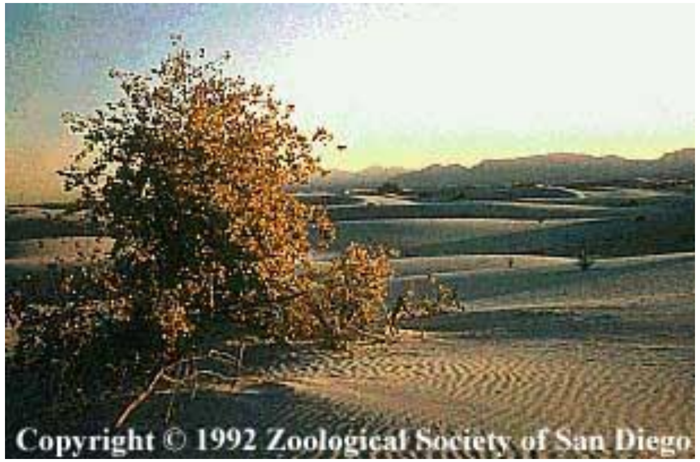
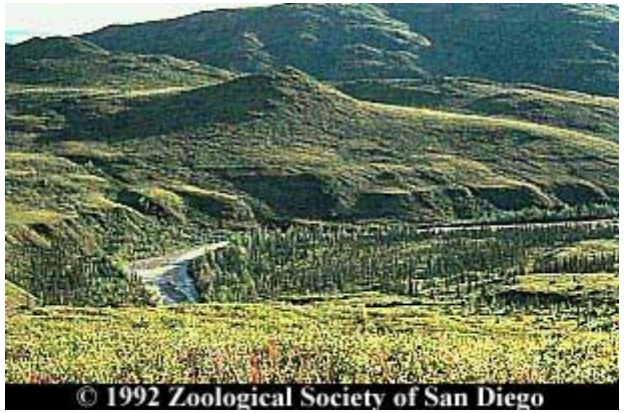
UNIT III ECOSYSTEMS





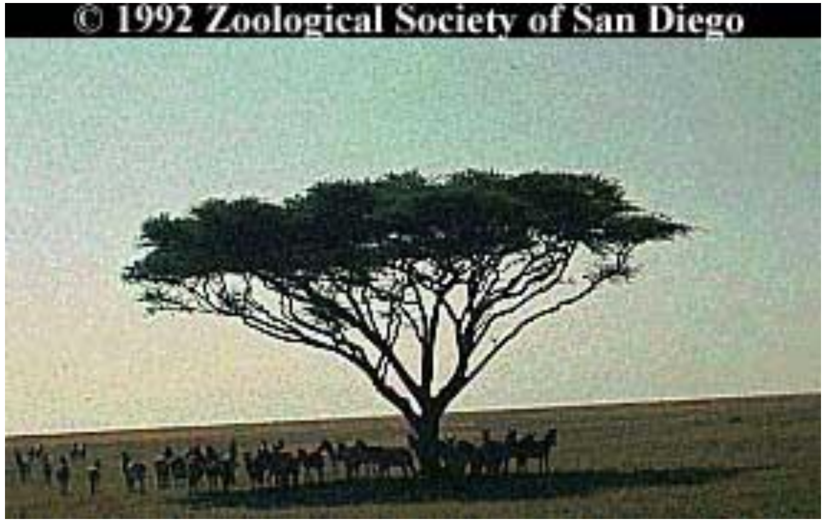
Unit 03 Ecosystems

- In this lesson you will:
  - 3.1.1 Define Ecosystem
  - 3.1.2 Differentiate the terms food web & food chain. P. 94
  - 3.1.3 Describe energy Flow through an ecosystem P. 95

Ecosystem Basics

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

Savannah



Organisms in an Ecosystem

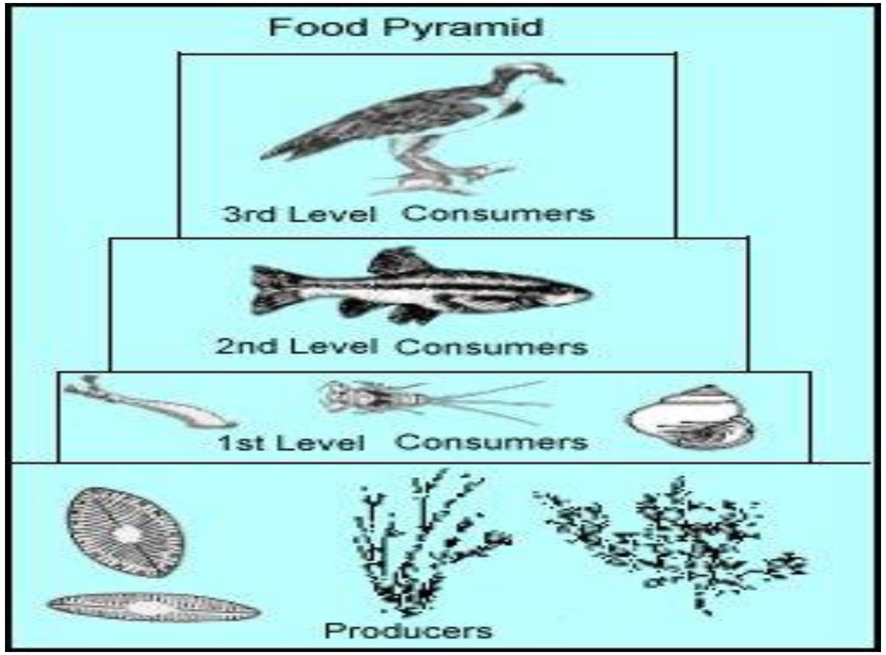
- PRODUCERS
- CONSUMERS
- DECOMPOSERS

Producer

- a plant which can synthesize carbohydrates using carbon dioxide and the sun's energy.
- *for example in figure 6.3 on page 94 all the plants, like Duck weed, Willow, cat tails etc. are producers and convert the sun's energy into carbohydrates (food energy) for all other organisms in the ecosystem.*
- Producers are so named because they actually produce the food for the ecosystem.

Consumers

- All those organisms in **trophic levels** other than producers. Consumers eat their food.
  - *For example in figure 6.3 on page 94 all the animals, Raccoon, bass, duck etc. are consumers.*



1st-order or **primary** consumers eat producers.
2nd-order or **secondary** consumers eat primary consumers.
3rd-order or **tertiary** consumers eat secondary consumers.

Decomposers

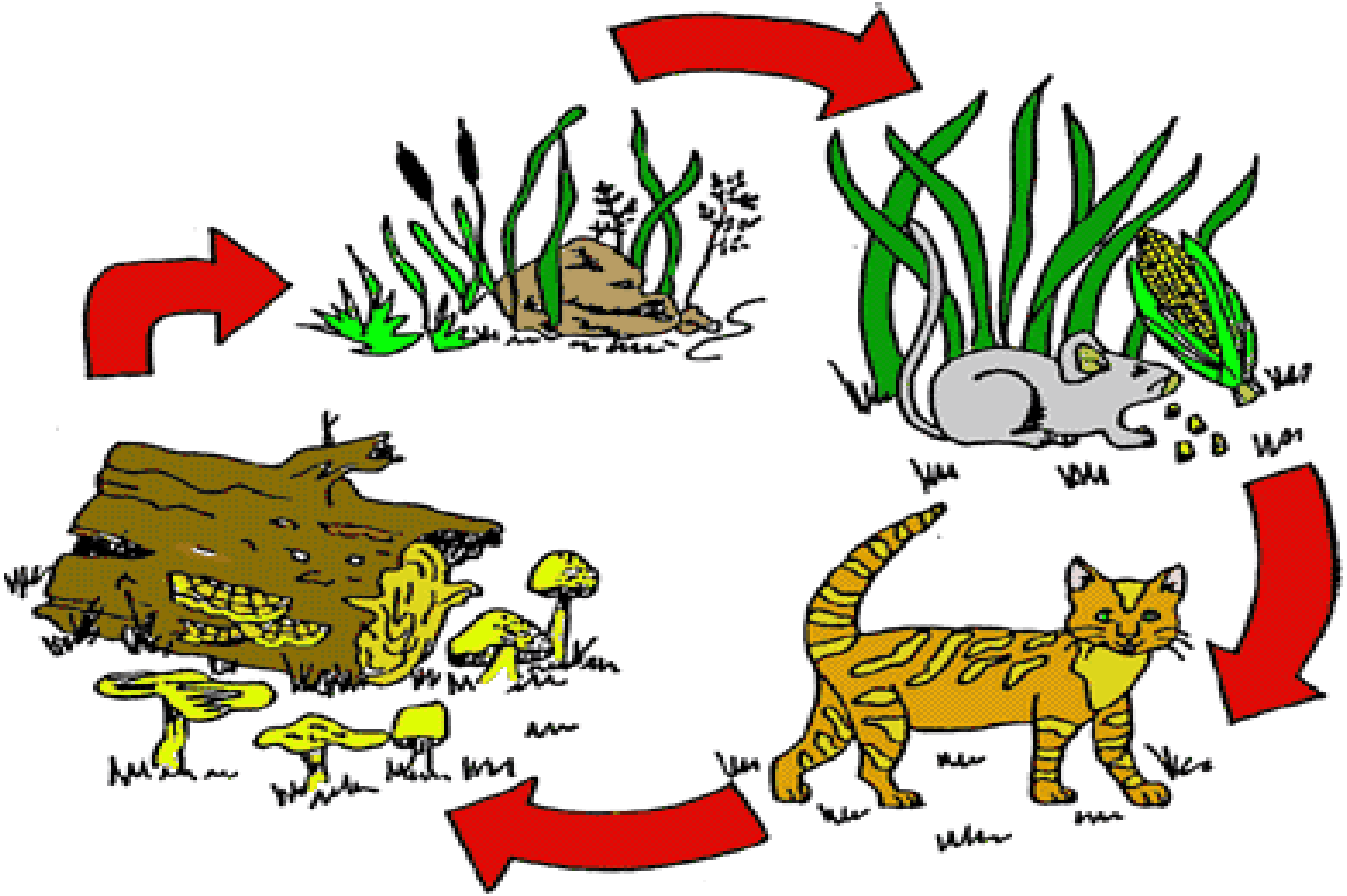
- Simple organisms that obtain their food from dead organisms and wastes.
- For example in Figure 6.3 on page 94 of your text the colony of bacteria, protozoa, and flatworms are all decomposers.
- Decomposers are so named because they are actually responsible for decomposing dead organisms.

Producer/Consumer/Decomposers

- Similarities—all three are terms referring to the way organisms obtain food & energy
- Differences—the way they obtain food. Producers make it, consumers eat it, decomposers feed on wastes & dead material.

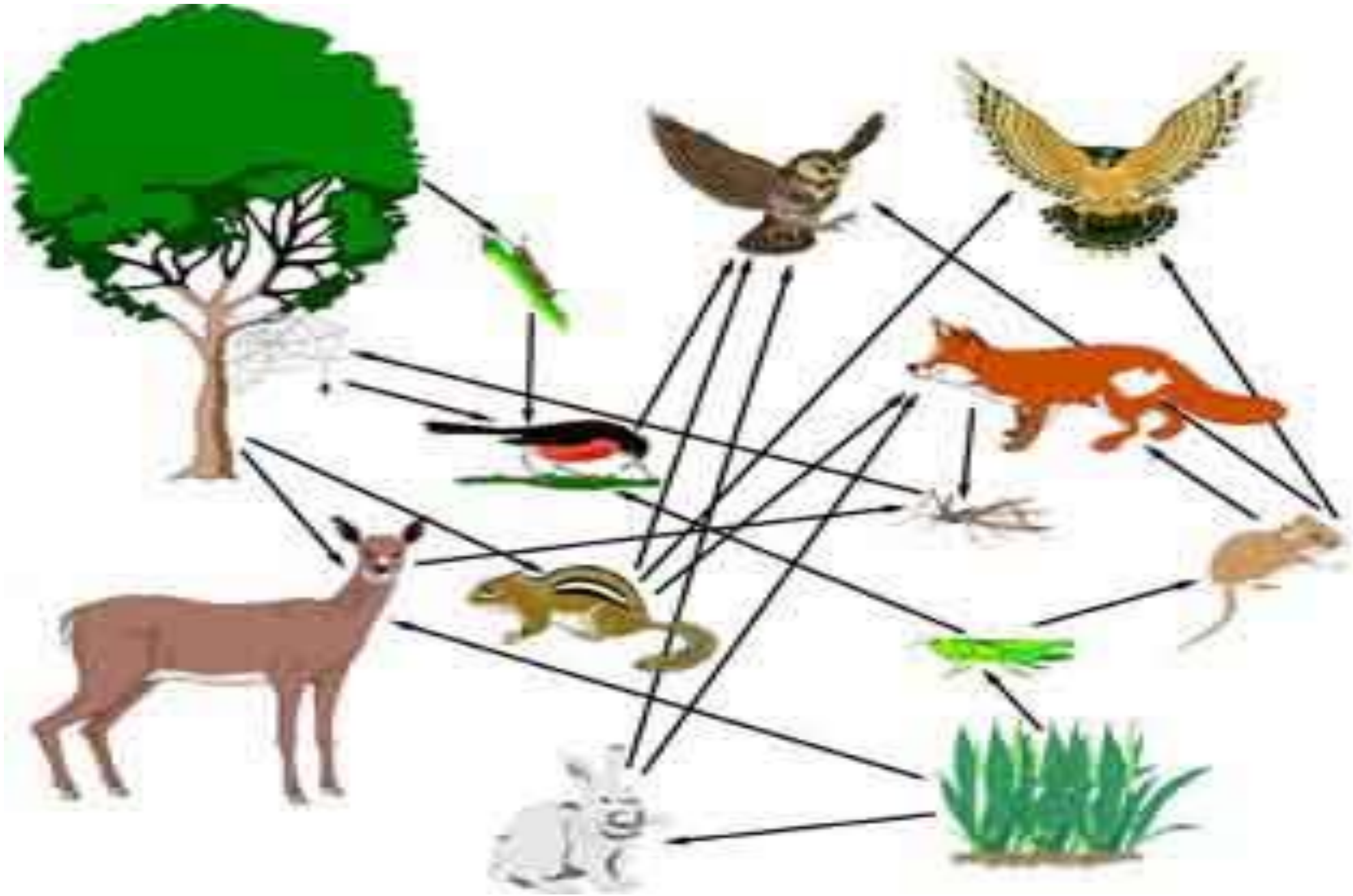
Food Chains & Food Webs

- **Food chain**: linear sequence representing the flow of energy & nutrients from the simplest plant to the top carnivore.
- an example of a food chain from fig. 6.4. P. 95
  - Tree → insect → insect-eating bird → hawk
    - Producer: Tree
    - 1st-order consumer: insect
    - 2nd-order consumer: insect eating bird
    - 3rd-order consumer: hawk



Food Chains & Food Webs

- **Food web**: a series of interconnecting food chains in an ecosystem.
- Figure 6.4 on page 95 of your text book depicts a food web in a temperate deciduous forest.
- Similarity—both food chains and food webs show the flow of nutrients and energy in an ecosystem.
- Differences—Food webs are: more complex; composed of several food chains; a more realistic picture of an ecosystem.



Energy Flow in an Ecosystem

- Using figure 6.5 on page 95 you can summarize the main energy flows in an ecosystem:
  - the Sun is the source of all ecosystem energy;
  - producers make food via photosynthesis;
  - consumers eat plants and other consumers to get energy;
  - each time energy moves from one organism to another, energy leaves the system in the form of heat;
  - decomposers return nutrients to the soil but energy is not recycled.

Ecosystem Balance & Food Pyramids

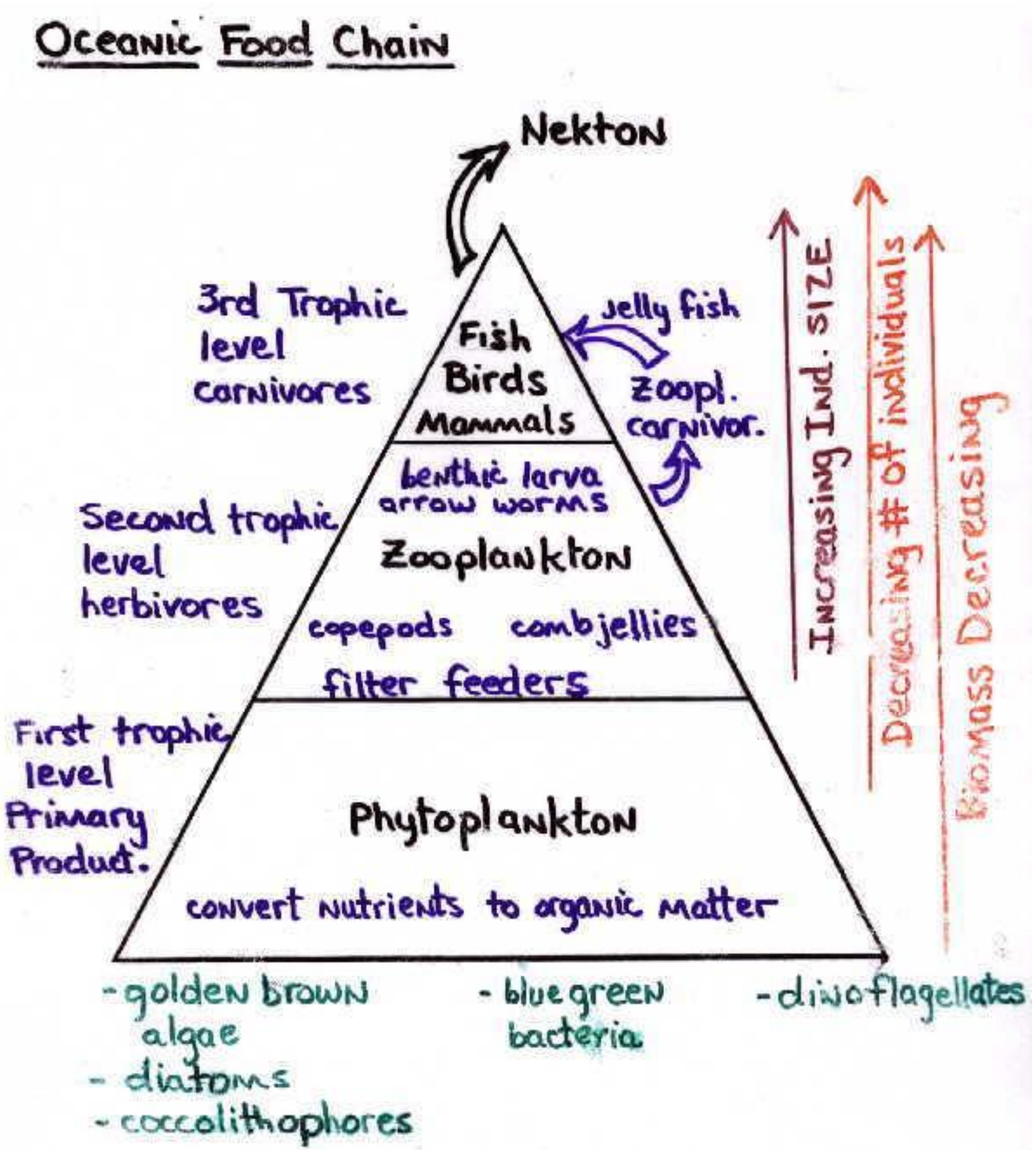
- The student will be expected to demonstrate an understanding that the relationships among the living and non-living elements of an ecosystem are delicately balanced, including the following delineations:
  - 3.2.1 Define the term biological amplification. (k)
  - 3.2.2 Explain why there are fewer organisms at each trophic level. (k)
  - 3.2.3 With reference to a food pyramid, explain how pesticides can reach toxic levels for organisms at a higher trophic level.
  - 3.2.4 Predict the effect on an ecosystem of the introduction of a new organism. (i)

Food Pyramid

- is a diagram showing each trophic level as a horizontal bar;
- producers are located on bottom & higher trophic levels are placed on top of each other;
- each bar is drawn in proportion to the mass of organisms, giving the triangle shape.

Pyramid of Numbers

- There are fewer organisms at each increasing trophic level:
  - **less energy available** at each increasing level;
  - fewer organisms can obtain energy to live;
  - therefore fewer organisms at increasing levels.



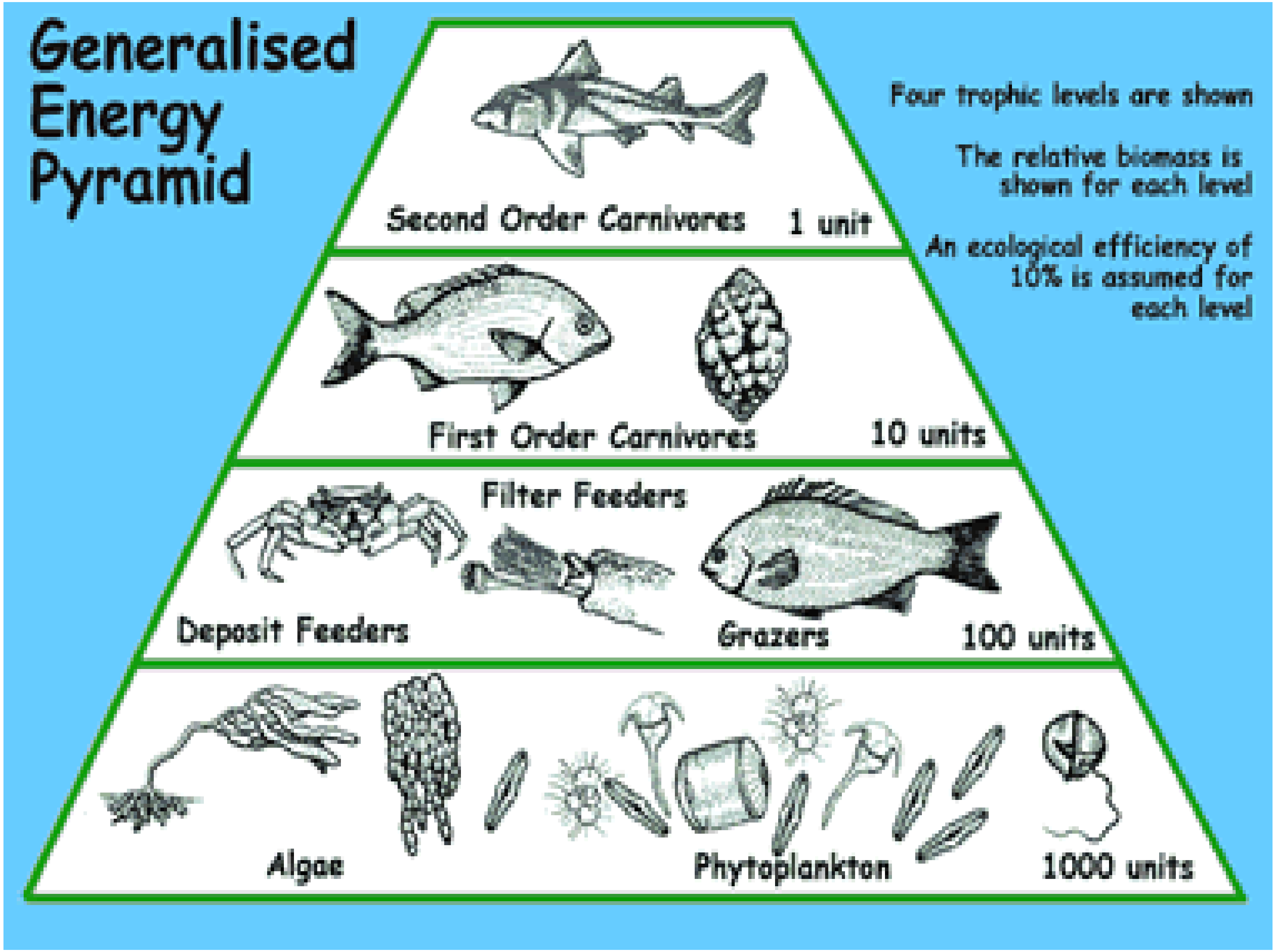
Pyramid of Energy

- There is a **high degree of energy loss** at each trophic level.
    - The producers only store **1% of the sun's energy** as food energy.
- Each consumer level loses energy AS YOU GO UP the pyramid.

Pyramid of Energy

- **A Consumer level loses energy for several reasons:**
  - much of the energy is lost as heat;
  - most of the energy is used to carry out life functions. EX: we burn many calories of energy each day…so do all organisms;
  - if an organism dies without being eaten, the energy goes to the decomposers and not up the trophic levels;
  - so only about **10-15%** of the energy is stored as usable food energy at each level.

- **Let’s start with 1000 units of energy at the producer level then: (diagram next slide)**
  - the primary consumers would only have 100-150 units of food energy stored for the next level;
  - the secondary consumers would only have 10-15 units of food energy stored for the next trophic level;
  - the tertiary consumers would only have 1-1.5 units of food energy stored as food **energy—it is easy to see why we do not often see a quaternary trophic level**


Generalised Energy Pyramid
Four trophic levels are shown
The relative biomass is shown for each level
An ecological efficiency of 10% is assumed for each level
Second Order Carnivores
1 unit
First Order Carnivores
10 units
Filter Feeders
Deposit Feeders
Grazers
100 units
Algae
Phytoplankton
1000 units

Magnification of Toxin Levels

- **Biological Amplification**
  - is the term used to describe the fact that higher trophic level receive a higher dose of food chain toxins.
- **Biological Amplification** has occurred in our environment. The most common case was that of **DDT** which was used to control insect populations.
  - DDT is a particularly dangerous toxin because it is **fat soluble** and stays in an animal's fat. (Some poisons are water soluble and can be excreted from the system.)
  - Lower order organisms ingest some poison which may or may not affect them.
  - **Higher order organisms eat large numbers of lower order organisms.** *Therefore a small amount in a frog becomes large in a hawk that eats 100 frogs*.

Upsetting the Balance

You will learn

- In this lesson you will:
- 3.2.4 Predict the effect on an ecosystem of the introduction of a new organism.

Upsetting the Balance

- Ecosystems are in a very delicate balance. Changing one thing in the ecosystem will have a domino effect through the system because of the relationships that exist.

  - Question #13 on page 98 is about a pond ecosystem with blue gill sunfish. This is a sample question.

Upsetting the Balance

- Ecosystems are in a very delicate balance. Changing one thing in the ecosystem will have a domino effect through the system because of the relationships that exist.

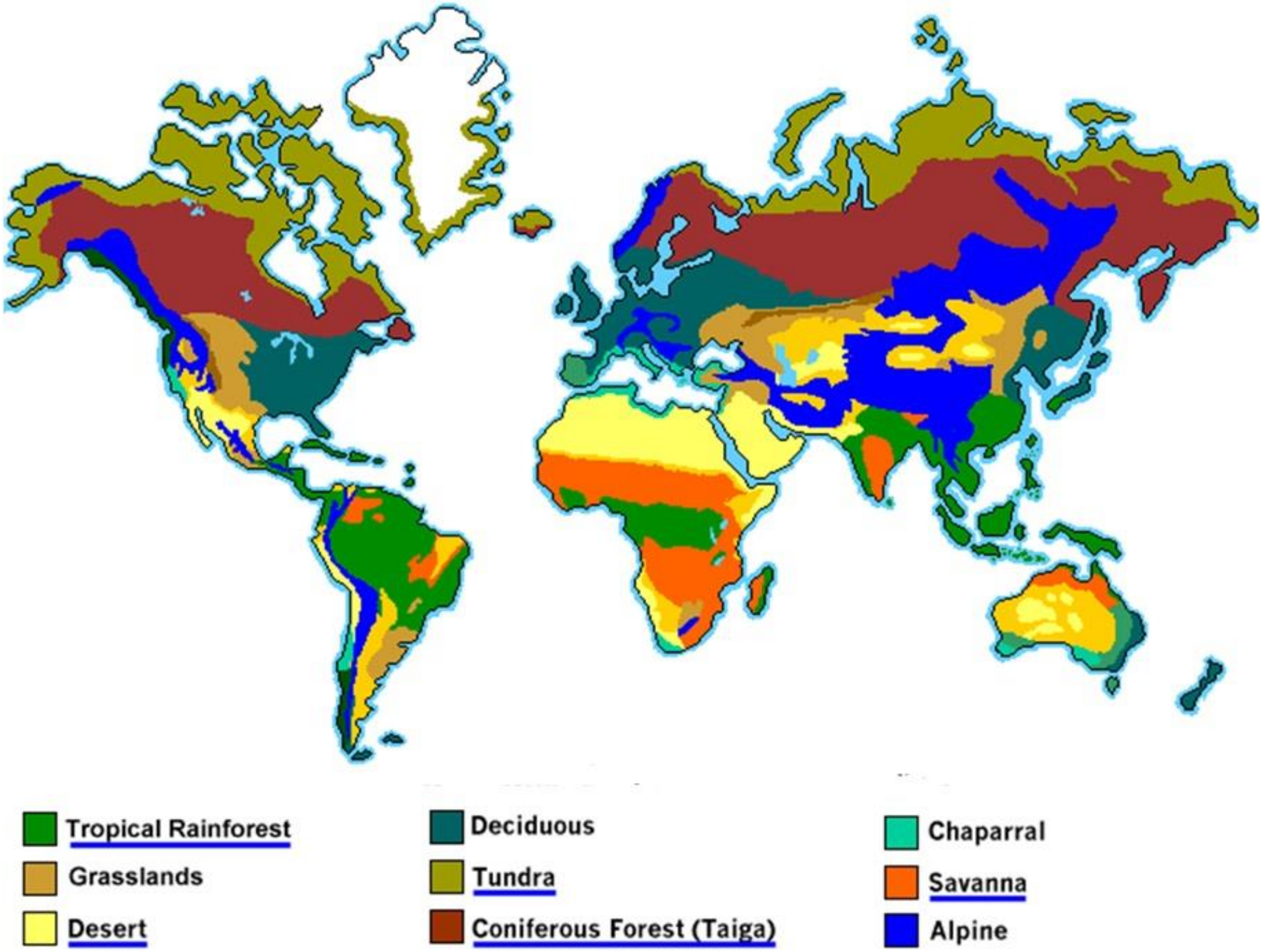
Any question could be asked where we have to predict possible outcomes. Question #14, 15 & #16 p. 98 make perfect review questions for the test.)   "Balance in the Ecosystem" Lab

High Latitude Ecosystems

- three major type of ecosystems found in **high latitude regions**:
  - **Coniferous (Boreal) Forests**
  - **Tundra**
  - **Polar Ice Caps**

Coniferous (Boreal) Forests

- ***Climax vegetation…*****evergreen trees** with:
  - needle-like leaves
  - thick bark
  - conical shape
  - dense growing which blocks sun.
- ***Location***:
  - **found only in the northern hemisphere**
  - located in a broad band **across Northern North America and Northern Eurasia**.
    - Shown in the following map as **dark red**
    - Analyze the world ecosystem map (figure 6.8) on page 102.

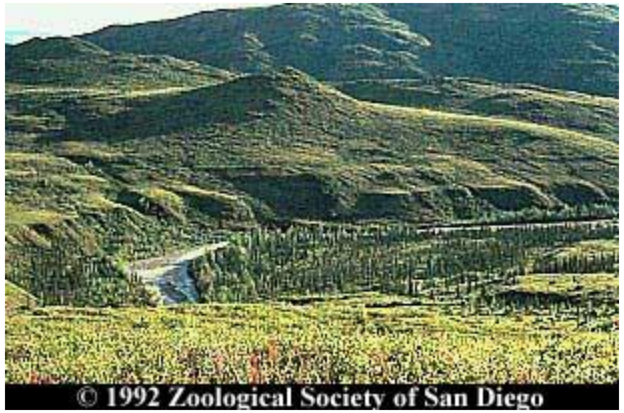

Tropical Rainforest
Grasslands
Desert
Deciduous
Tundra
Coniferous Forest (Taiga)
Chaparral
Savanna
Alpine

Coniferous (Boreal) Forests

- Coniferous trees are well ***adapted*** **to lack of water in winter** (it is all frozen):
  - **needle leaves** reduce surface area for **transpiration** (loss of water out of leaves)
  - **drooping branches** and **conical shape** allow heavy snow to fall off relieving the pressure;
  - **thick bark** reduces water loss.
- ***Climate***: **temperate cold winter**.
    - Look at figure 6.8 on page 102 and locate the boreal forest; then turn to page 75 and locate the temperate cold winter (sub arctic) climate region. They match very closely.

Tundra

- ***Climax vegetation*…grasses, shrubs and low plants** with:
  - shallow roots
  - fast reproduction/flowering cycles.
- ***Location:***
  - **found only in the northern hemisphere**
  - located **north of the Boreal forest** across Northern North America and Northern Eurasia.
  - can be seen by analyzing the world ecosystem map (figure 6.8) on page 102.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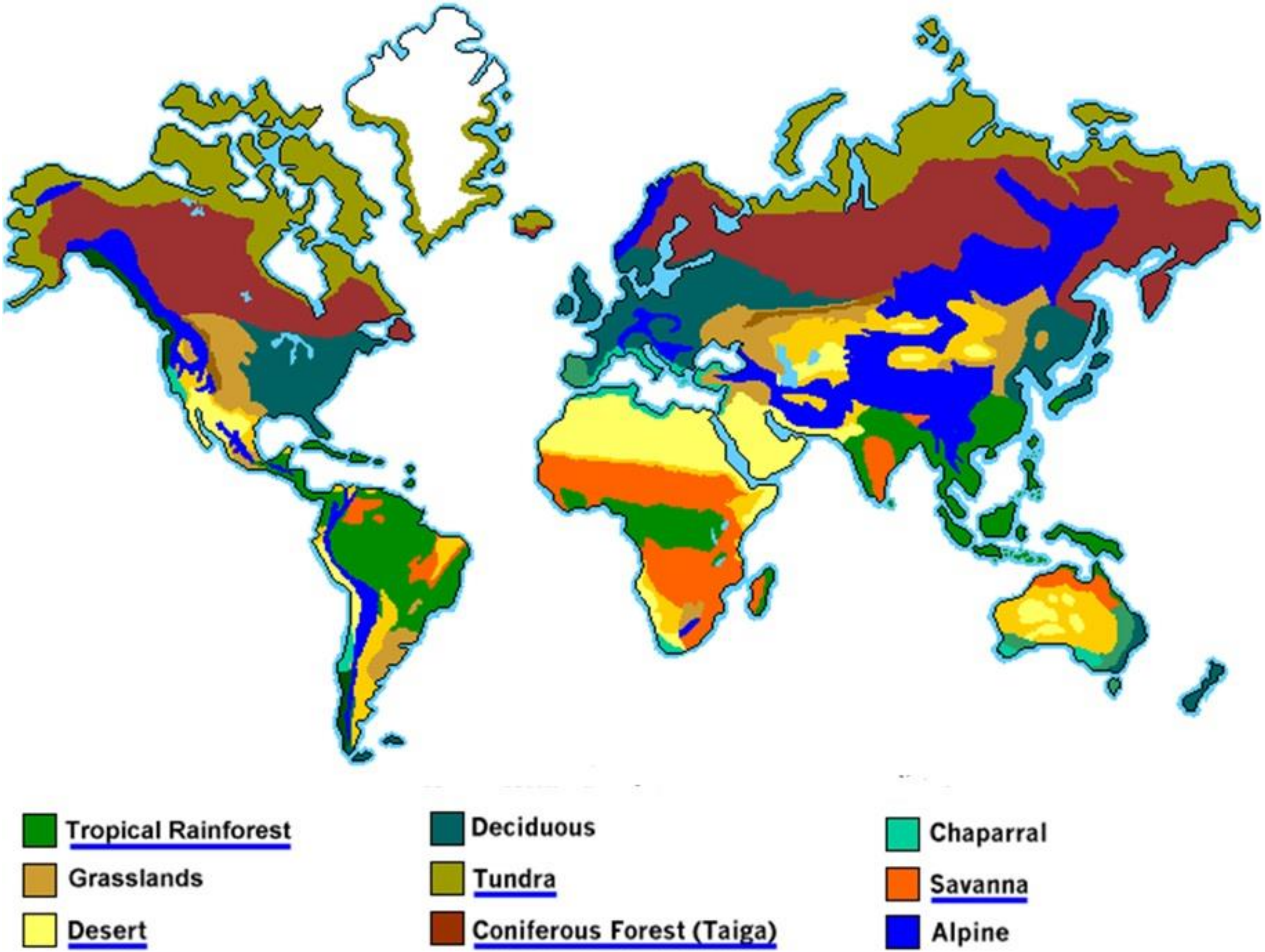
Tropical Rainforest
Grasslands
Desert
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Coniferous Forest (Taiga)
Chaparral
Savanna
Alpine

Tundra

- The shrubs and bushes are well ***adapted*** to the extreme climate of the north where winter is long and summer is very short:
  - **shallow roots** are needed because **1-3 meters below the surface the soil is completely frozen** (Permafrost)
  - the **fast flowering and reproduction cycle** is needed because the **growing season is very short**, lasting only 1-2 months.

Tundra

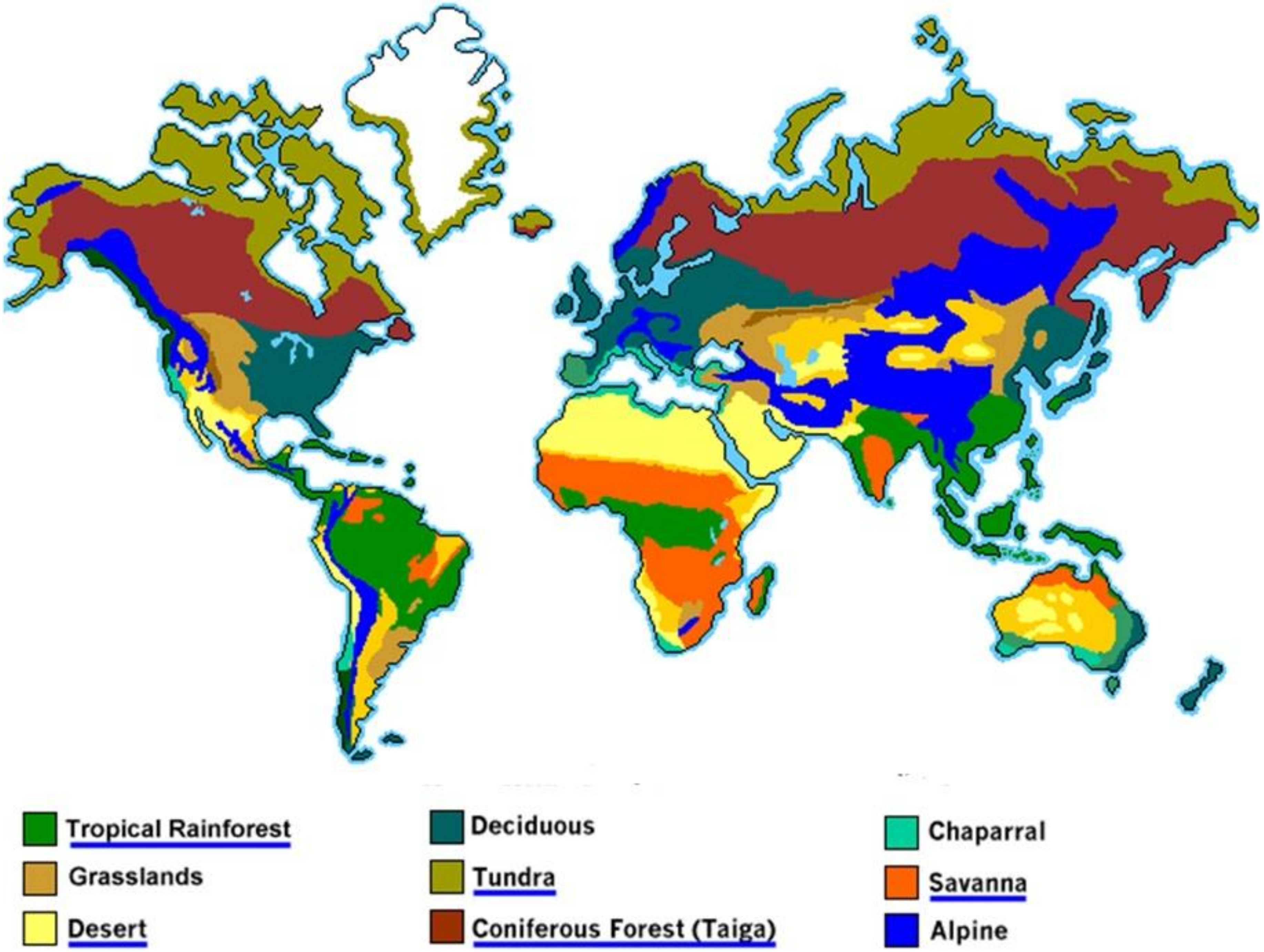
- Animals have a variety of ***adaptations*** to the harsh Tundra climate.
  - **hibernation** from the cold winter
  - **In-migration**…summer season and **out-migration**…winter season is a common strategy for birds and even larger animals like caribou
  - the development of **insulating features like thick fur & fat insulation** is common among polar bears and other mammals
  - **white fur/feathers** to help with camouflage is another common adaptation.

Tundra

- **Climate**: so definitive of the tundra that it is called **Tundra climate**.
  - Look at figure 6.8 on page 102 and locate the Tundra; then turn to page 75 and locate the Polar (Tundra) climate region. They match very closely.

Polar Ice Caps

- ***Climax vegetation:*** **Phytoplankton** beneath the ice.
- ***Location***: in **both hemispheres** and only in the **extremely high latitudes**.
    - It can be seen by analyzing the world ecosystem map (figure 6.8) on page 102.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Polar Ice Caps

- The ***adaptation*** of producers to this ecosystem is extreme.
- There is no land for the producers to grow in so there are only small phytoplankton to form the base of the food chain.
- Animals have a variety of ***adaptations*** to the harsh Polar ice cap climate similar to the Tundra:
  - **In-migration/out-migration**
  - **insulating features like thick fur & fat insulation**
  - **white fur/feathers**




Polar Ice Caps

- ***Climate***: so definitive of the Polar ice cap that it is called **Polar (ice cap) climate**.
  - Look at figure 6.8 on page 102 and locate the Polar ice cap; then turn to page 75 and locate the Polar (Ice cap) climate region. They match very closely.
  - Complete Question #19 on page 102 of your text book.

Mid Latitude Ecosystems

- Continued: In this lesson you will:
  - 3.3.1 List the general characteristics of a given ecosystem. (k)
  - 3.3.2 Analyze patterns in the distribution of world ecosystems. (a)
  - 3.3.3 Predict which kind of ecosystem is likely to result from a stated set of climatic conditions (i)

Mid Latitude Ecosystems

- **Temperate Grasslands**

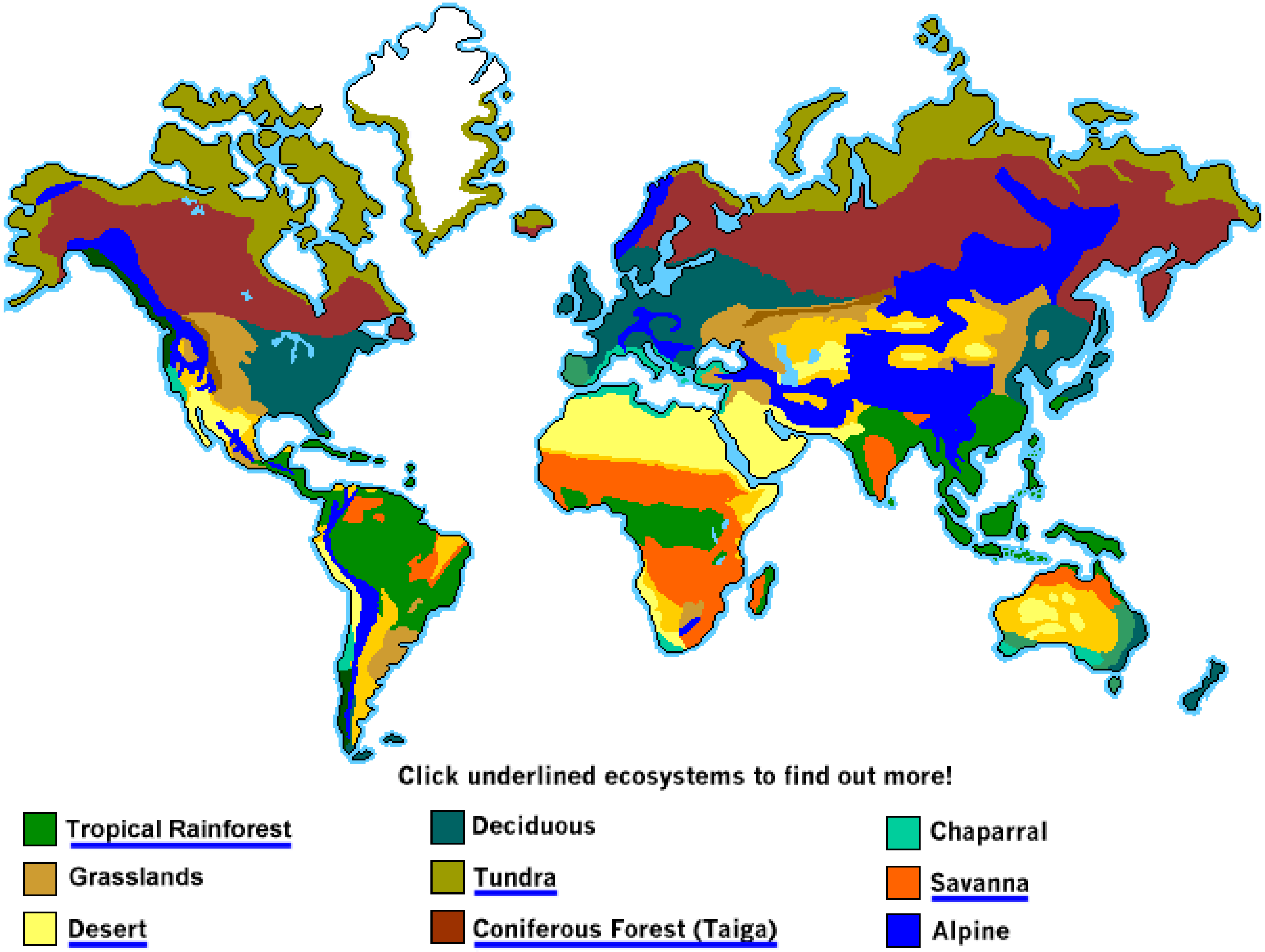
- **Temperate Deciduous Forests**

- **NOTE: Refer to the world ecosystem map (figure 6.8) on page 102**

Temperate Grasslands

- ***Climax vegetation…*****grass** with:
  - **shallow roots**
  - a **small water requirement**.
- ***Locations***: North America, South America, Australia and Eurasia.
- **Adaptations:** Grasses are well adapted to lack of water:
  - the **small size of the plant** means that it **requires less water**.
- ***Climate***: **semi-arid** in most locations but in **some regions it is temperate cold winter**.

  - Look at figure 6.8 on page 102 and locate the temperate grassland; then turn to page 75 and locate the semiarid climate region. They match very closely.


Click underlined ecosystems to find out more!
Tropical Rainforest
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Deciduous
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Coniferous Forest (Taiga)
Chaparral
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Alpine

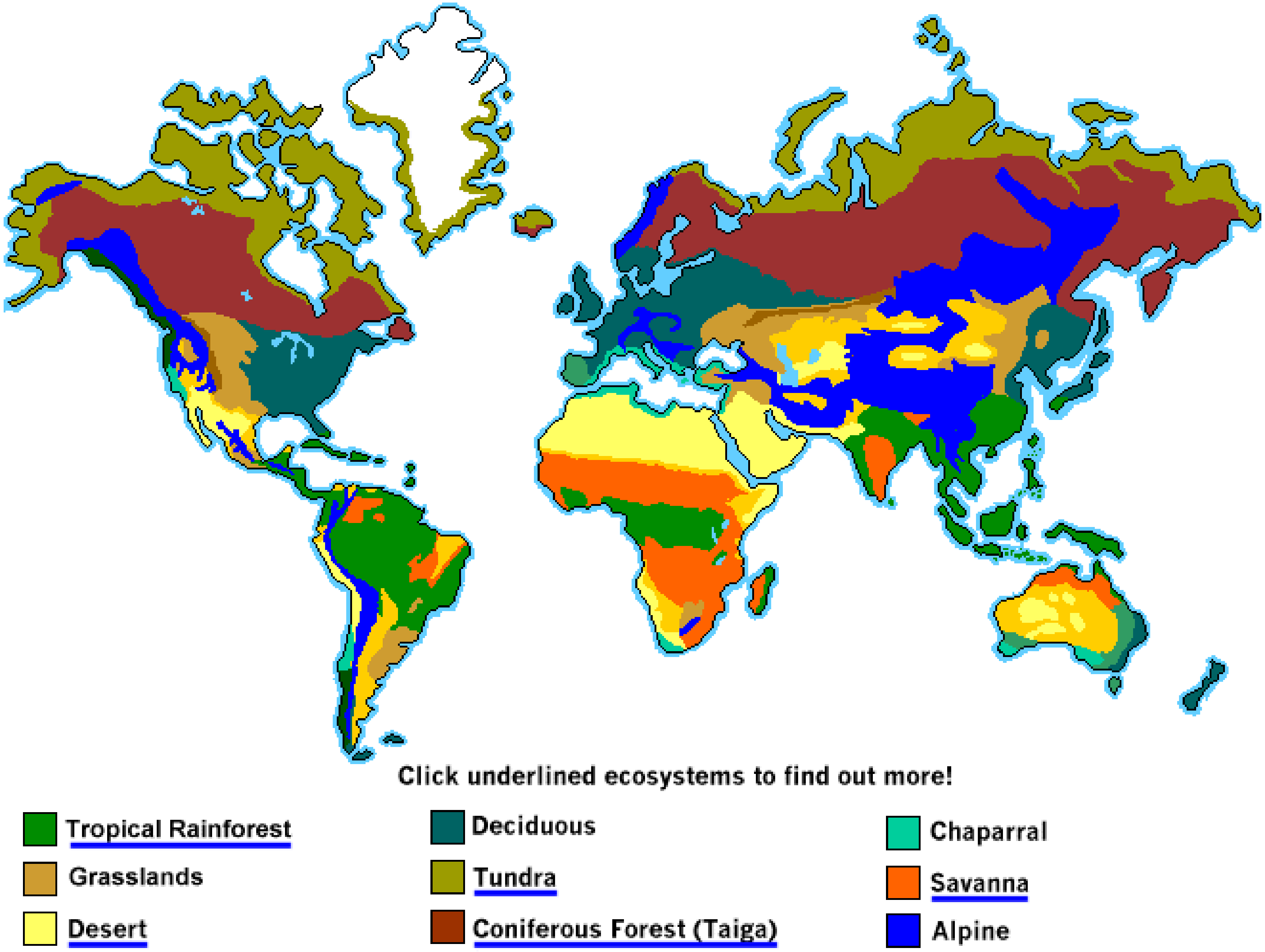
U.S. Fish and Wildlife

Temperate Deciduous Forests

- ***Climax vegetation:*** deciduous trees like **oak, birch and maple** which:
  - lose leaves in fall/winter
- ***Location:*** mainly in North America and South America but is present in Australia and Europe and Asia.
- It can be seen by analyzing the world ecosystem map (figure 6.8) on page 102.
- **Adaptations:** Deciduous trees are well ***adapted*** to lack of water in winter.
  - Losing their leaves in winter helps them reduce water loss. Most water loss occurs through the leaves.

- ***Climate***: **<u>temperate mild winter.</u>**

  - Look at figure 6.8 on page 102 and locate the Temperate forests; then turn to page 75 and locate the temperate mild winter climate region. They match very closely.
  - Complete question #22 on page 104 of your text book.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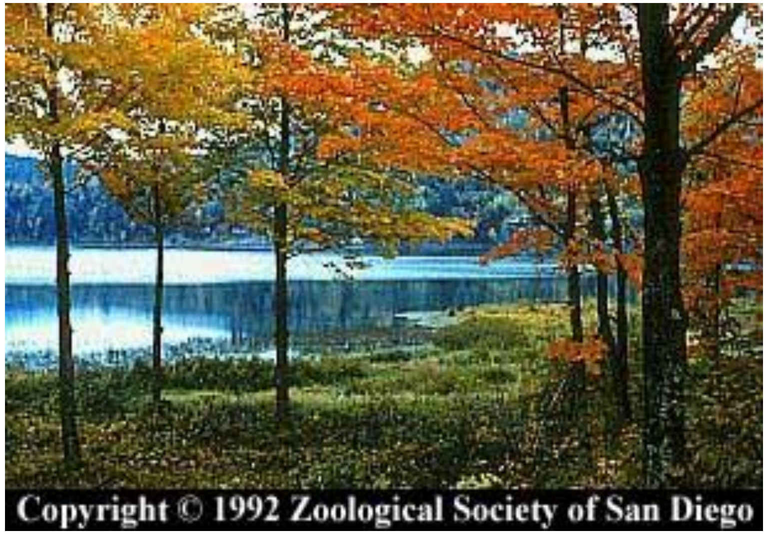
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Low Latitude Ecosystems

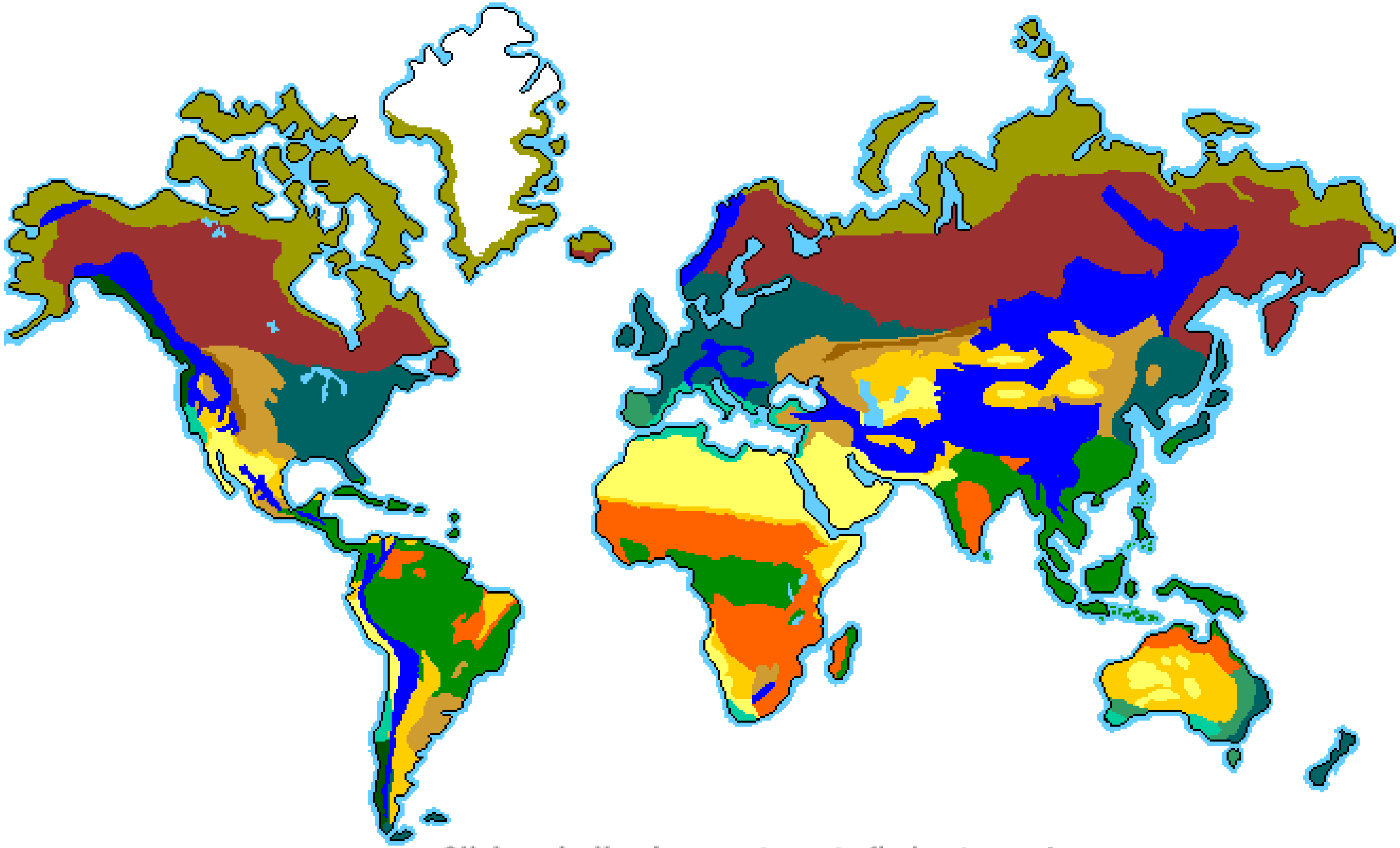
- **Four ecosystems in this section:**
  - **Tropical Rain Forests**
  - **Savanna Grasslands**
  - **Deserts**
  - **Mountain Ecosystems**

Tropical Rain Forests

- ***Climax vegetation***: **tall evergreen broadleaf trees** with:
  - **Buttress roots** (also called stilt or prop roots)
- ***Location:*** South America, Africa, Australia and Southeast Asia and is **contained within the tropics**.
  - It can be seen by analyzing the world ecosystem map (figure 6.8) on page 102.
- The tall trees are well ***adapted*** to the thin soil with buttress roots to help support their height. (figure 6.15 on page 108)







Click underlined ecosystems to find out more!

- Tropical Rainforest
- Grasslands
- Desert
- Deciduous
- Tundra
- Coniferous Forest (Taiga)
- Chaparral
- Savanna
- Alpine

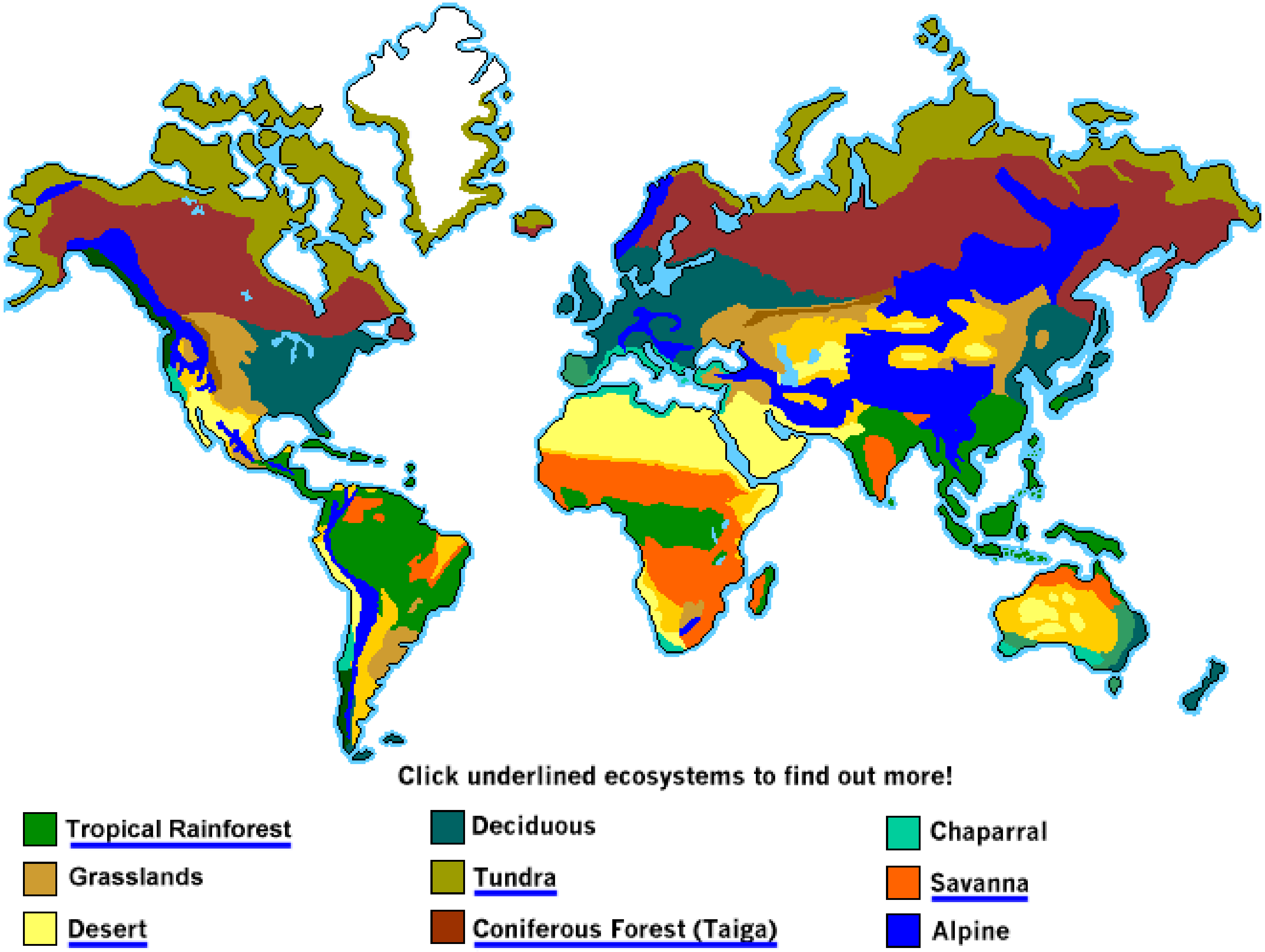
Tropical Rain Forests

- Some plants are **epiphytes** (a plant that grows on another plant) which are well ***adapted*** to the rain forest.
  - They reach the sun by lying in the canopy while they get water through roots that hang in the air and absorb moisture.
- Some animals are ***adapted*** to spend their entire life in the canopy.
- ***Climate:*** **Tropical wet** in most locations but in **some regions it is tropical wet and dry**.

  - Look at figure 6.8 on page 102 and locate the Tropical rain forest; then turn to page 75 and locate the tropical wet climate region. They match very closely.

Savanna Grasslands

- ***Climax vegetation***…grass with:
  - shallow roots
  - small water requirement.
- ***Location***: South America, Australia, Africa and Southeast Asia.
    - It can be seen by analyzing the world ecosystem map (figure 6.8) on page 102.
- Grasses are well ***adapted*** to lack of water:
  - the small size of the plant means that it requires less water.
- ***Climate***: **tropical wet & dry** in most locations but in some regions it is **semi-arid**.
    - Look at figure 6.8 on page 102 and locate the Savannas; then turn to page 75 and locate the Tropical Wet and dry climate region. They match very closely.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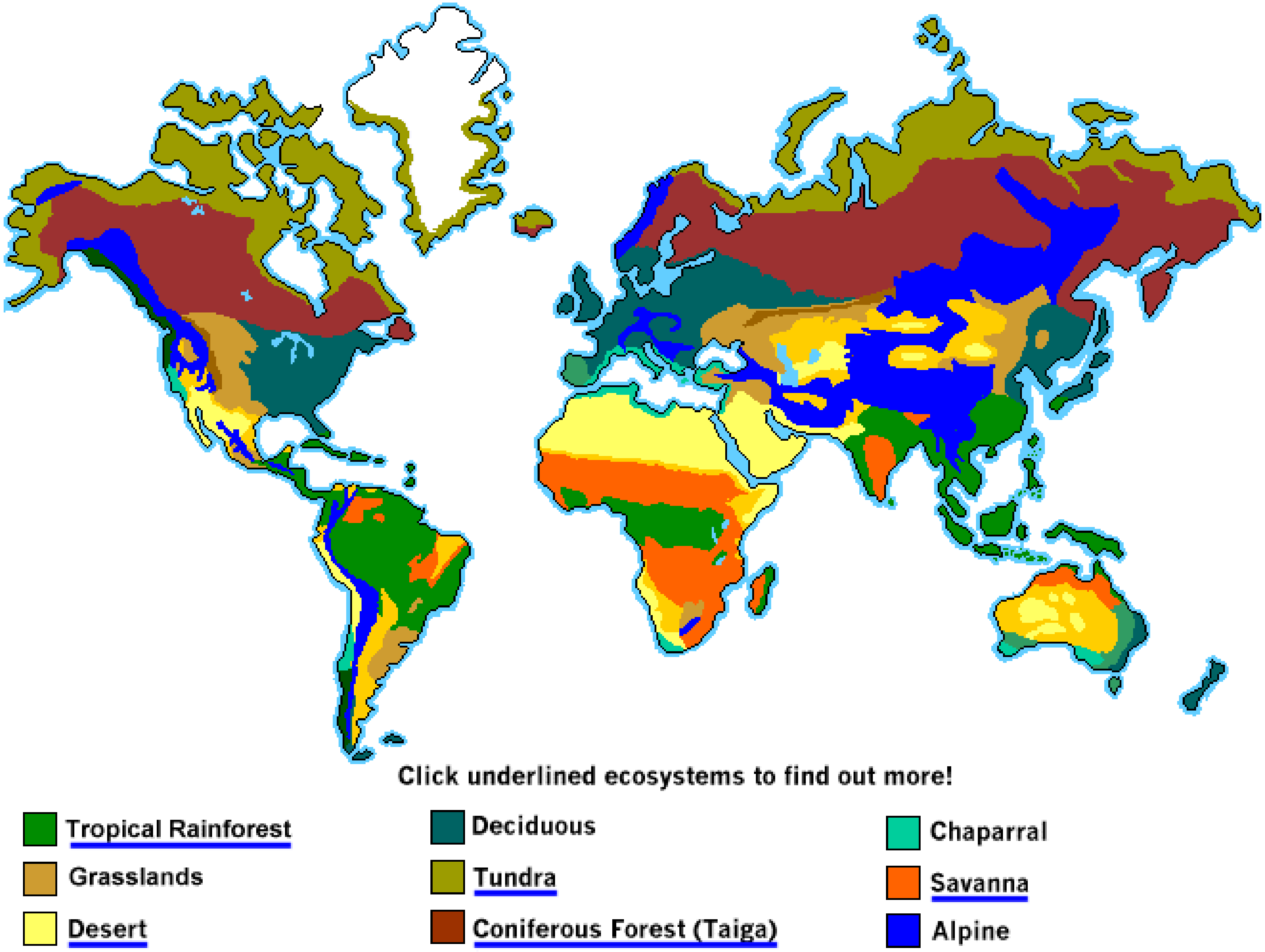
Deserts

- ***Climax vegetation***: cacti and fleshy plants with:
  - long roots
  - water storage capability
  - leaves modified as needles.
- ***Location***: North America, South America, Australia, Africa and Asia.
- Deserts are mostly concentrated in two bands around the earth **10-30˚ North and South of the equator**.
    - It can be seen by analyzing the world ecosystem map (figure 6.8) on page 102.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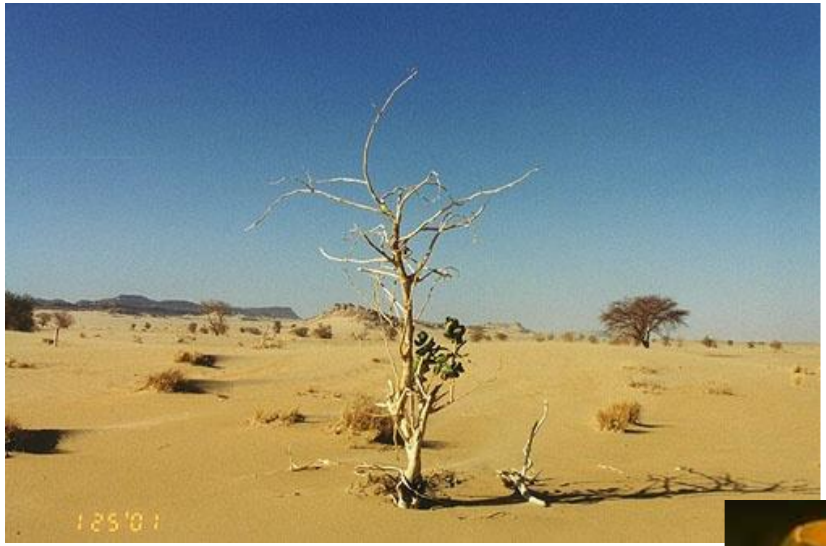
Deserts

- Cacti are well ***adapted*** to lack of water. They are often referred to as **Xerophytes**:
  - **long roots** help them obtain water deep in the water table
  - **water storage capability** gives them the ability to endure long periods without rain
  - **leaves modified as needles** reduces the surface area for transpiration and helps reduce grazing which would severely increase water loss.





Deserts

- Many animals have unique ***adaptations*** to the desert:
  - deer mice can get all the water they need from the food they eat;
  - toads have the behavioural adaptation of hibernating thorough the driest seasons;
  - some reptiles reduce water loss by excreting solid uric acid crystals instead of water containing urine;
  - some mammals have the adaptation of nocturnal behaviour, which keeps them out of the day time heat.
- ***Climate:*** Arid
  - Look at figure 6.8 on page 102 and locate the Deserts; then turn to page 75 and locate the arid climate region. They match very closely.

Mountain Ecosystems

- Mountains ecosystems are not exclusively low latitude…**they occur in most latitudes**.
  - As you will see in figure 6.10 on page 104 mountains can contain all types of ecosystems from all latitudes.
- Figure 6.10 on page 104 well-illustrates the fact that **latitudinal succession closely parallels altitudinal succession**.

World View

- Two contrasting **world views** typically exist:

(i) The natural world exists to service human needs and is to be exploited to the fullest.

(ii) Humans are a part of the larger web of life having the same rights as any other being. Basically, we deserve NO MORE NO LESS.

QUESTIONS:

- Which world view do you agree with?
- Is there a middle ground?

World Soils

- You will be expected to demonstrate an understanding of the characteristics of soil quality and the need to reduce the threat to our soils, including the following outcomes:
  - 3.4.1 Describe the factors that affect soil quality. (k)
  - 3.4.2 Analyze the quality of a soil in terms of its soil texture. (a)
  - 3.4.3 Draw conclusions about global patterns related to soil loss. (a)
  - 3.4.4 Assess statements about soil availability. (i)

World Soils

- **Soil**- Defined as the surface layer of the earth.
- True soil must be:
  - Composed of mineral, organic materials , air , and water.
- Soil characteristics include:

1. Mineral material
2. Organic materials
3. Air
4. Moisture
5. **Soil texture**

- The key factor in the development of soil is **climate.**
- Climate provides moisture needed to determine if the soil will be **“good.”**

1. Mineral Materials

- **Mineral Materials**- are rock particles that have been broken down into sand, silt ,and clay . **These particles give the soil it's structure** .
  - Many of the minerals (eg. Calcium , phosphorous , and potassium) provide nutrients to plants.
  - Soil structure varies with precipitation because heavy rains tend to **leech** soils, removing minerals from the root region of soil.

2. Organic Materials

- **Organic Materials**- are decaying plant and animal remains that form **humus**.
- The humus:
  - **adds soil structure** and **provides nutrients** for plant growth.
  - gives the soil its dark colour.
- A soil's **fertility** is determined as a ratio of the organic content to the content of ground bed rock.

3. Air

- Air is **required for chemical and biological processes** in the soil.
- To function properly, plants need air around their roots . Organisms and humus add air to the soil.

4. Moisture

- Moisture is **necessary for plants to survive** and for the **chemical and physical processes** that weather rock and decay organic materials.
  - Too little/too much moisture can cause issues for plant life as well.

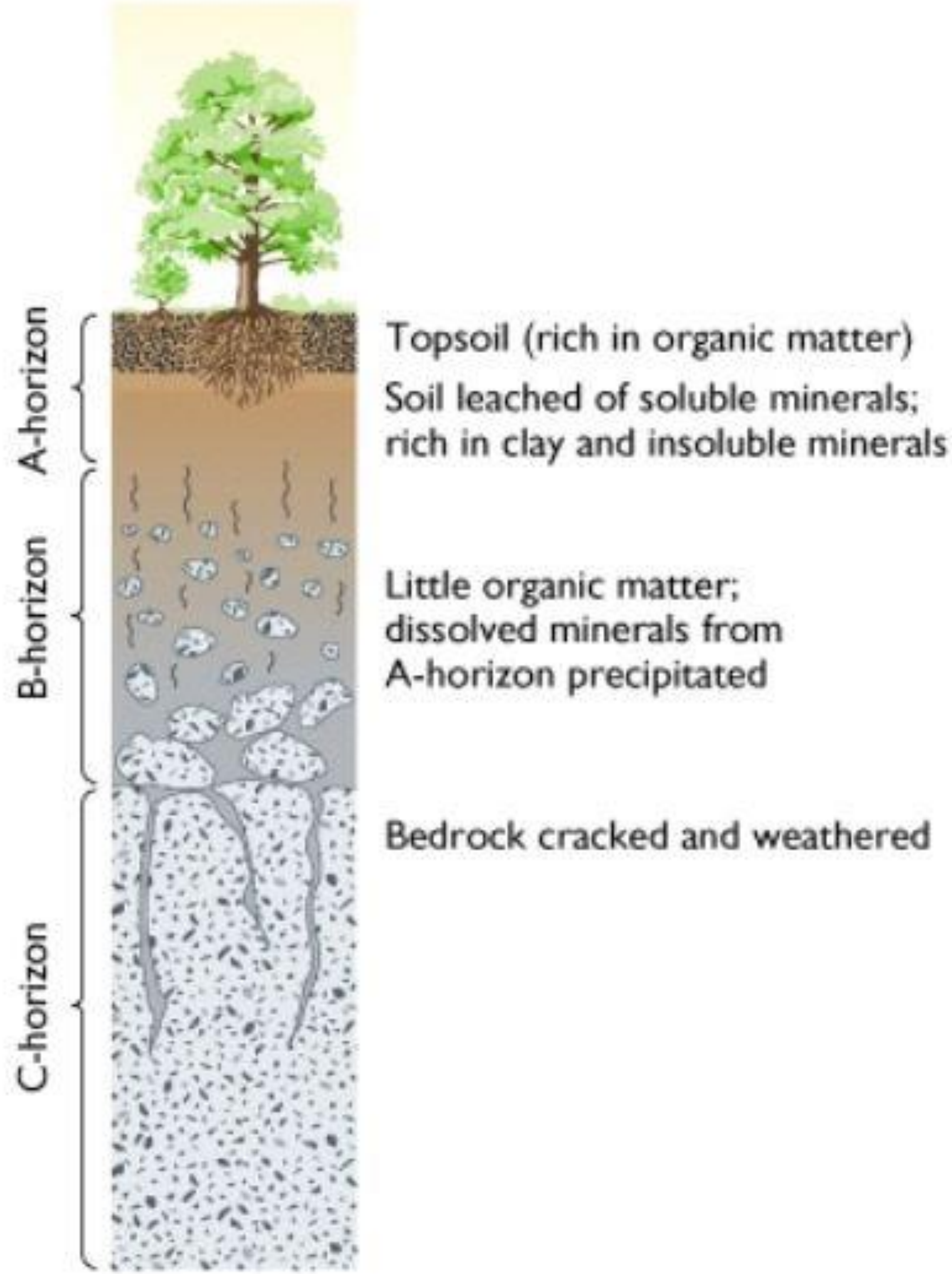
5. Soil Texture

- Refers to the mixture of fine particles (**sand**), very fine particles (**silt**) and extra fine particles (**clay**).
- ***IMPORTANT POINT:*** **The best texture for agriculture is an even mixture of each**.

Soil Profile

- A **soil profile** shows the different horizontal soil layers and the rock layers(bedrock) below the soil.
- A typical soil profile includes:
  - **Topsoil**…typically the top 6 inches (15 cm) of soil.
  - 2nd Layer (**subsoil**): Mineral layer deposited from above
  - 3rd Layer(**parent material**): weathered bedrock
  - 4th Layer: **Bedrock**

Soil Profile

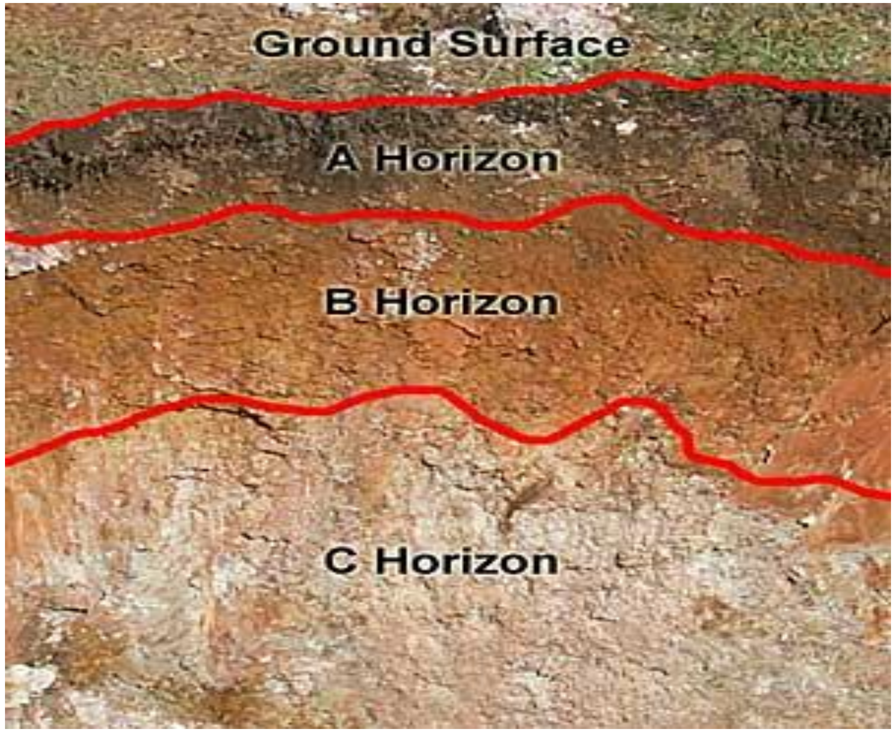


Soil Profile

- **Topsoil** (Top Layer)
  - **Rich in organic materials**, especially near surface.
  - **Dark brown or black** in colour
  - Thickness and quality of the top humus layer is very important for plant life.

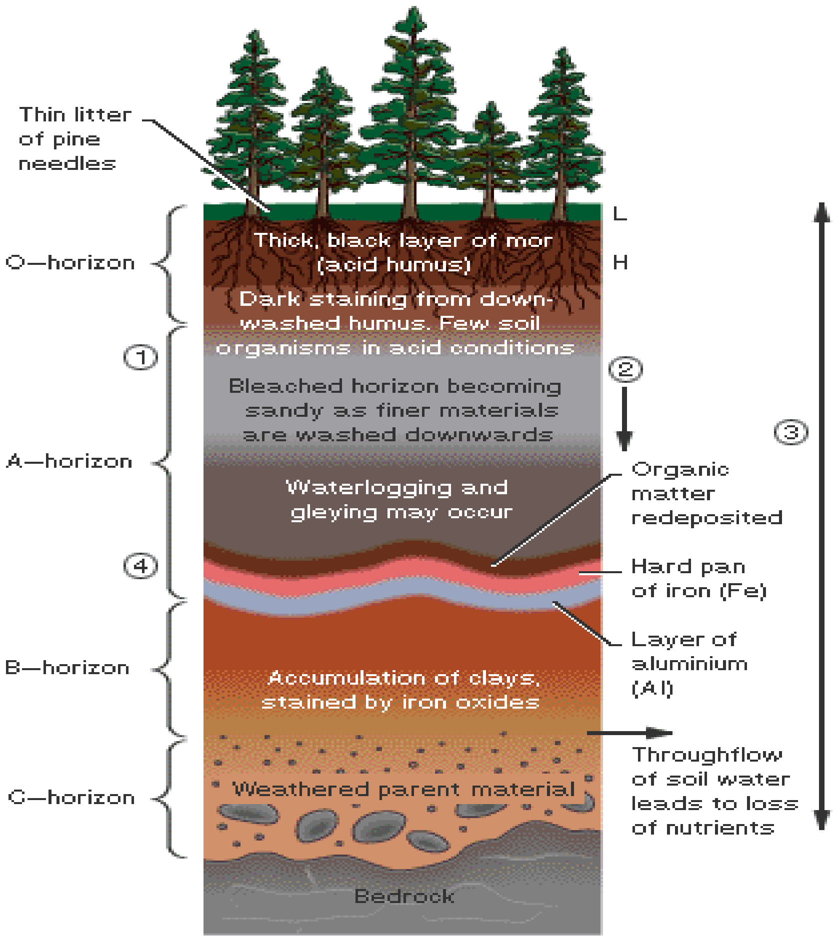
- 2nd Layer- **Subsoil:**
  - **Combined mineral and organic** layer
  - **Lighter brown** in colour

- 3rd Layer- **Parent Material**:
  - Mineral materials **from which soil is made**
  - Usually bedrock, or glacial deposits
- 4th Layer- **Bedrock:**
  - Solid parent material



Three Types of Soil

1) **Podzol**
2) **Chernozem**
3) **Latosol**



① E (zone of eluviation)

② Increasing acidity
Precipitation exceeds evaporation, resulting in leaching of clays, organic matter, bases, oxides

③ Soil depth rarely exceeds 1 m (3 ft)

④ Zone of illuviation

1) Podzol

- These are soils which:
  - widely found in the **boreal forest**
  - tend to be **somewhat acidic**.

2) Chernozem

- These are soils which:
  - tend to be the **best for agriculture**
  - **found in grasslands** which are **semi-arid** resulting in **less leeching** and a **mineral rich soil**.

3) Latasol

- These are soils which:
- are **very infertile** due to the **high amount of leeching**.
- They are **found in tropical rain forests** with high amounts of rain…mineral-poor soil

Environmental Factors Affecting Soil

1) Leeching

- is the **downward movement of water through the soil** which **dissolves the nutrients out of the soil** and carries them away.
  - Found in areas with **high precipitation**.
  - Leeched soil is identified by it **poor, often thin topsoil layer.**

2) Calcification:

- An **upward movement of water** caused by evaporation.
- As water evaporates near the surface of the soil it **leaves behind the minerals**.
  - occurs in areas of **dry climates**.
  - This creates a **thick topsoil layer rich in minerals**.
  - **Too much mineral deposits can create a poisonous salt layer**

3) Temperature: affects the development of humus.

  - Too cold and the decay of organic matter is slowed considerably.

Soil Texture

In this lesson you will:

- 3.4.2 Analyze the quality of a soil in terms of its soil texture. (a)

Soil Texture

- The ***texture*** of soil determines its "value".
    - Refers to the **types of particles** in the soil and **how well they bond to each other** (both affect value)
    - Texture also **affects how well water and air flow**.
- The 3 smallest particle types *(**sand, silt, & clay**)* are the main components of soil.

1) Sandy Soil

- Made up of **85% (+) sand**, with silt & clay making up the rest.
- **Loose & coarse**; sand does not bond.
- Water & air penetrates this type of soil easily; **easy drainage**.
- Not good for large-scale plant growth; **lack of moisture**.

2) Clay Soil

- Consists of **40% clay particles**.
- Fine grains enable bonding.
- Absorbs & holds water very well, **but no air penetration so air-dependent nutrients are absent**.
- this type of soil is **slow to drain & hard to work**.

3) Silty Soil

- Combines basic elements of sandy & clay soil.

- Particles vary in size.

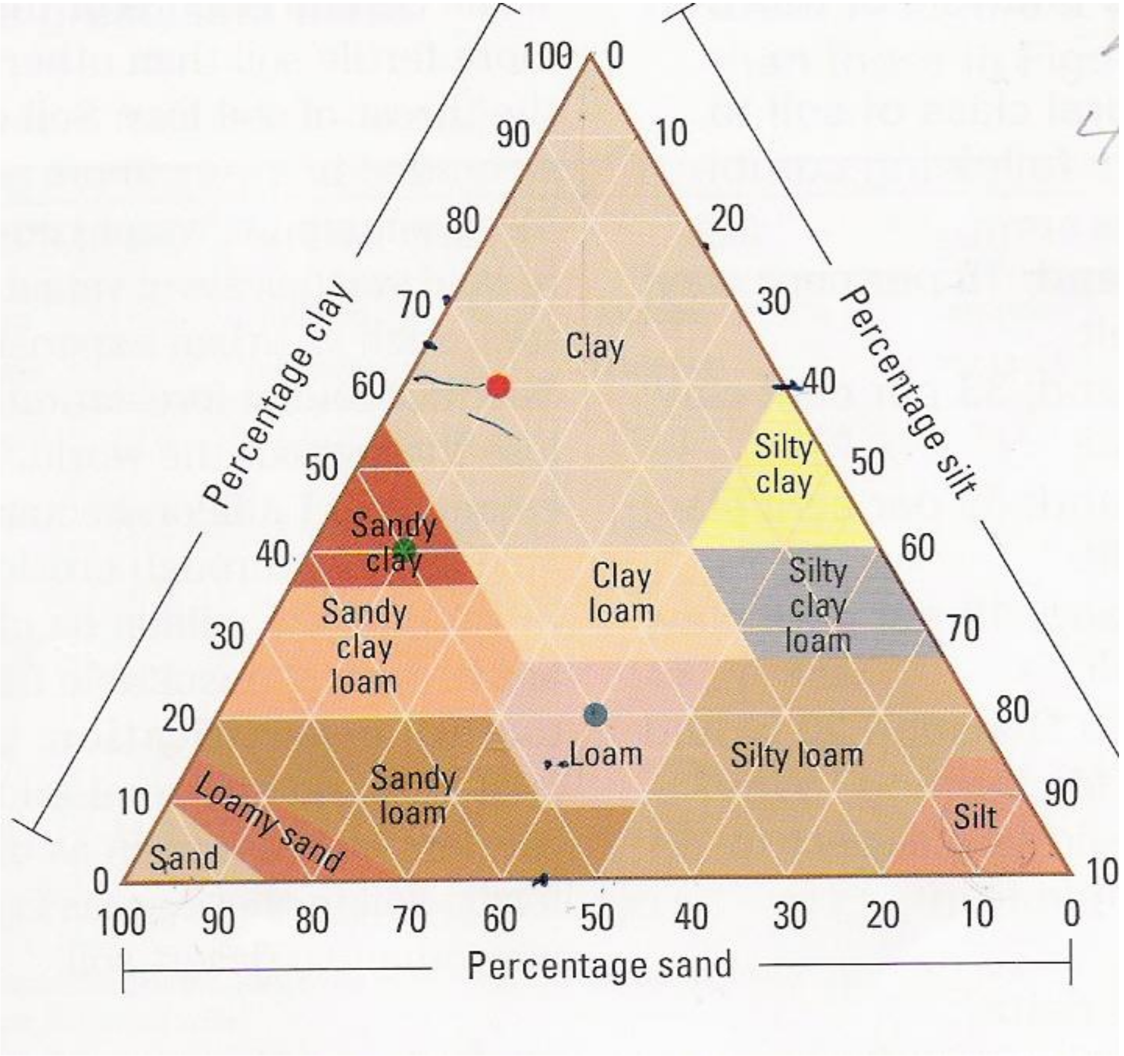
OVERALL

- Best type of soil for farming is a “balanced” combination of sand, clay, & silt particles, which form ***“loam”.***

See. P. 139

Green Dot:
- Clay = 40%
-Silt = 10%
- Sand = 50%

Red Dot:
- Clay = 60%
-Silt = 10%
- Sand = 30%



Blue Dot:
- Clay = 20%
-Silt = 40%
- Sand = 40%

FIGURE 3-16

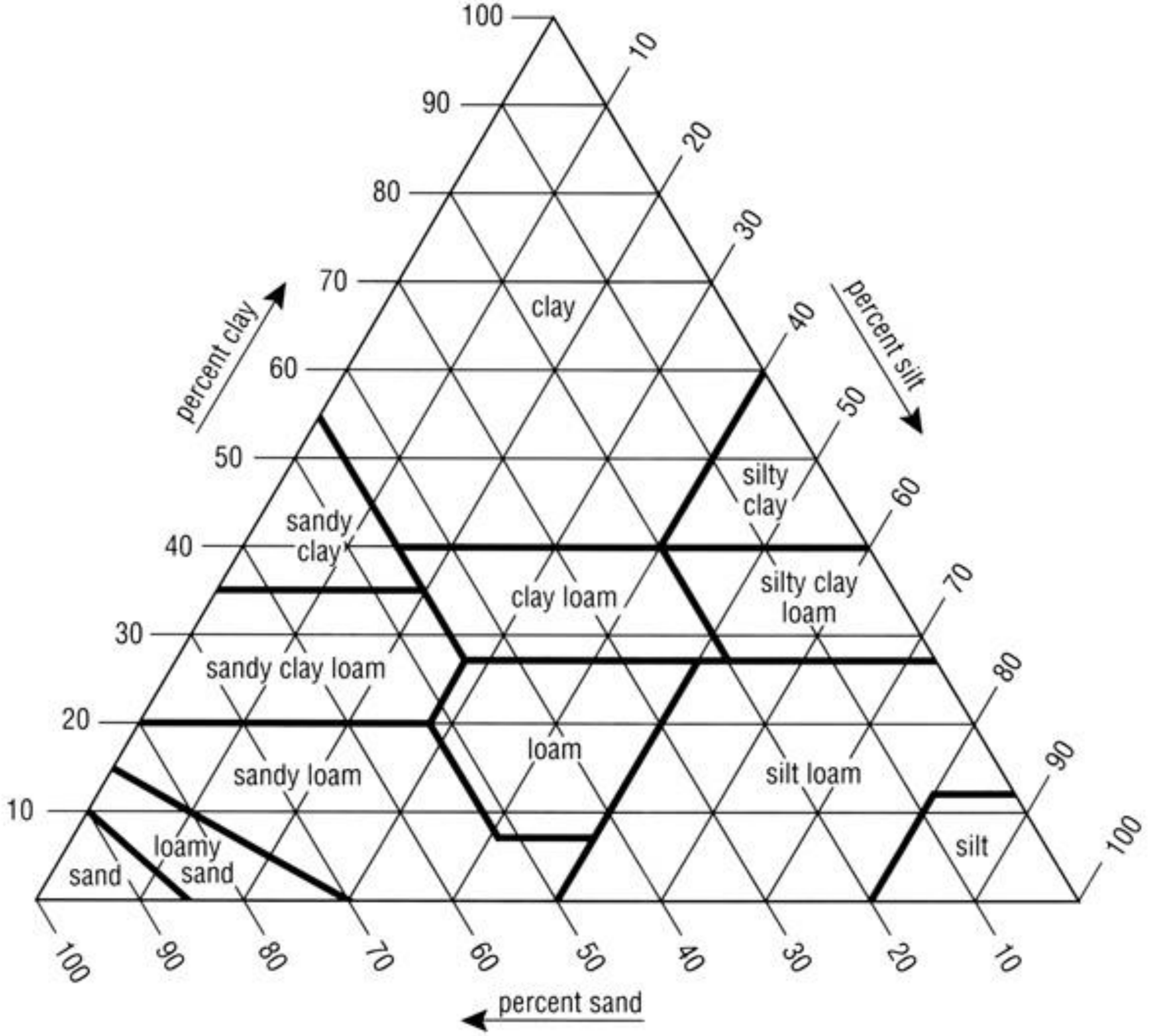
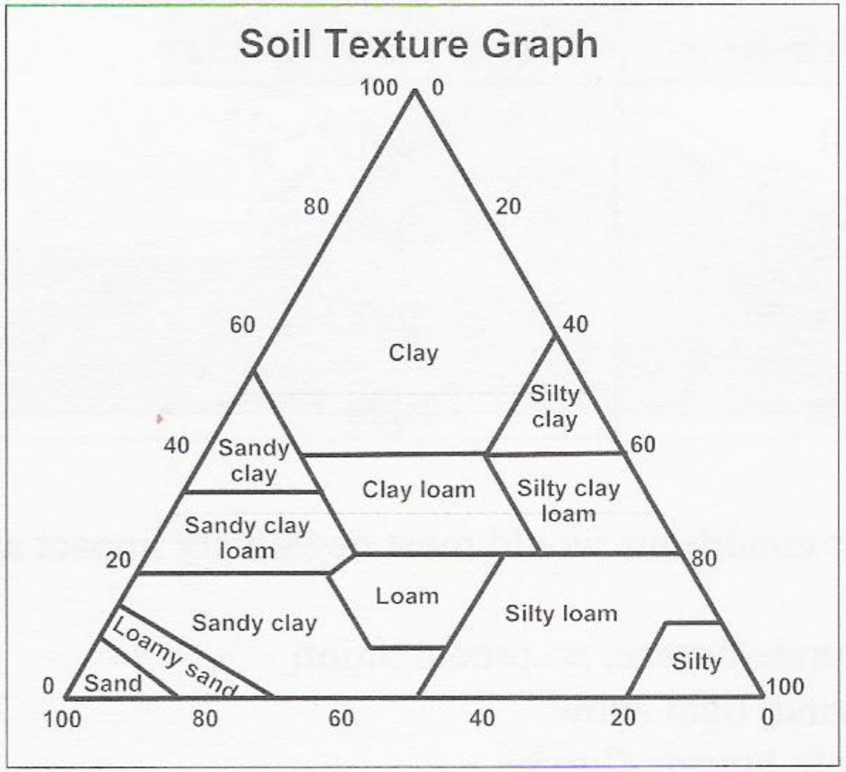


Chart showing the percentages of clay, silt, and sand in the basic textural classes.

21. According to the graph below, which soil texture would be least suitable for farming?



(A) 20% sand, 30% clay, 50% silt
(B) 30% sand, 60% clay, 10% silt
(C) 33% sand, 33% clay, 34 silt
(D) 40% sand, 30% clay, 30% silt

Threats to Soil

In this lesson you will:

- 3.4.3 Draw conclusions about global patterns related to soil loss. (a)
- 3.4.4 Assess statements about soil availability. (i)

Threats to Soil

- While the earth's surface is covered in soil the amount of fertile soil valuable for agriculture is limited and is dwindling yearly.
- Poor soil management can lead to loss of fertile soil.
- Grasslands are semi-arid regions with extremely fertile soil.
- However, if proper soil management is not practiced these are among the most fragile places.

Desertification

- **Desertification-**is the process by which land becomes desert

- **Drought and overpopulation** are main causes

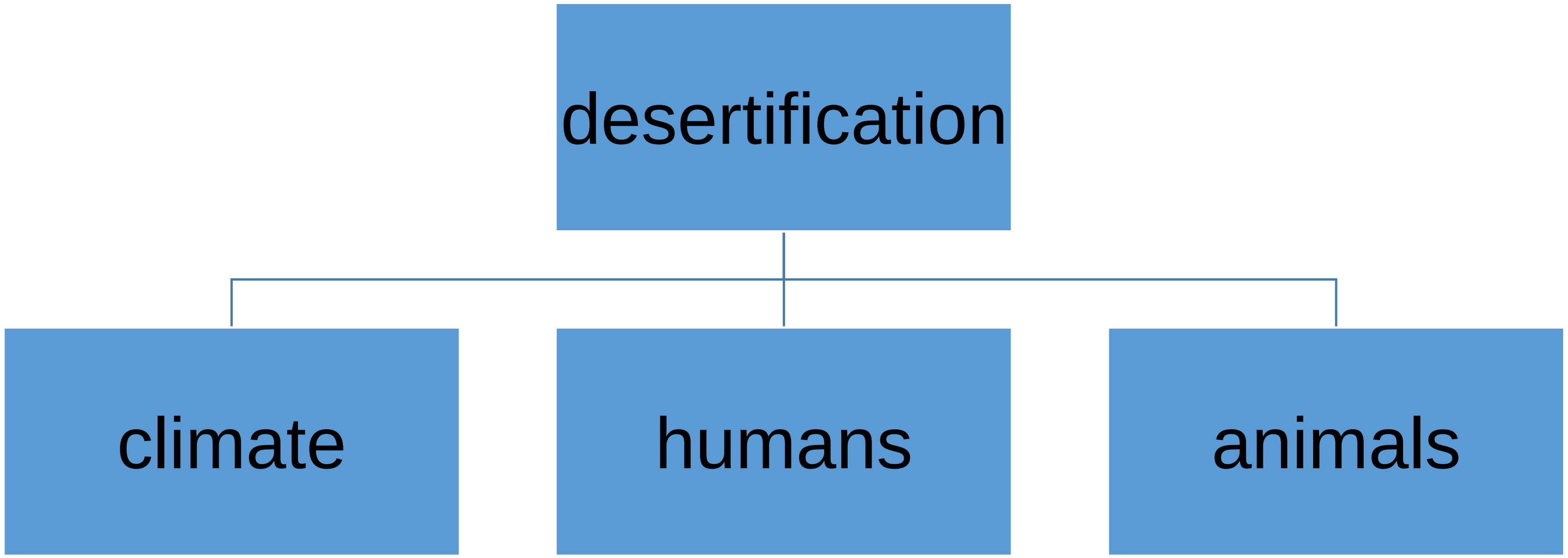
- **Signs**
  - ◆**Lowering of water table**
  - ◆**Marked reduction of water supply**
  - ◆**Progressive destruction of native vegetation**
  - ◆**Accelerated soil erosion**

Case Study: The Sahel

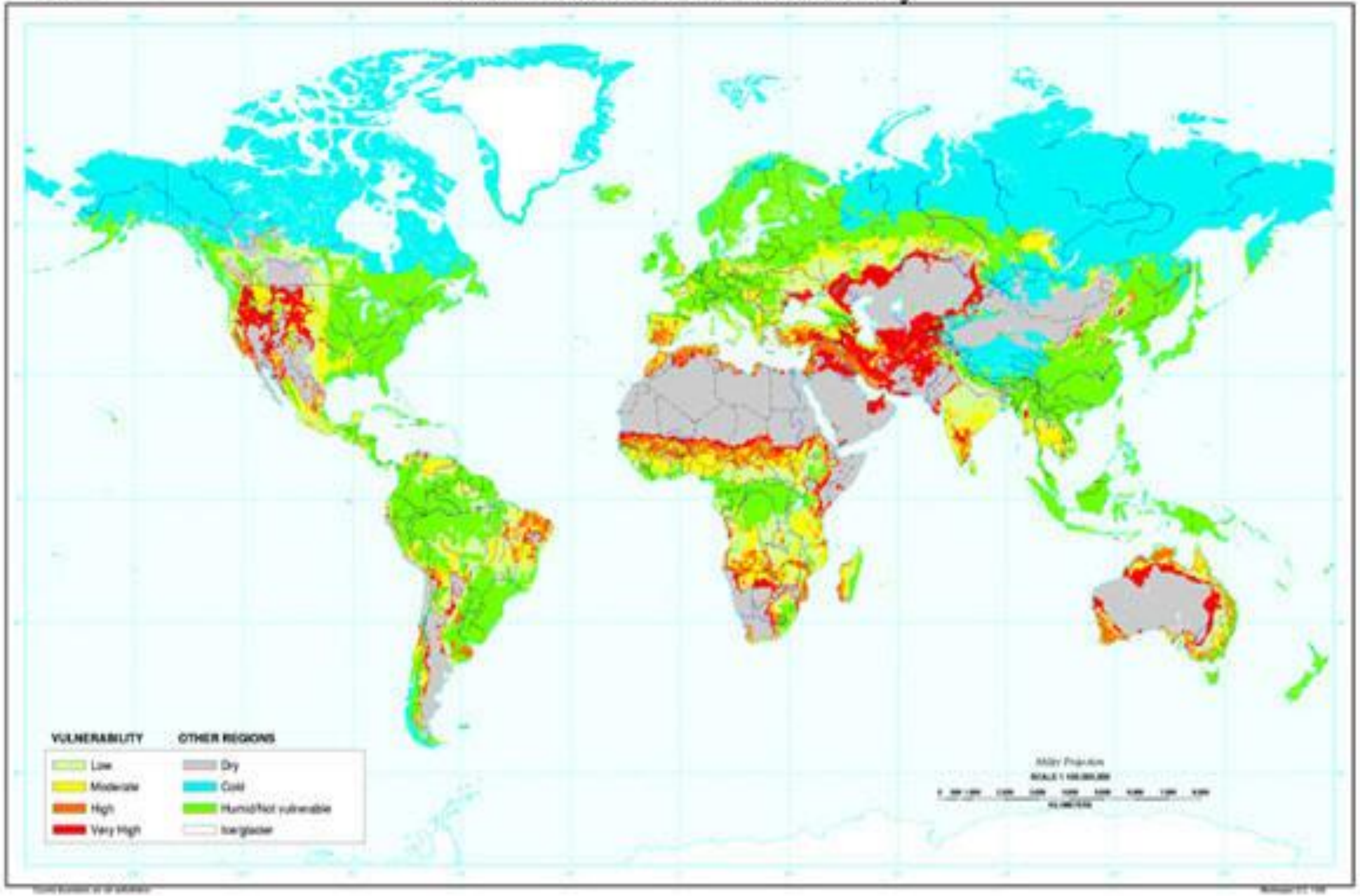
- **The Sahel is becoming more like desert with thin, dry, sandy soils**
- **Soil erosion has created bare rock**
- **Vegetation is sparse**

Desertification- Map of the Sahel

Each of these factors has contributed to desertification



Global Desertification Vulnerability



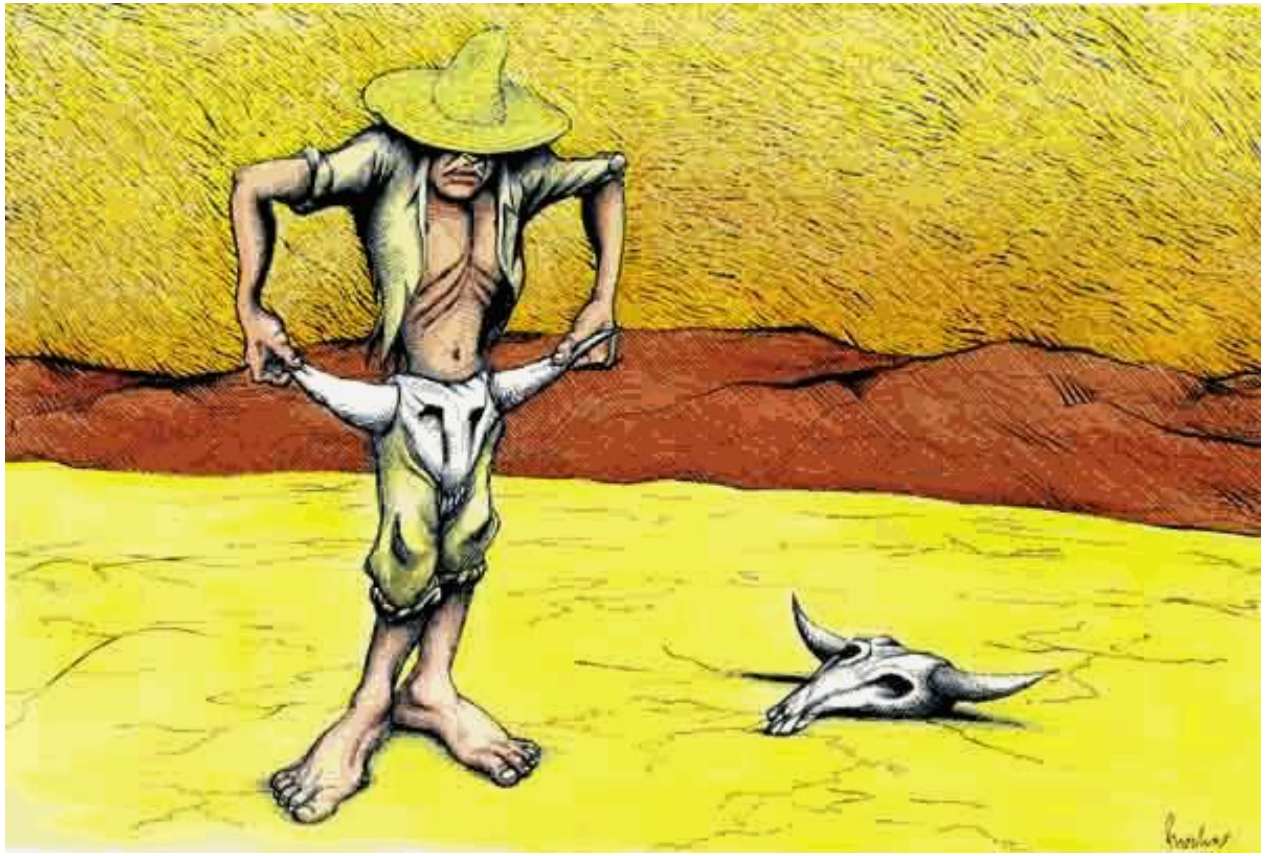
Human activity

- **Population is high and increasing fast.**
- **To increase food supplies more crops are grown and more cattle kept leading to over-cultivation and over-grazing.**
- **Yields decline and cattle are undernourished and die.**
- **Demand increases for water as population grows.**
- **Trees are cut down for fuel supplies.**
- **Less vegetation; more dry, bare soil; more wind erosion.**

Animals/insects

- **Locusts destroy the crops.**
- **Overgrazing means all vegetation is eaten.**
- **Animals trample the ground reducing it to dust.**
- **Animals die and can't breed.**

What are the effects of desertification?



Starvation

- Food and water shortages lead to malnutrition, famine, disease and high death rates.

??????????????????

Aid Programmes

Large numbers of people become dependent on food aid programmes.

Migration

- From rural to urban areas causing over-population in towns.

- To refugee camps.

How can we solve the problems of desertification?

- **In the short-term, provide food aid and water supplies to prevent suffering.**
- **Improve water supplies by building large reservoirs and drilling deeper wells.**
- **Conserve water in local small-scale schemes**
- **Encourage sustainable farming practices (using locally-made tools, not tractors).**
- **Provide drought-resistant seed such as millet (northern Nigeria). GM crops.**
- **Tree planting schemes to reduce soil erosion (Mauritania).**
- **International action to reduce the causes of global warming.**

Solving the Problems: the results

Before

After

Which scheme do you think solved these problems?

Problems?

- **Civil wars, as in Ethiopia and Sudan prevent aid reaching stricken areas and cause mass migration to refugee camps.**

- **Population growth continues to outstrip food supplies.**