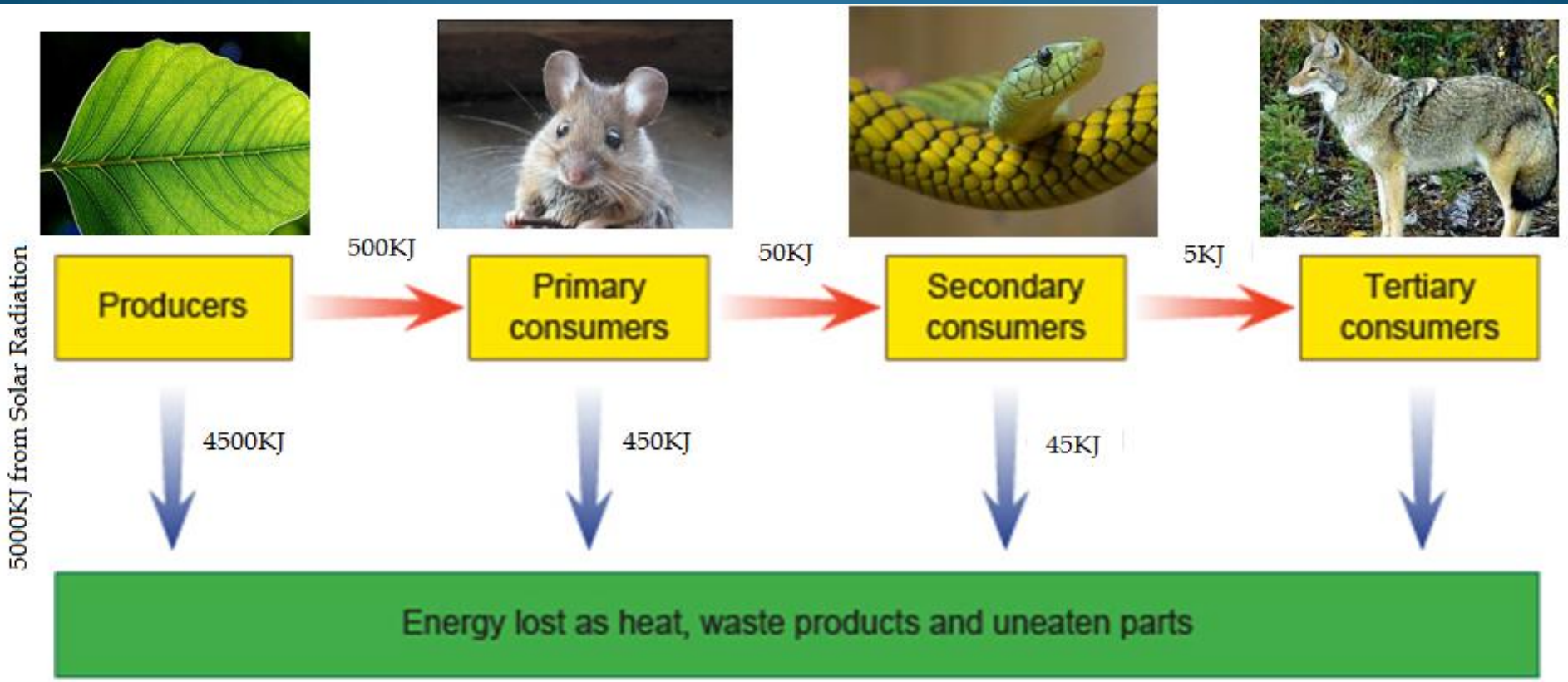
- Once the herbivores are eaten by carnivores, much of that energy is once again lost as heat.

- At the top of the food chain, the animal that dies is broken down into chemical compounds by decomposers.

The energy and chemical nutrients (in addition to solar radiation) feed the plants at the start of the energy flow once again.



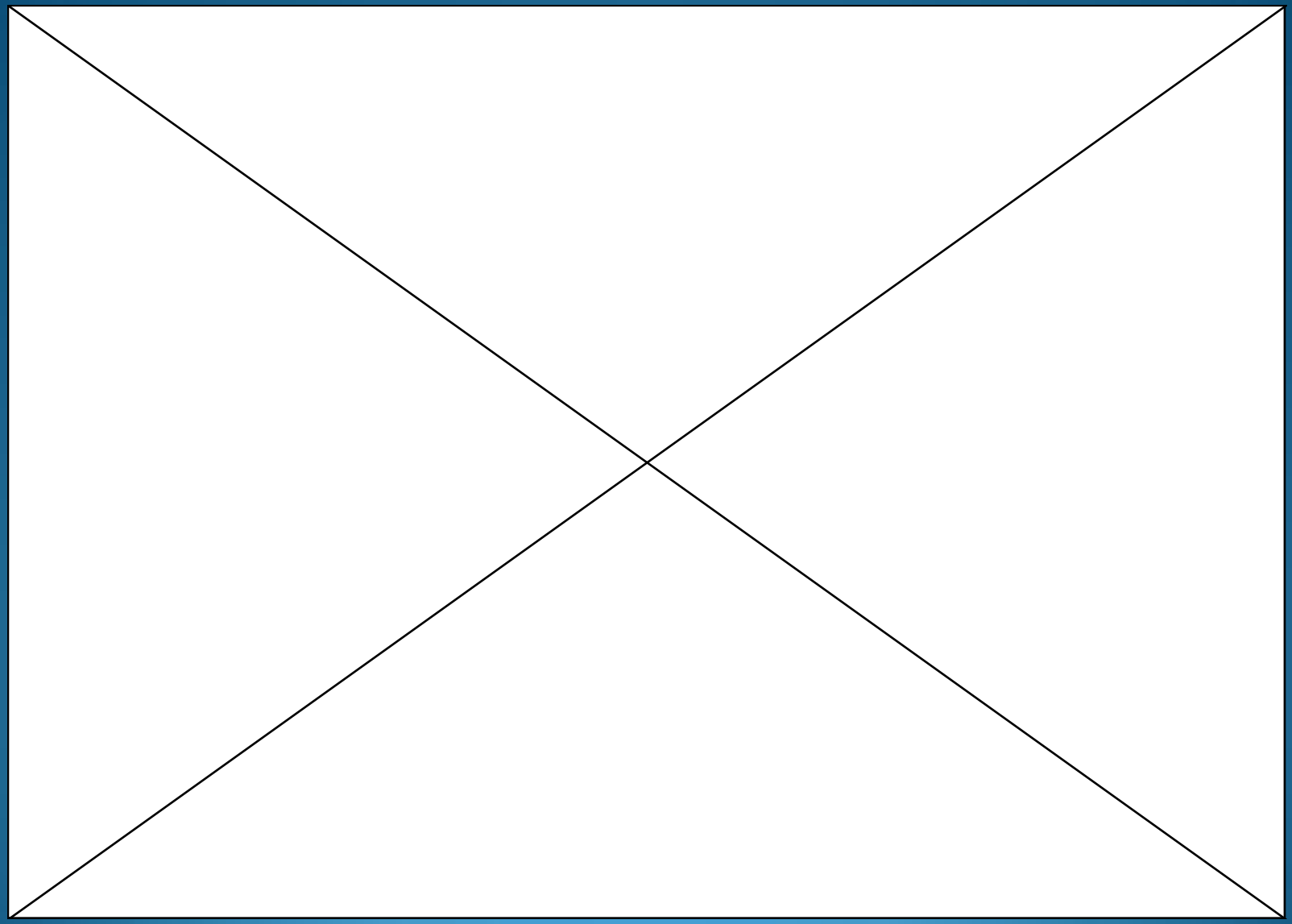
Energy flow through an ecosystem



Why are there fewer organisms at each trophic level?

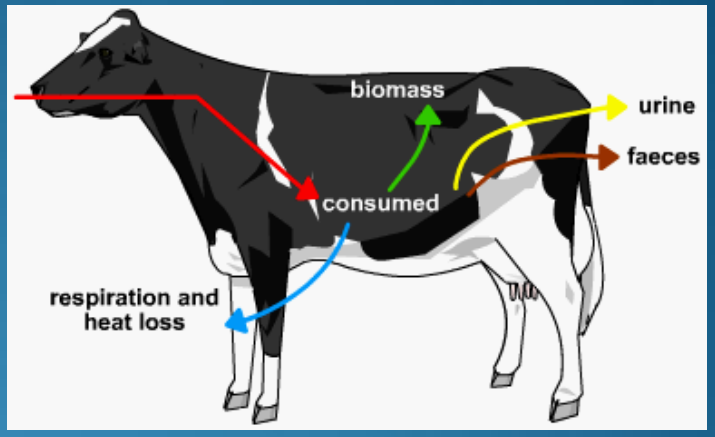
- Each succeeding layer in the pyramid is narrower than the one below it because only about 10% of one layer's energy is available to the organisms in the next layer.

- As mentioned earlier, most of the energy an organism consumes (about 90%) is lost as heat and in maintaining the bodily functions necessary for life.



Energy Loss

Most of the energy an organism consumes is lost as heat, in maintaining its life processes, and in waste material (85-90% energy loss).



- Only a small amount of energy (10-15%) is stored as food energy. This is the amount of all the energy taken in that can be transferred to the next level consumer.

- As you move to higher levels in an ecosystem or *food pyramid*, the number of organisms that can be supported by the energy of the previous level steadily decreases.

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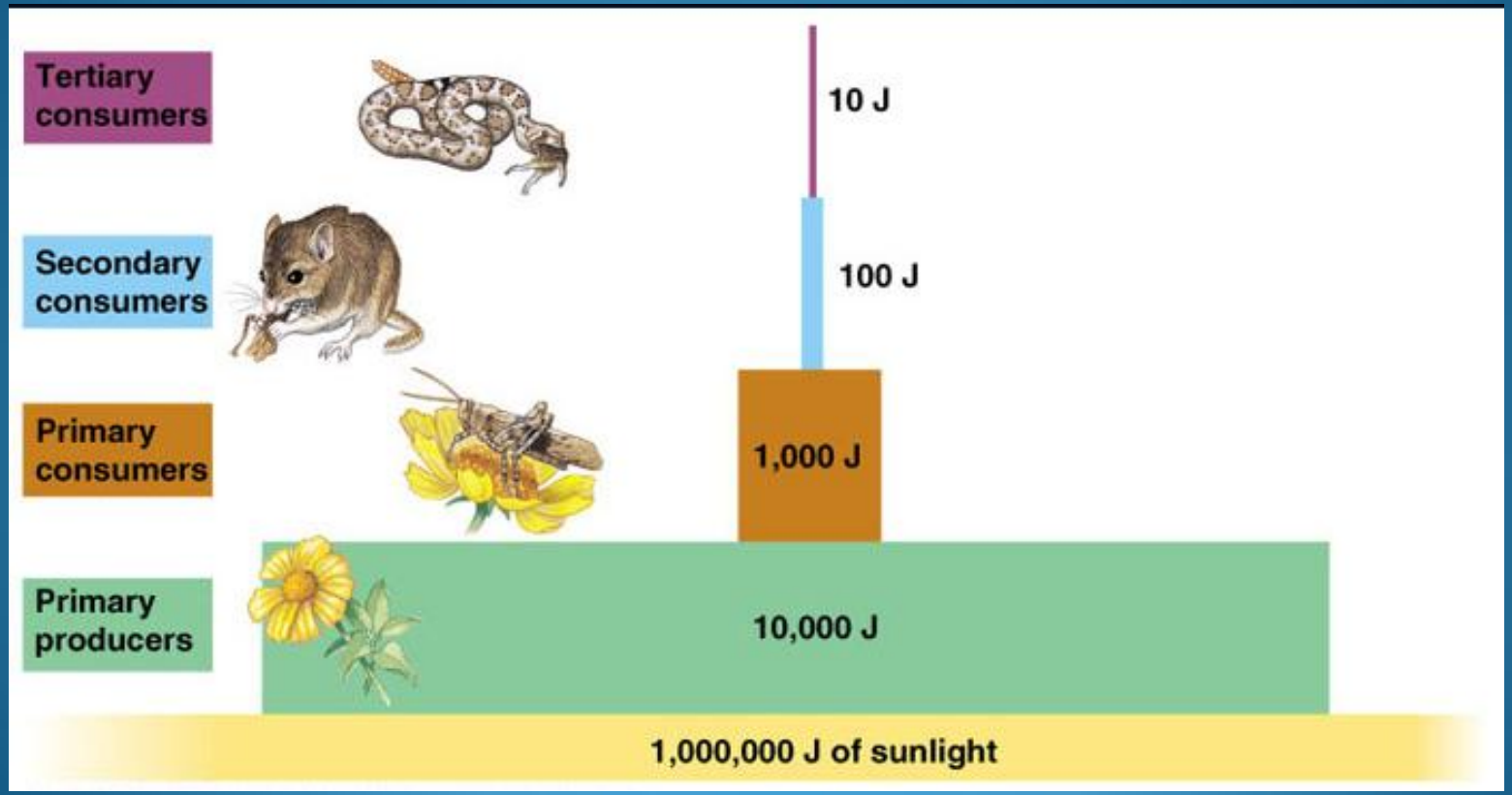
- Because of the energy loss at each level, organisms at higher trophic levels must consume a higher quantity of lower level organisms in order to survive.



Introduction of a new organism

- All introductions of non-native species are potentially dangerous. It is difficult to predict how the new species will interact with (or change) the existing relationships in an ecosystem.
- Any resources the new species utilizes or any organisms it consumes will alter the ecosystem in some way.
- By altering the food web, the new organism will have affected the overall transfer of energy that the ecosystem is dependant upon.

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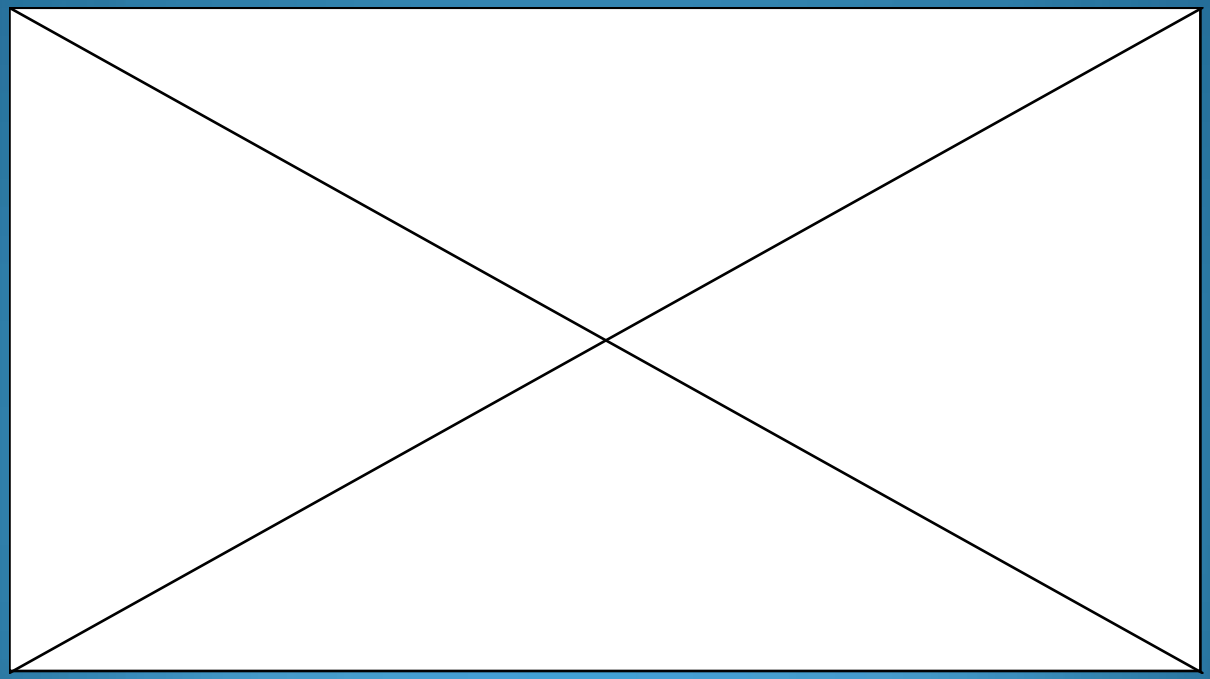
- May create unstable competition for food and resources.
- Interbreeding between species may affect the gene pool (ex: wolves and coyotes).



Moose in Newfoundland

- Moose were introduced to Newfoundland in two groups: a pair in 1878 and four more in 1904.

- While the Moose have survived very successfully without any known ecological disasters, there are concerns that they are becoming overpopulated.

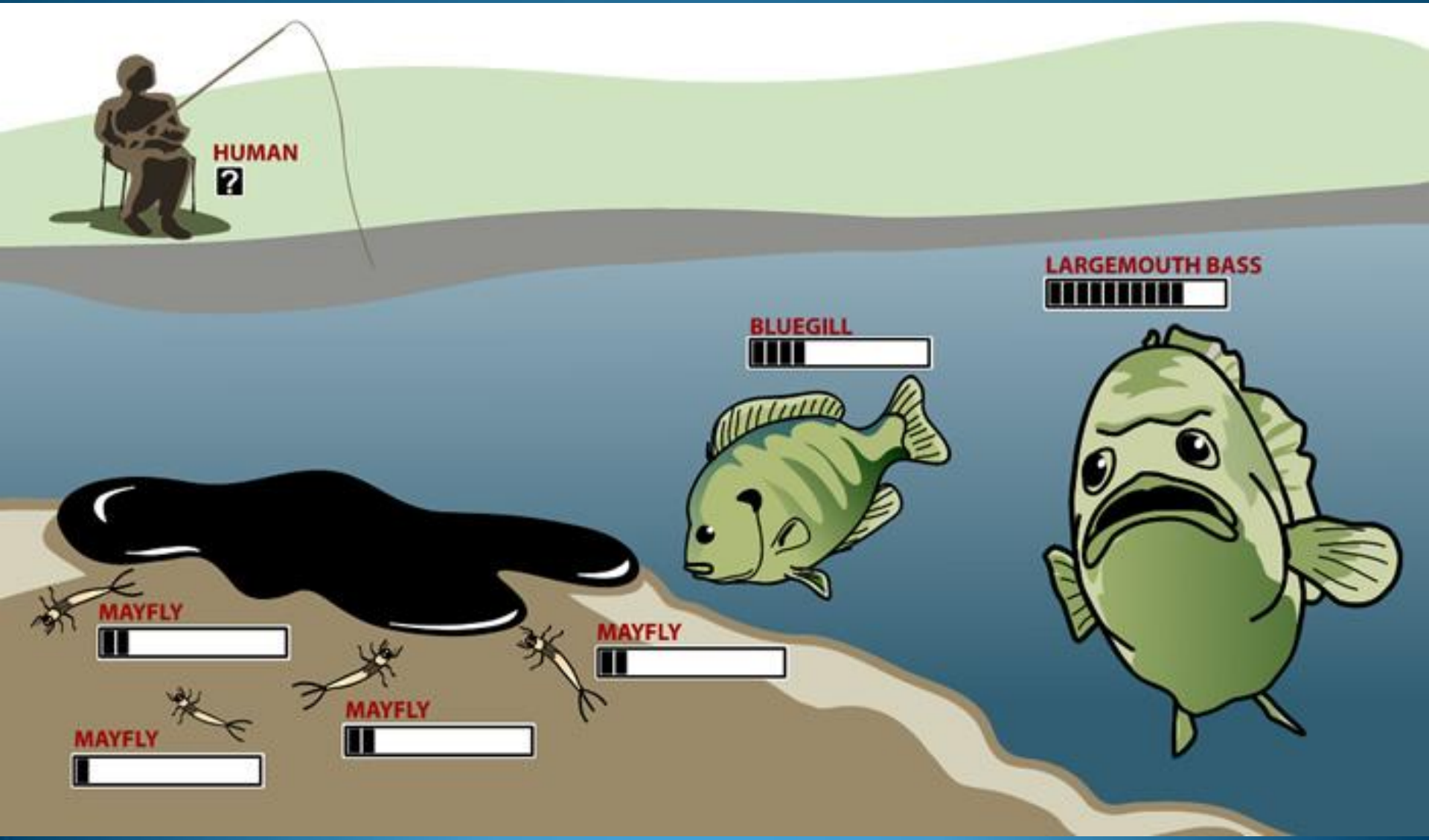
What effect has the introduction of moose in Newfoundland had on humans?

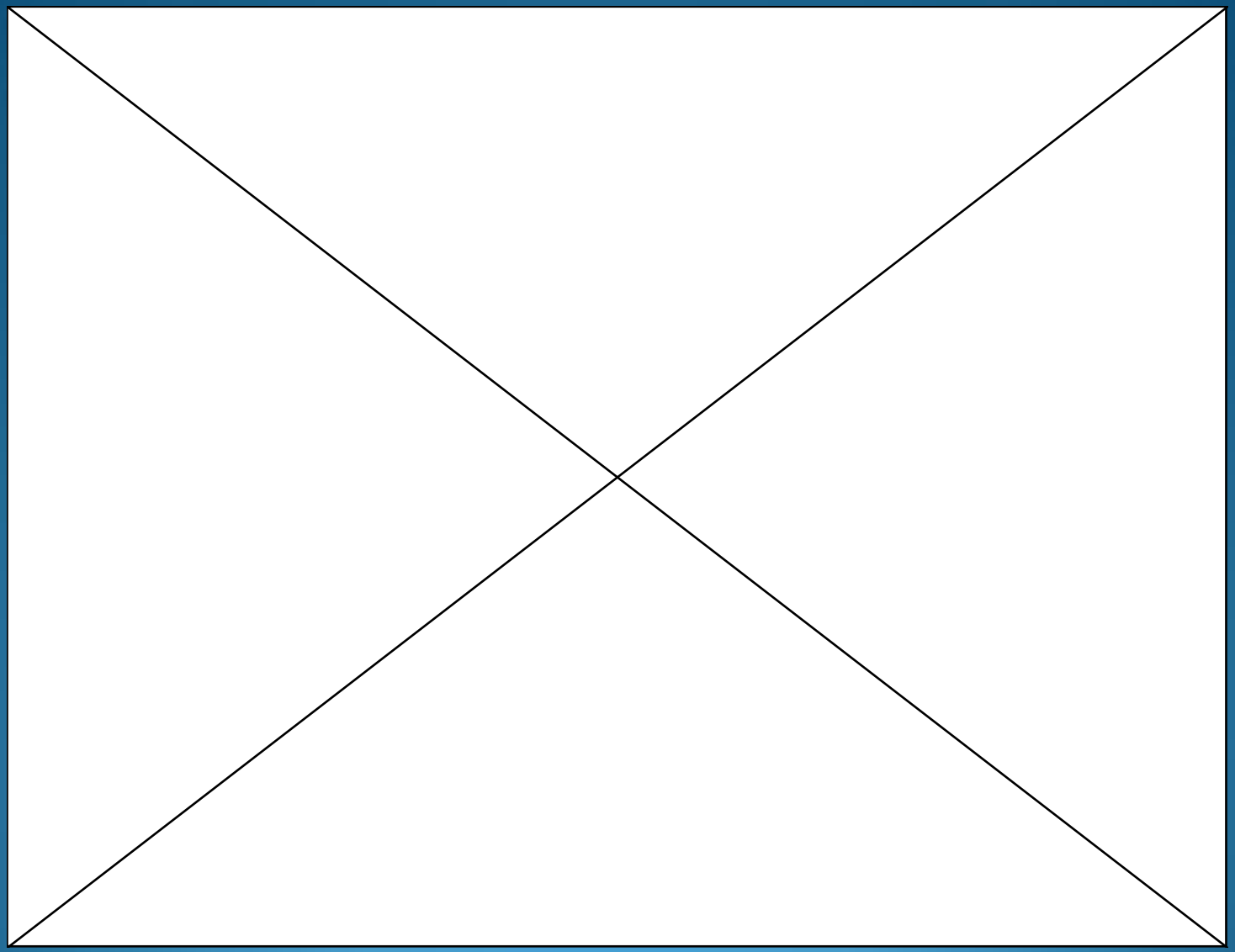
Biological Amplification

- **Biological amplification (biomagnification)**: An increase in the concentration of toxic fat-soluble chemicals in organisms at successively higher trophic levels because of the increased consumption of organisms at lower trophic levels.

- **Fat-soluble** means that the toxin:
  - Cannot be broken down by water.
  - Is stored in fat and tissue cells in the body.

Biological Amplification

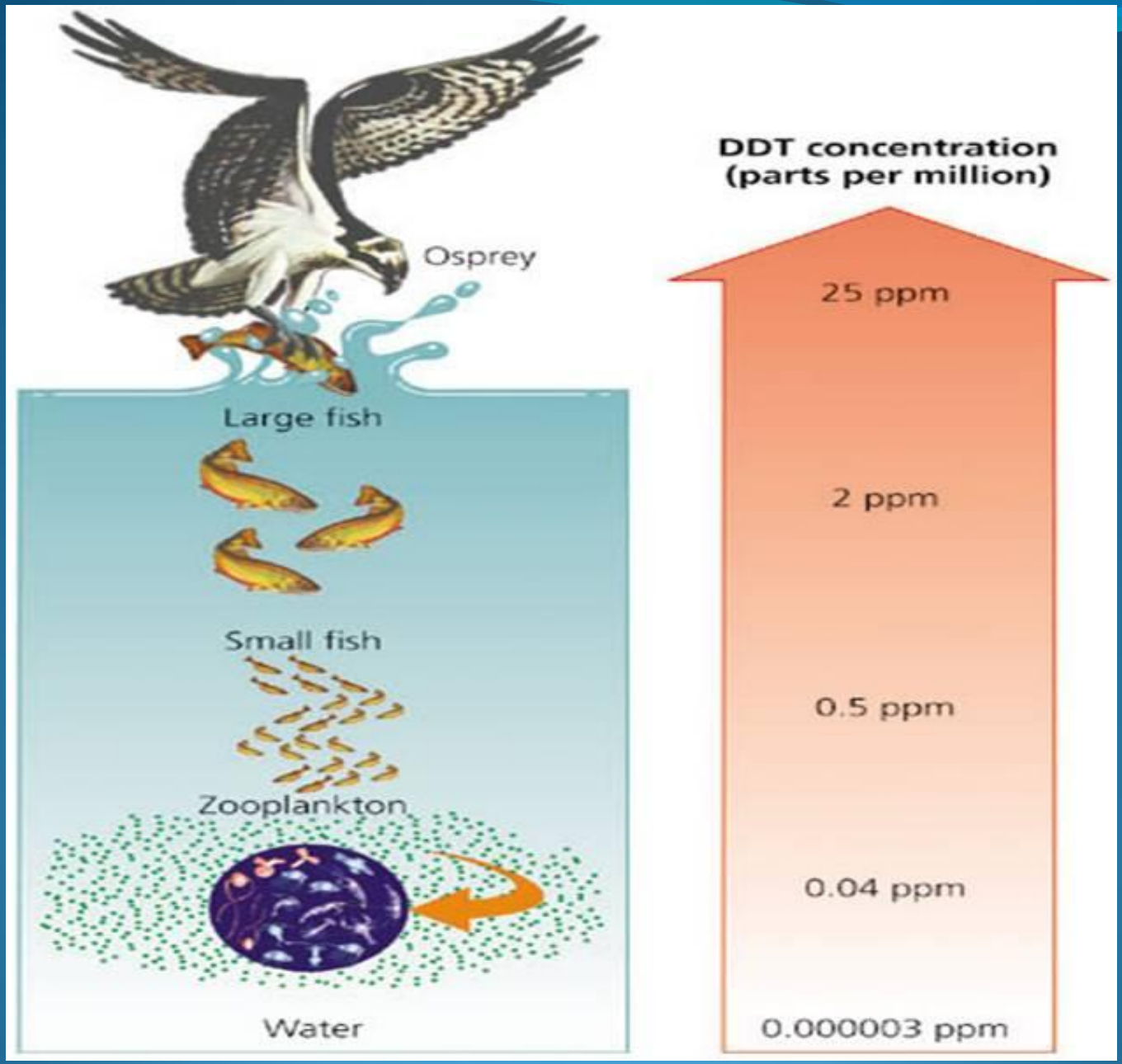




Pesticides in Food Pyramids

- When consumers at higher levels in a food chain eat organisms that have toxic chemicals in their tissues, they receive a higher concentration (%) of the toxins than did the lower-level organisms.

- This is due to the larger number of contaminated organisms being consumed at each higher trophic level.


DDT concentration
(parts per million)
Osprey
Large fish
Small fish
Zooplankton
Water
25 ppm
2 ppm
0.5 ppm
0.04 ppm
0.000003 ppm

Example

- From human pollution, mercury (or methyl mercury) is present in seawater in very small concentrations.
- It is absorbed by algae at the start of the food chain. This algae is then eaten by small fish and other organisms.
- Because mercury is fat-soluble, it accumulates in the organs and muscle tissue of the fish. The more algae these fish consume, the more mercury they may have absorbed.

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- Anything which eats these fish within the food chain consumes the high level of mercury the fish have accumulated.

- The effect is **amplified** at each higher trophic level where consumers eat a larger quantity of fish with higher contamination levels.

. . .

- Predatory fish such as swordfish and sharks or birds like osprey and eagles have higher concentrations of mercury in their tissue than could be accounted for by direct exposure to seawater alone.

Species high on the food chain can build body concentrations of mercury up to ten times higher than the species they consume (**biological amplification**).

DDT (**d**ichloro**d**iphenyl**t**richloroethane)

- DDT was used as an agricultural insecticide starting in the 1950s.
- Passed through the food web, eventually to find its way into human breast milk in the 1970s.
- Banned in most Western countries when its effect on the ecosystem became apparent.
- Has been linked to diabetes, cancer, and neurological disorders.
- Some African countries still use DDT as an effective form of malaria control.

Lab Exercise

http://en.wikipedia.org/wiki/Biomagnification

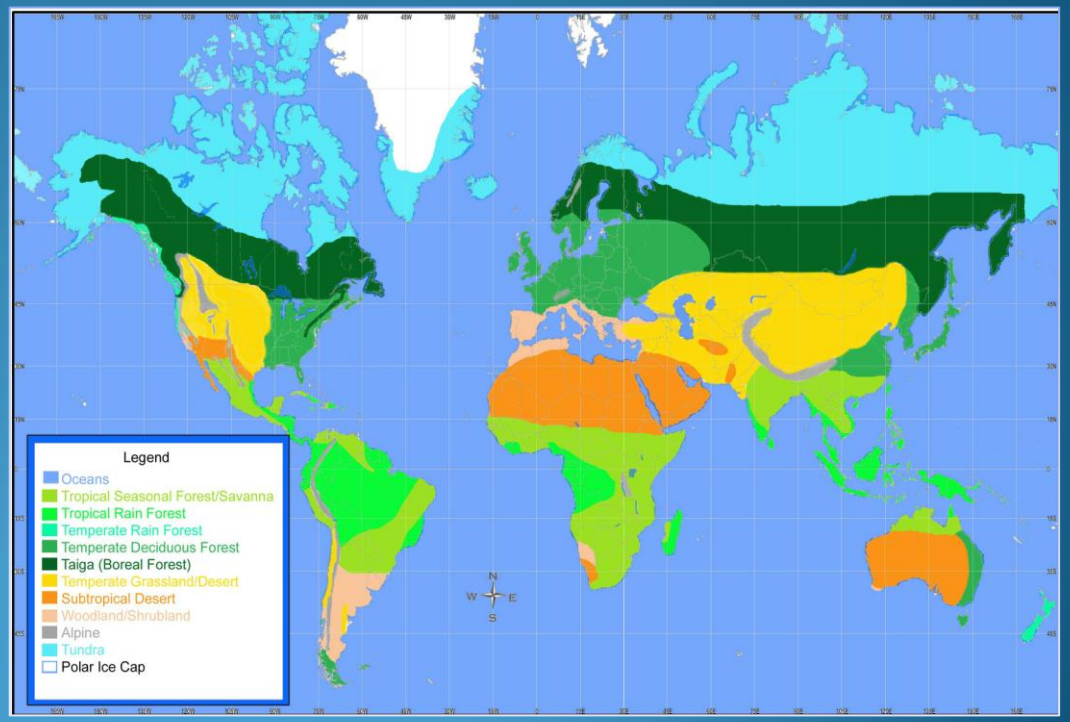
- Find an example of a toxin (pollutant, pesticide, etc.) that has been harmful to an ecosystem through biological amplification (biomagnification).
  A. Describe the toxin (its chemical makeup)
  B. Describe the source of the toxin or its intended use.
  C. Describe the effects of the toxin on the ecosystem.

World Ecosystems

WORLD ECOSYSTEMS (Biomes)

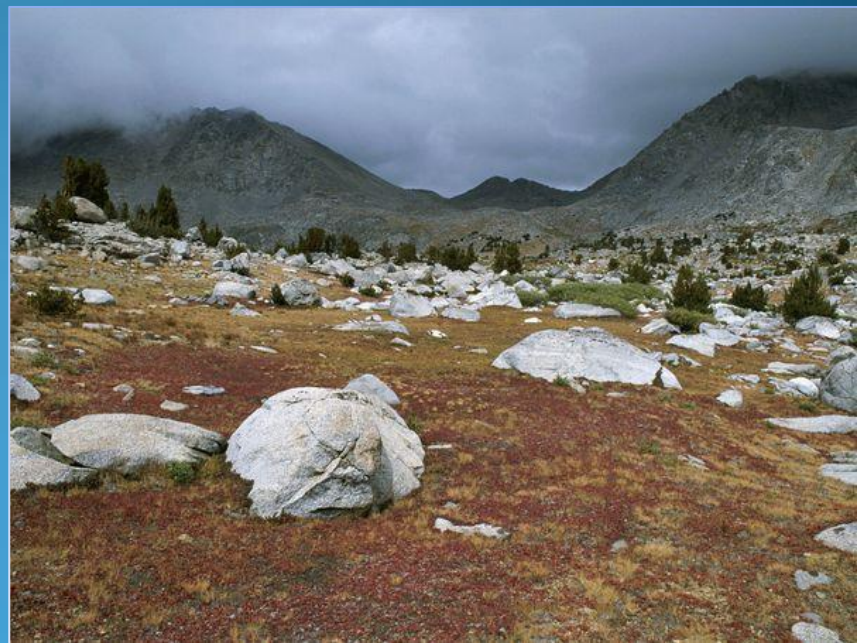
- Tundra
- Boreal Forest
- Temperate Forest
- Temperate Grassland
- Savannah
- Desert
- Tropical Rain Forest
- Mountain
- Scrub

Figure 6.8 (p. 102) in Textbook



TUNDRA (or high mountain)

- Cold temperatures all year.
- Very little variety of organisms.
- Limited plant life (close to the ground to absorb heat).
- Short season of growth and reproduction (6 to 8 weeks).
- Energy and nutrients come from dead organic material (decomposers).
- Moss, lichens, short grasses, dwarf shrubs, and stunted woody plants.



TUNDRA...

BOREAL FOREST (Coniferous)

- Long, snowy winters in which water is frozen and not available for plant growth.
- Summers have moderate temperatures.
- Thick forests of evergreen trees (pines, firs, spruce, and cedars) with small, thin needle leaves.
- High amounts of precipitation in the winter months (snow).

BOREAL FOREST...

TEMPERATE FOREST (Deciduous)

- Long growing season.
- Abundant rainfall.
- Warm summer temperatures.
- Broad-leaf trees; larger trees form a dense canopy that allows some light to filter through for smaller tree growth.
- Forest floor covered with leaf-litter layer providing soil nutrients.

TEMPERATE FOREST…

TEMPERATE GRASSLAND (Steppe)

- Annual rainfall insufficient for tree growth.
- High summer temperatures.
- Comprised primarily of tall and short grass, flowers, and herbs.
- Drought and fire prevent large forests from growing.

TEMPERATE GRASSLAND…

SAVANNA

- Months-long rainy seasons alternate with months-long dry seasons.
- Tall grasses with scattered shrubs and trees.
- Warm temperature year round.
- Large herds of grazing and browsing hoofed animals.

SAVANNA...

DESERT

- Temperature variations are extreme (hot in daytime, cold at night).
- Very little rainfall (less than 25 cm/year).
- Precipitation falls during a very short period of time.
- Plants (cactus, etc.) tend to have thick skins or extended root systems and are almost all ground-hugging shrubs and short woody trees.

DESERT…

TROPICAL RAIN FOREST

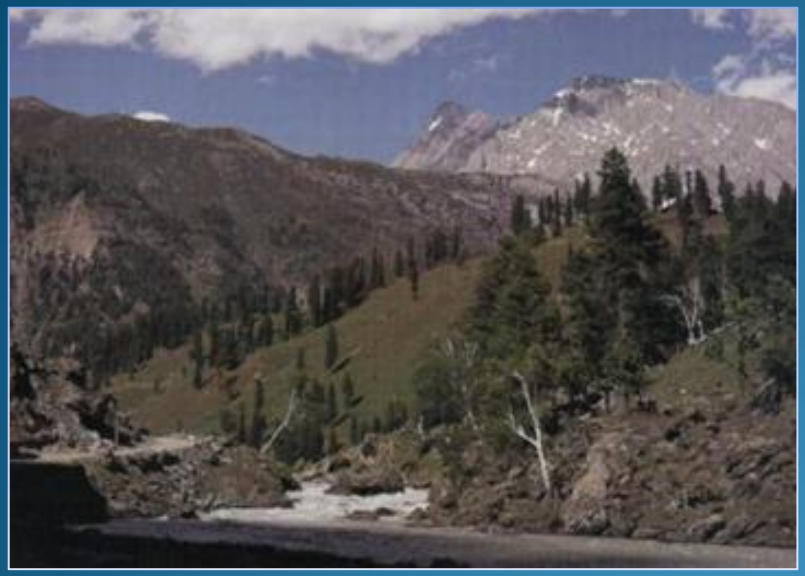
- Warm temperatures all year.
- High amounts of rainfall.
- Many varieties of broadleaf evergreen trees of all sizes.
- Large variety of animal life.
- Smaller plants can live on the large branches of larger trees.

TROPICAL RAIN FOREST...

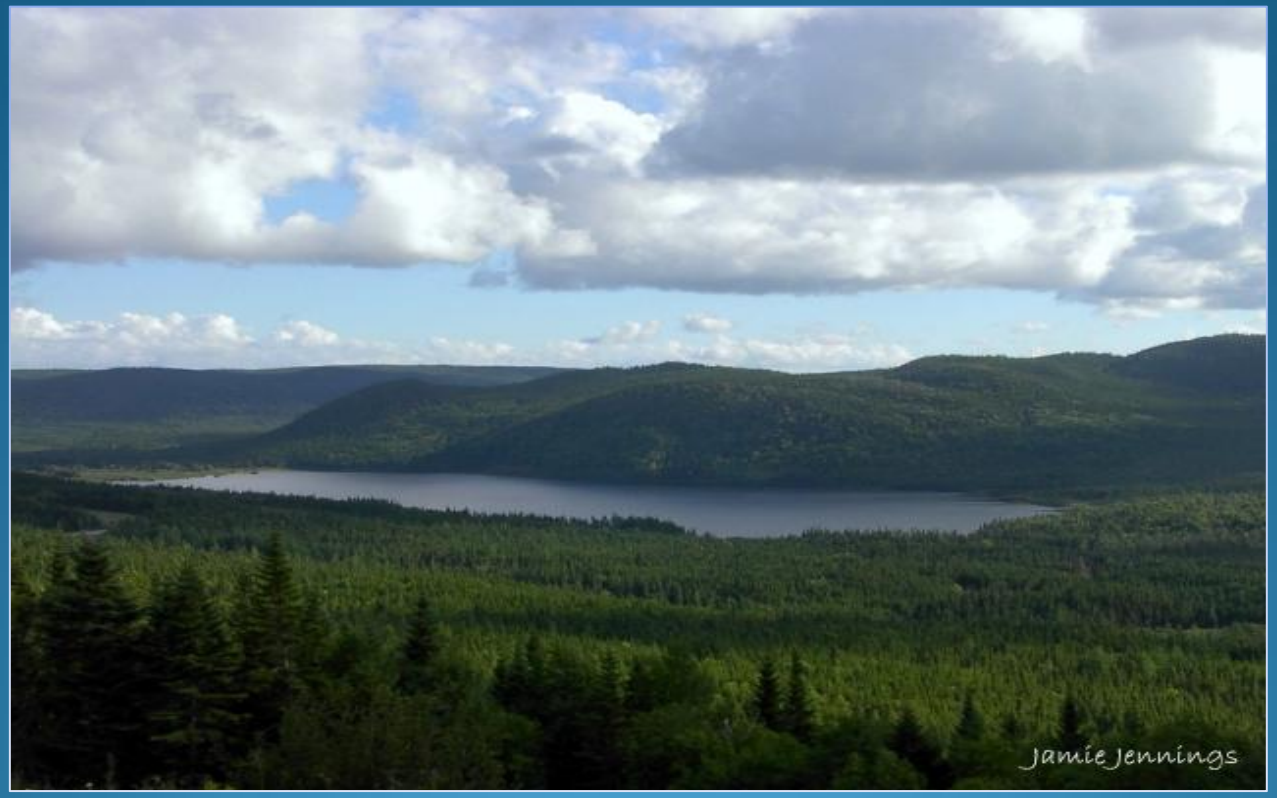
MOUNTAIN (Alpine)

- Mountain ecosystems vary dependant upon their elevation.
- As you climb a mountain, you will travel through many *world ecosystems*.
- Highest and most barren are usually at an altitude of about 10,000 feet or more.
- The higher the elevation, the fewer organisms the ecosystem can support (harsh climates).

MOUNTAIN (Alpine)…



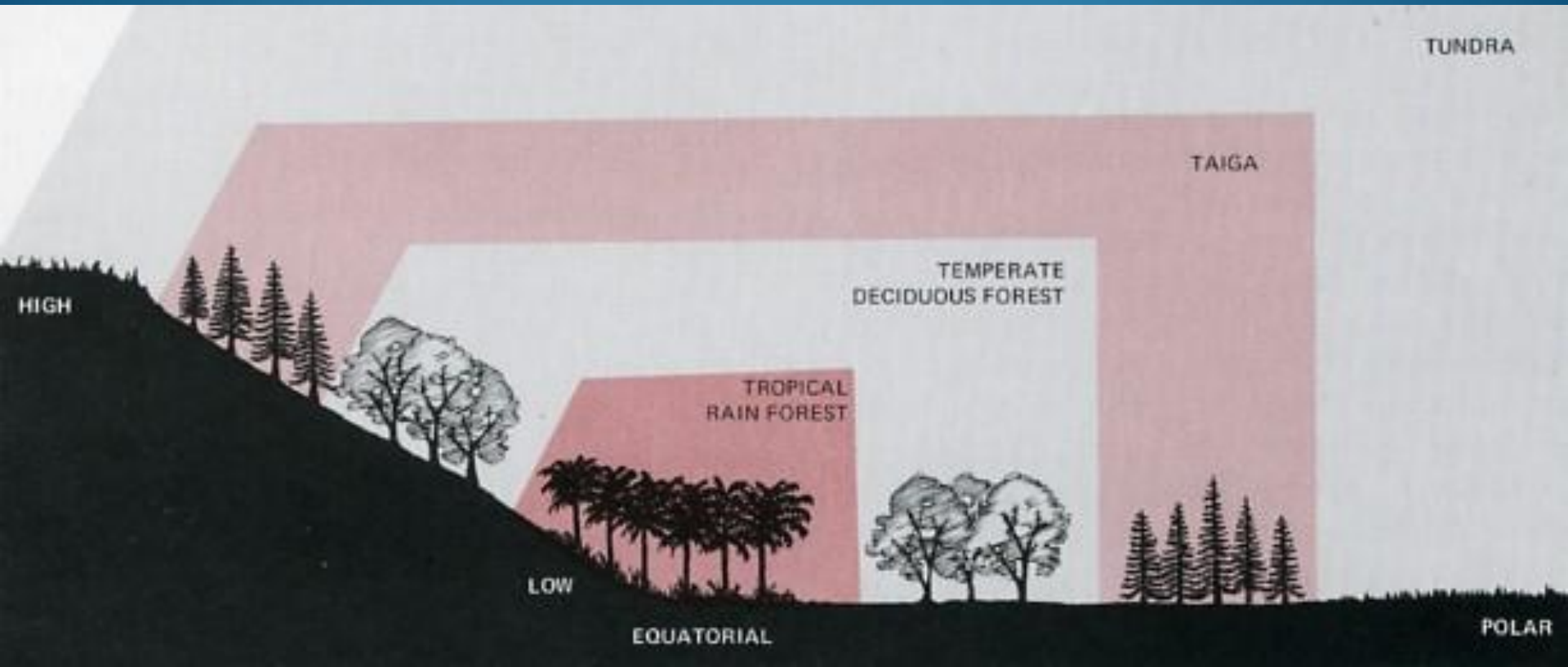
Lab Exercise



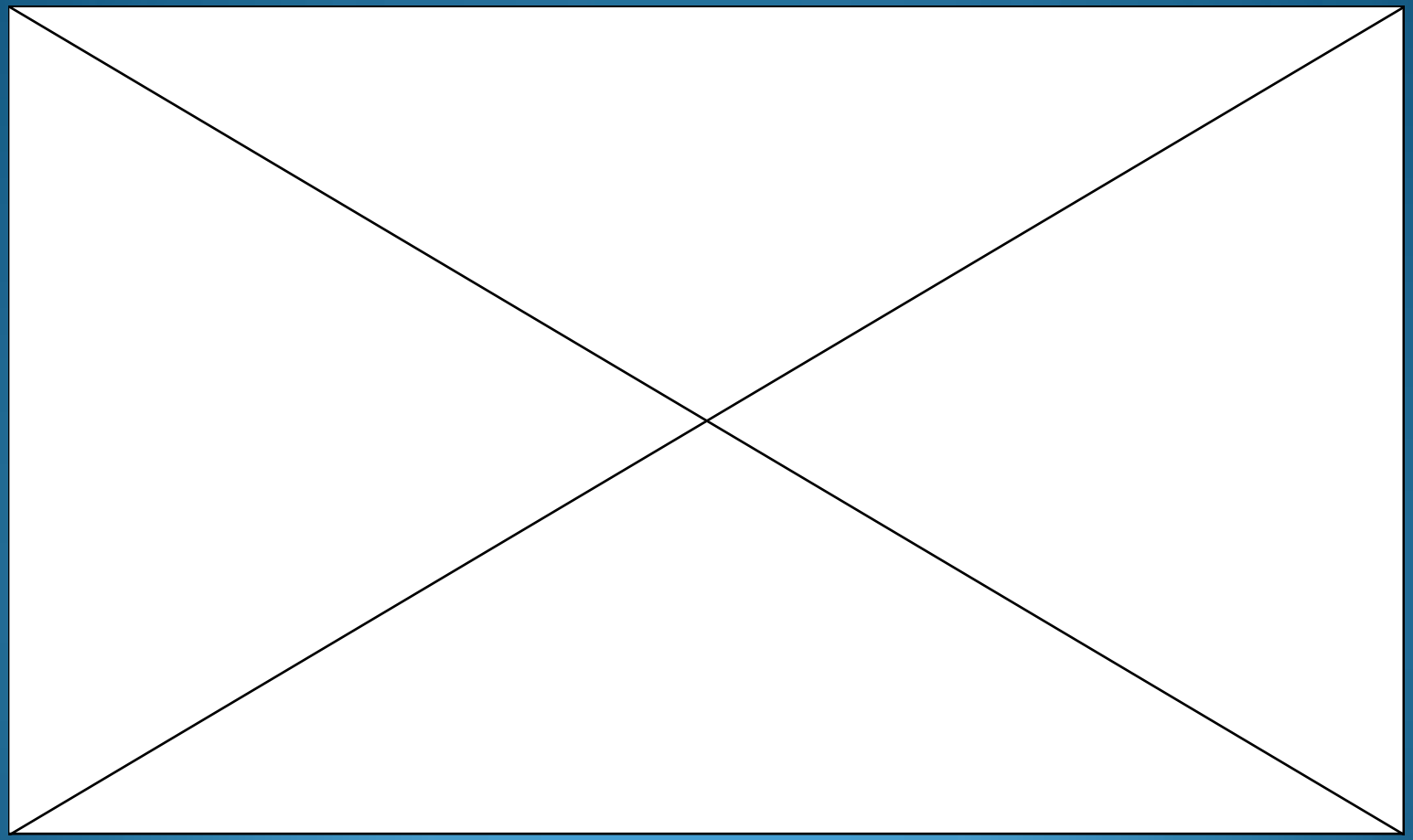
- Write 100 words describing the dominant type of ecosystem in Newfoundland and its characteristics.

Latitude and Altitude

- The sequence of ecosystems from low to high altitude is the same as the sequence of ecosystems from low to high latitudes.



Video Review of World Ecosystems



Climate and Ecosystems

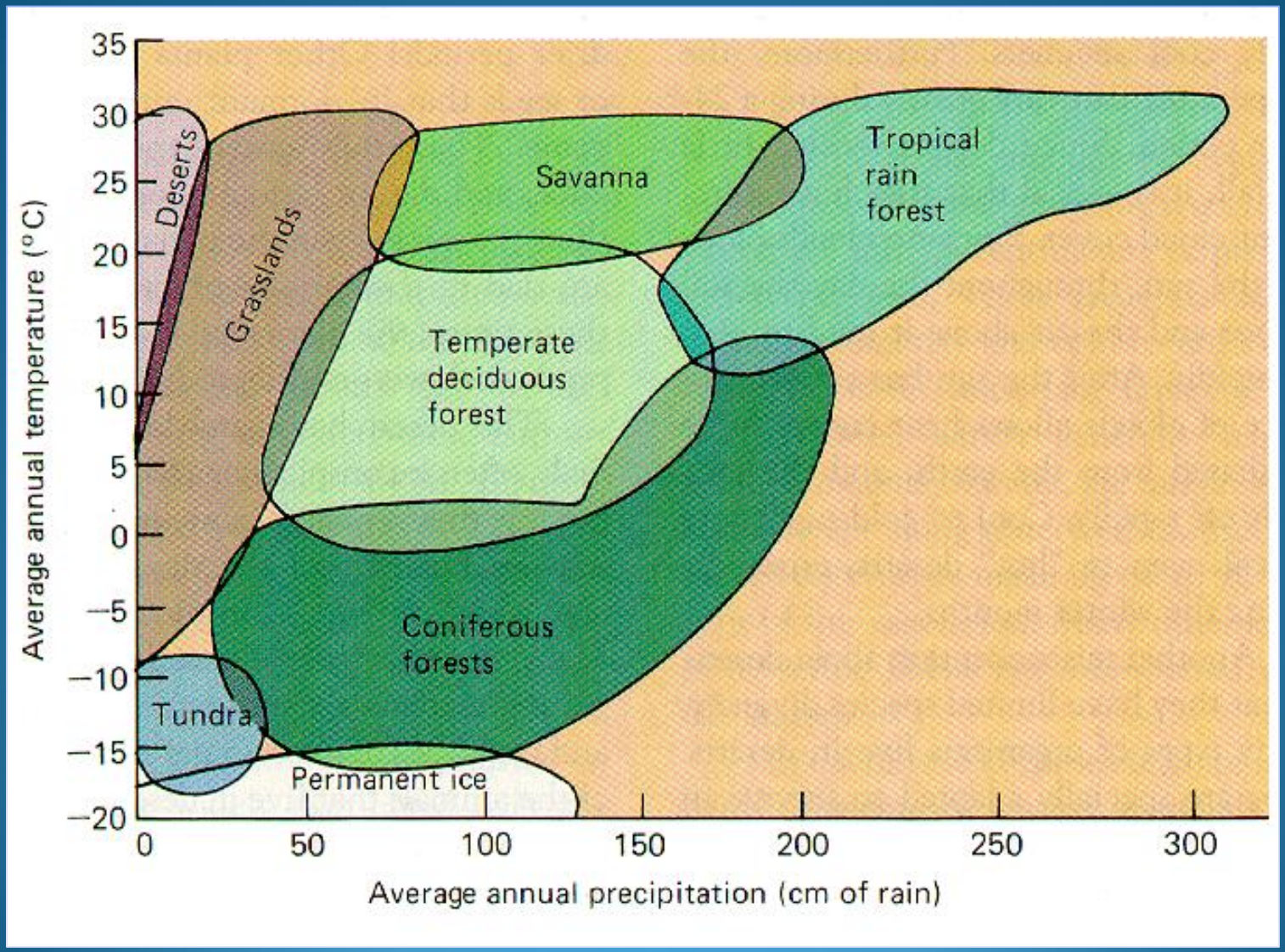
- Regions that are location in different parts of the world but that have similar climates tend to be classified as the same ecosystem.

- Climate zones and ecosystems are virtually interchangeable because the same factors that determine climate – solar radiation, average temperature rangers, annual precipitation, and so on – also determine the type of vegetation in an area.

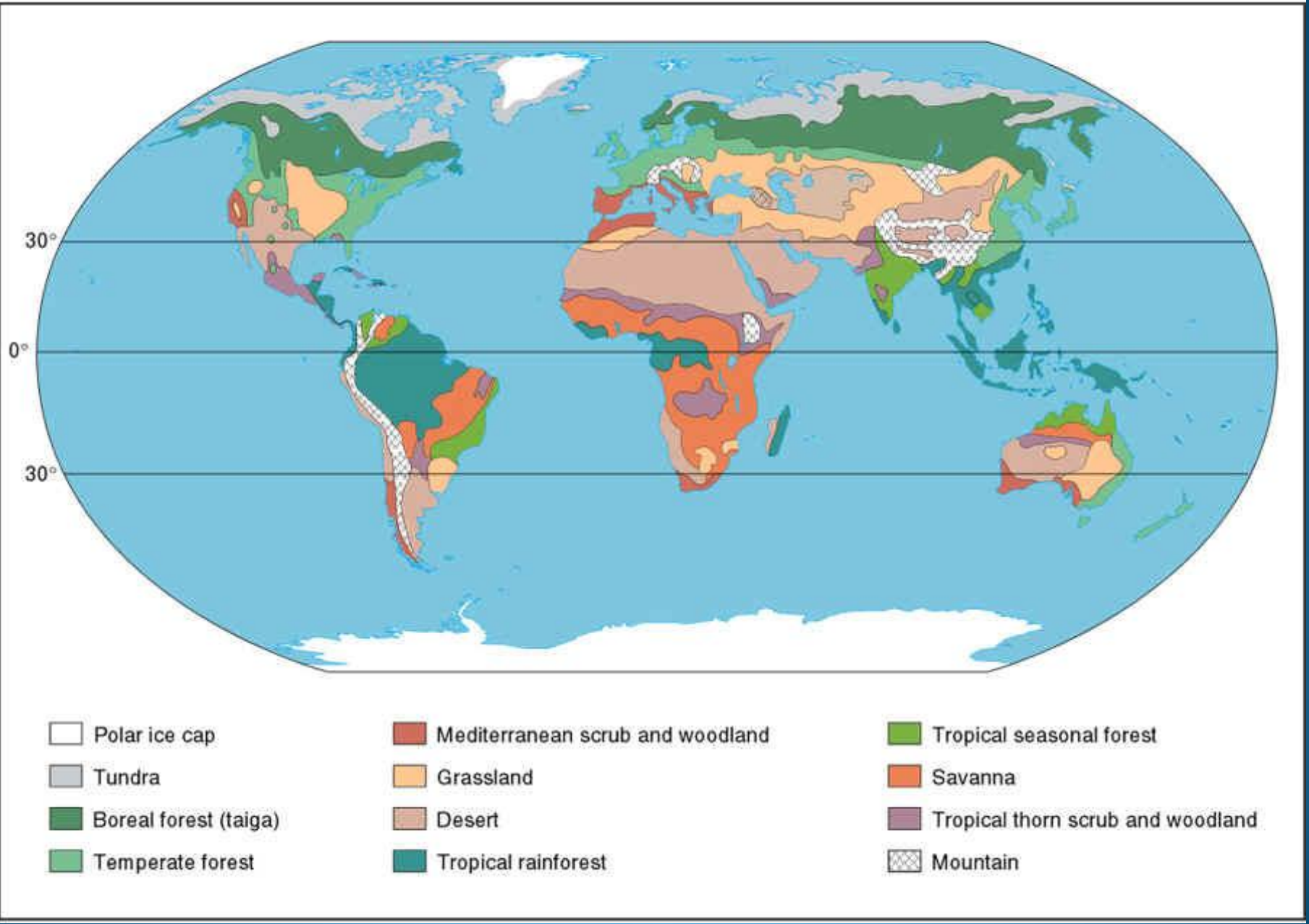
- Of all the climactic factors affecting vegetation, sunshine is the most important (though it is difficult to measure).

- Ecosystems are often defined or classified in terms of specific rangers of average annual temperature and precipitation because these figures are easily recorded. (figure 6.9 in textbook)

Identifying an ecosystem by climate



Distribution of World Ecosystems



What is Soil Quality?

Soil quality is a measure of how well soil does what we want it to do.

- Looking for evidence that the soil supports plant and animal productivity, maintains or enhances water and air quality, and supports human health and habitation.

- The quality of a soil is an assessment of how it performs all of its functions now and how those functions are being preserved for future use.

Why Does Soil Quality Matter?

- By determining if soil quality is deteriorating, stable, or improving, we have a good indicator of the health of an ecosystem.
- Using a soil improperly can damage it and the ecosystem.
- The information is used to protect and improve long-term agricultural productivity, water quality, and habitats of all organisms including people.

Desertification

- Desertification is the process by which productive drylands in arid areas become degraded and unproductive.
- Ecosystems in these areas have adapted to climactic conditions, especially the periodic shortages of water.
- Human-caused stresses to the ecosystem can and have permanently upset the ecological balance.

Causes of Desertification

- Dryland ecosystems are already very fragile, and can rarely sustain the increased pressures that result from intense population growth.
- The most common cause of desertification is the over-cultivation of desert lands.
- Over-cultivation causes the nutrients in the soil to be depleted faster than they are restored.

Causes of Desertification

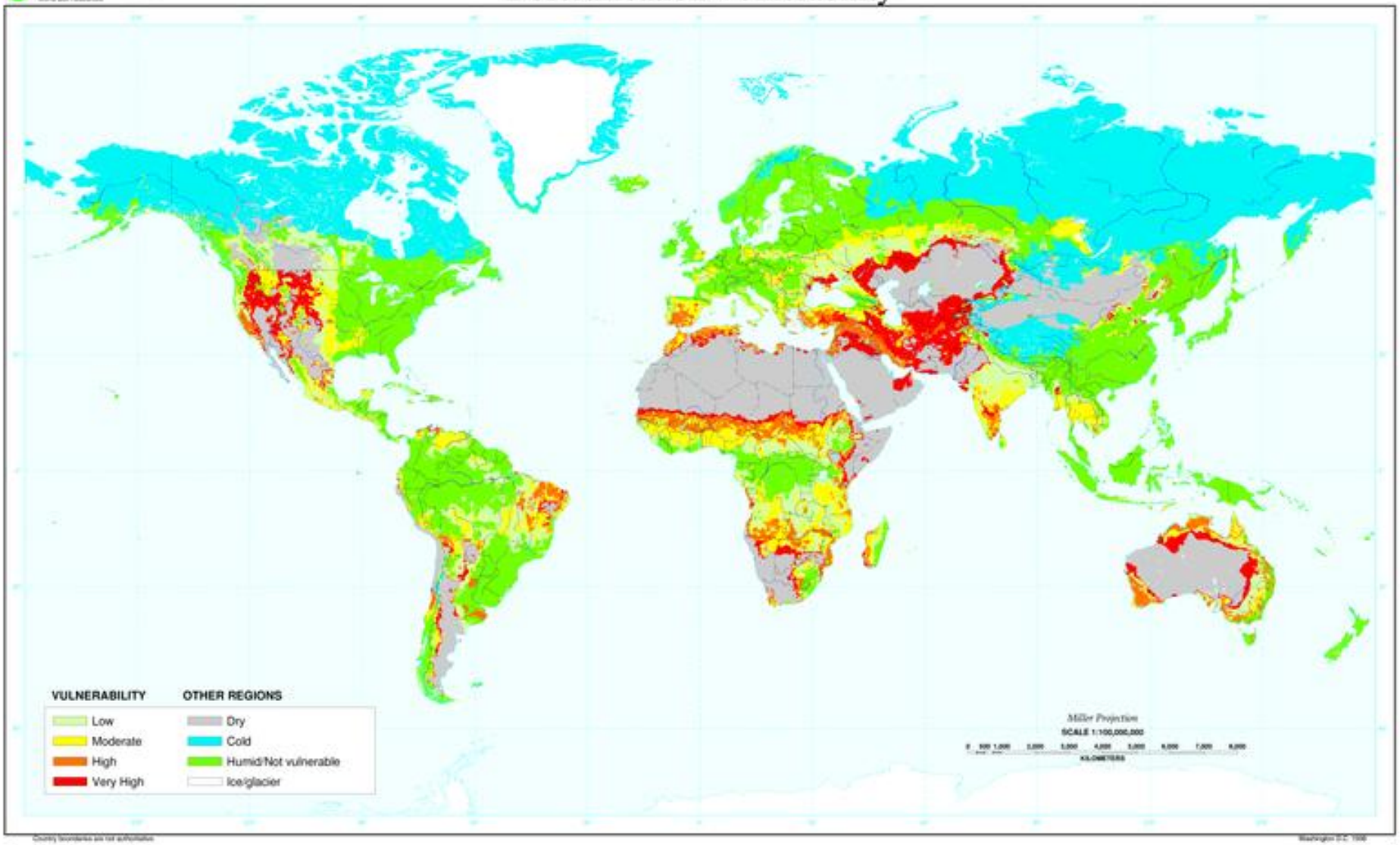
Areas affected by Desertification

- Drylands occupy approximately 40–41% of Earth's land area and are home to more than 2 billion people.

- It has been estimated that some 10–20% of drylands are already degraded.

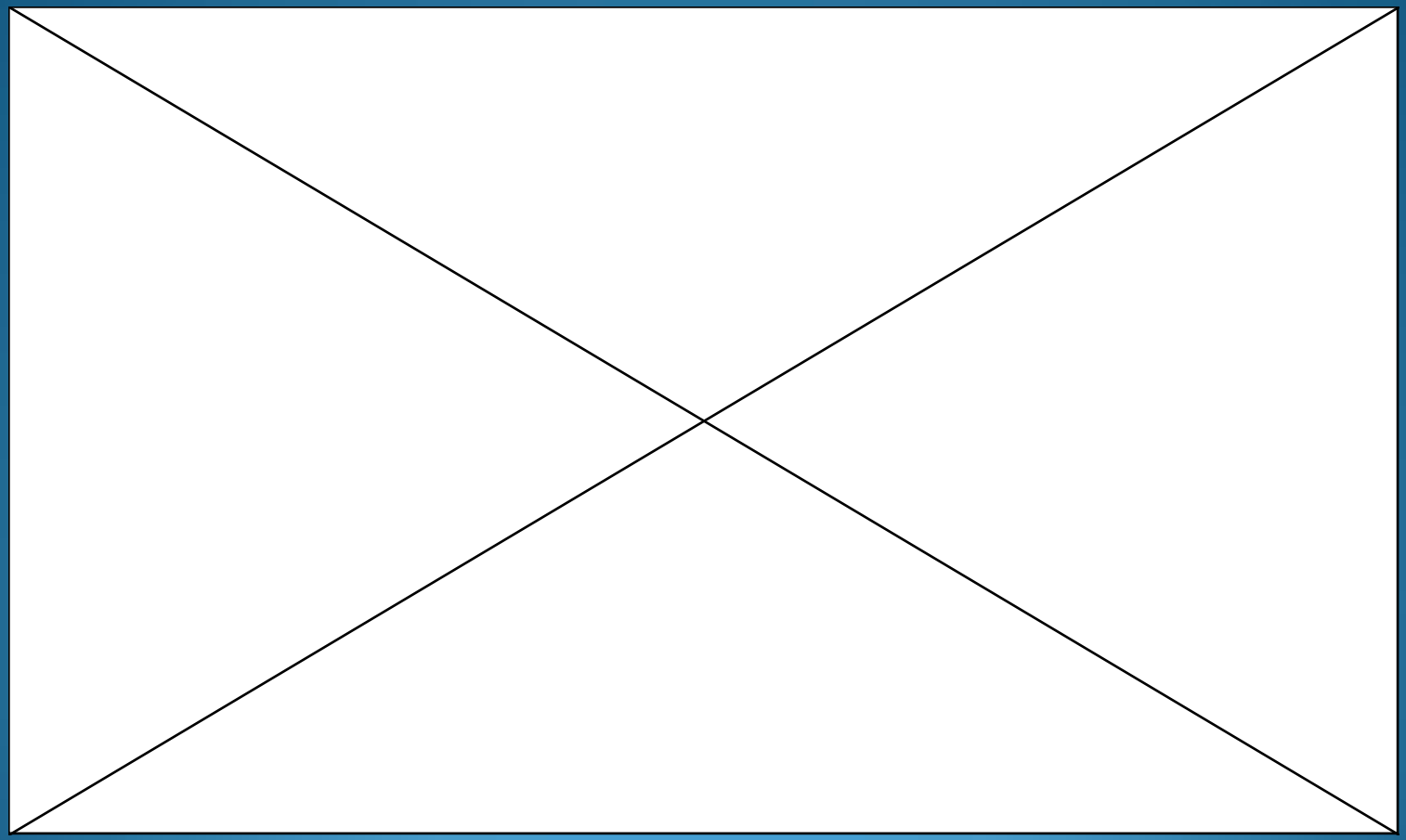
The Sahara desert is currently expanding south at a rate of up to 48 kilometers per year.

Desertification Vulnerability



Leading into the next unit…

Soil Texture



Soil Texture

- Soil texture is the key component in determining the value of a soil.
- Texture refers to the type of particles in the soil (both the particle size and the extent to which particles bond one another).
- These characteristics determine how much water will flow through the soil, the water-holding capacity of the soil, and air movement through the soil.

Factors that affect soil quality

- Sediment Deposition
  - When sediment is transported via air, water, gravity, or ice to a field or low landscape position and deposited.
- Compaction
  - When soil particles are pressed together, reducing the pore space between them; caused by tilling, harvesting, or grazing when the soil is wet.
- Salinization
  - Water-soluble salts accumulate in the soil and become a concern because excess salts hinder the growth of crops by limiting their ability to take up water.
- Soil Biodiversity
  - The mix of living organisms in the soil which decompose plant residue and play a key role in nutrient cycling.

- Available Water Capacity
  - The amount of water that a soil can store that is available for use by plants.
- Pesticides
  - Synthetic organic chemicals that can adversely impact human and animal health, contaminate surface and groundwater, and possibly cause adverse impacts on aquatic ecosystems.
- Hydrophobicity
  - Soils that repel water are considered hydrophobic. A thin layer of soil at or below the mineral soil surface can become hydrophobic after intense heating (i.e. forest fire).

Adaptation

- Pick an organism (animal or plant) and describe how it has adapted to its ecosystem.