

ECOLOGY

Washington State Life Sciences Content Standards and Student Performance Expectations

Content Standard “A” (9-11 LS2A)	Student Performance Expectation
Students know that:	Students are expected to:
Matter cycles and energy flows through living and nonliving components in ecosystems. The transfer of matter and energy is important for maintaining the health and sustainability of an ecosystem.	<ul style="list-style-type: none"> Explain how plants and animals cycle carbon and nitrogen within an <i>ecosystem</i>. Explain how matter cycles and <i>energy</i> flows in ecosystems, resulting in the formation of differing chemical compounds and <i>heat</i>.

In other words:

- When studying ecosystems, we look at two different things: (1) The flow of energy and (2) the cycling of nutrients. Because nutrients are made of solid atoms and molecules, they never disappear from the face of the Earth. They just get rearranged into many different molecules. That is, they are constantly being recycled. Thus we say that “nutrients cycle.” Energy, on the other hand, is not a particle, although it is stored in the chemical bonds between atoms. But as atoms get rearranged, a little bit of energy is always given off as heat. Eventually energy that has come into a system will all dissipate as heat. Thus, energy (e.g., from the sun) has to constantly come into the system. Thus we say that “energy flows.”

Important notes:

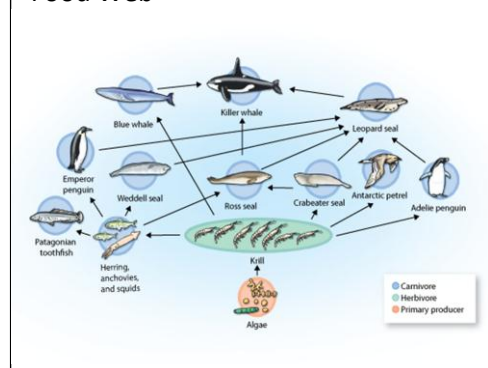
- All organisms expend energy (e.g., for growth, reproduction, metabolic processes).
 - Organisms cannot create their own energy. Most use energy from the sun. Some use chemical energy stored in inorganic compounds.
 - Autotrophs = primary producers = the first producers of energy-rich compounds that are later used by other organisms.
 - Only autotrophs (algae, certain bacteria, and plants) can capture energy from the sun or chemical compounds and use it to assemble inorganic compounds into complex organic molecules.
 - Energy From the Sun
 - Photosynthesis uses light energy to convert carbon dioxide and water into oxygen and energy-rich carbohydrates such as sugars and starches. Photosynthesis takes CO_2 from the air and adds O_2 . Accomplished by plants on land, algae in freshwaters, and cyanobacteria in oceans.
 - Energy from inorganic molecules
 - In the process called chemosynthesis, bacteria harness chemical energy from inorganic molecules (such as hydrogen sulfide) to produce carbohydrates. Often live in extreme environments = deep ocean vents, hot springs, etc.

Food Chain



- Food Chains and Food Webs: How does energy flow through ecosystems?**
 - Energy flows through an ecosystem in a one-way stream, from primary producers to various consumers.
 - Food Chains – a series of steps in which organisms transfer energy by eating and being eaten.
 - Food Webs = network of feeding interactions.
 - Food chains are found within food webs
 - Decomposers convert dead material to detritus, which is eaten by detritivores (e.g., worms).
 - Decomposition releases nutrients that primary producers can then recycle
 - Without decomposers, nutrients would remain locked within dead organisms and life on Earth would stop.
 - Food Webs and Disturbances – Because food webs are so complex, it is difficult to predict how they will be affected by an environmental disturbance.

Food Web



- **Trophic Levels and Ecological Pyramids: What do the three types of ecological pyramids illustrate?**

- Trophic Level = each step in a food chain or food web.
 - First level is always primary producers; various consumers occupy the other levels.
- Pyramid of Energy show the relative amount of **energy** available at each trophic level of a food chain or food web.
 - Organisms expend most of the energy they consume on life processes (respiration, movement, growth, reproduction, etc.) and most of the remaining energy escapes into the environment as heat.
 - The efficiency of energy transfer from one trophic level to another is typically **10%**. The more levels in an energy pyramid between producer and a given consumer, the smaller percentage of the original energy is available.
- Pyramids of Biomass (the relative amount of living **organic matter** available at each level in the ecosystem) and Numbers (the relative **number of individual organisms** at each trophic level in an ecosystem)
 - Shape of the pyramid of numbers is usually similar to the shape of the pyramid of biomass: large base, and numbers and biomass decrease with each step up the trophic levels.
 - The pyramid of numbers may be inverted if, for instance, thousands of insects feed off of one tree. The pyramid of biomass usually does not get inverted.
- **How do plants and animals cycle carbon and nitrogen within an ecosystem?**
 - The Carbon Cycle: carbon dioxide is exchanged between the atmosphere and oceans through chemical and physical processes. Plants take in CO_2 during photosynthesis and use the carbon to build carbohydrates. The carbohydrates are used by the plants or organisms that consume the plants for the process of cellular respiration. Cellular respiration produced CO_2 which is released back into the atmosphere. Carbon is also recycled when organisms die, decompose, and become fossil fuels. These carbon compounds are released as CO_2 back into the atmosphere.

Trophic Levels

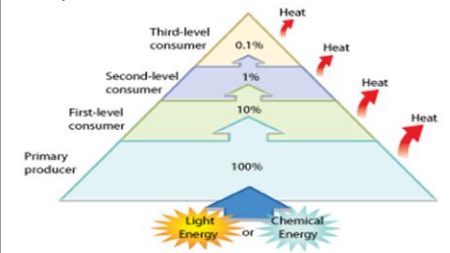
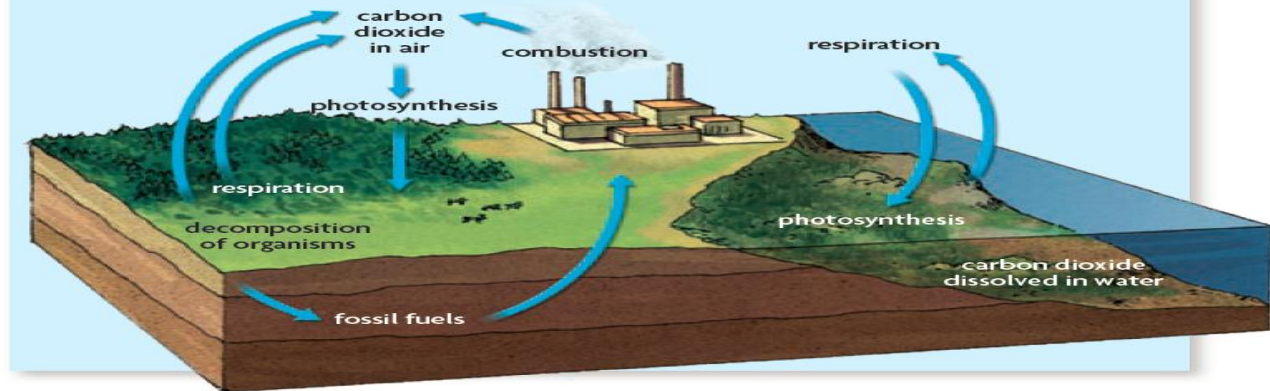


FIGURE 5.3 Carbon Cycle

Photosynthesis and respiration account for much of the transformation and movement of carbon.

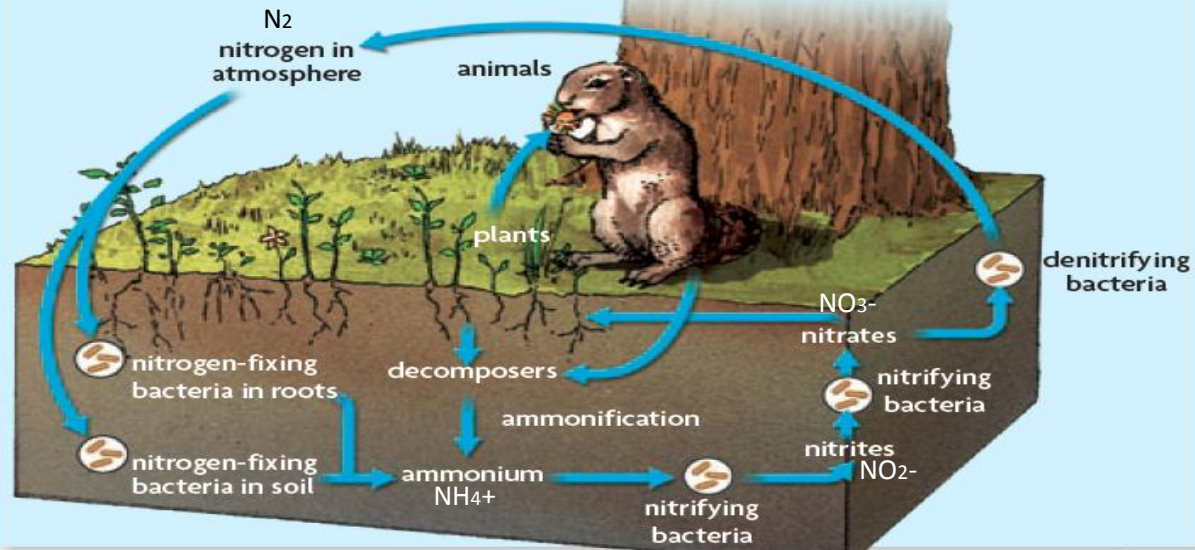


Systems Diagram

- The Nitrogen Cycle: The atmosphere is the largest reservoir of nitrogen in the biosphere. Nitrogen fixing bacteria fix the N_2 and it is taken up by primary producers (plants), reused by consumers (animals) and released back into the environment by excretion and decomposing matter. Humans also make fertilizers from the N_2 gas in the air; the fertilizer is used by plants and enters the environment without the aid of bacteria.

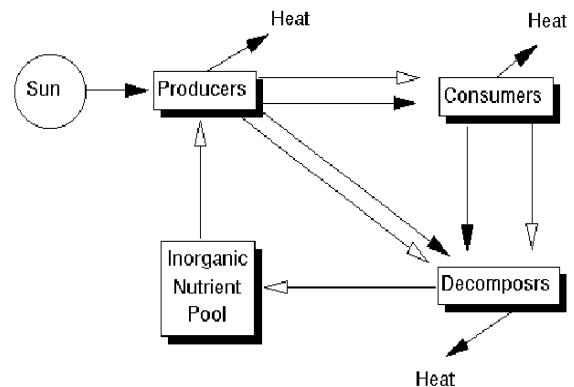
FIGURE 5.4 Nitrogen Cycle

Much of the nitrogen cycle occurs underground. **Systems Diagram** bacteria transform ammonium into nitrates, which are used by plants to make amino acids.



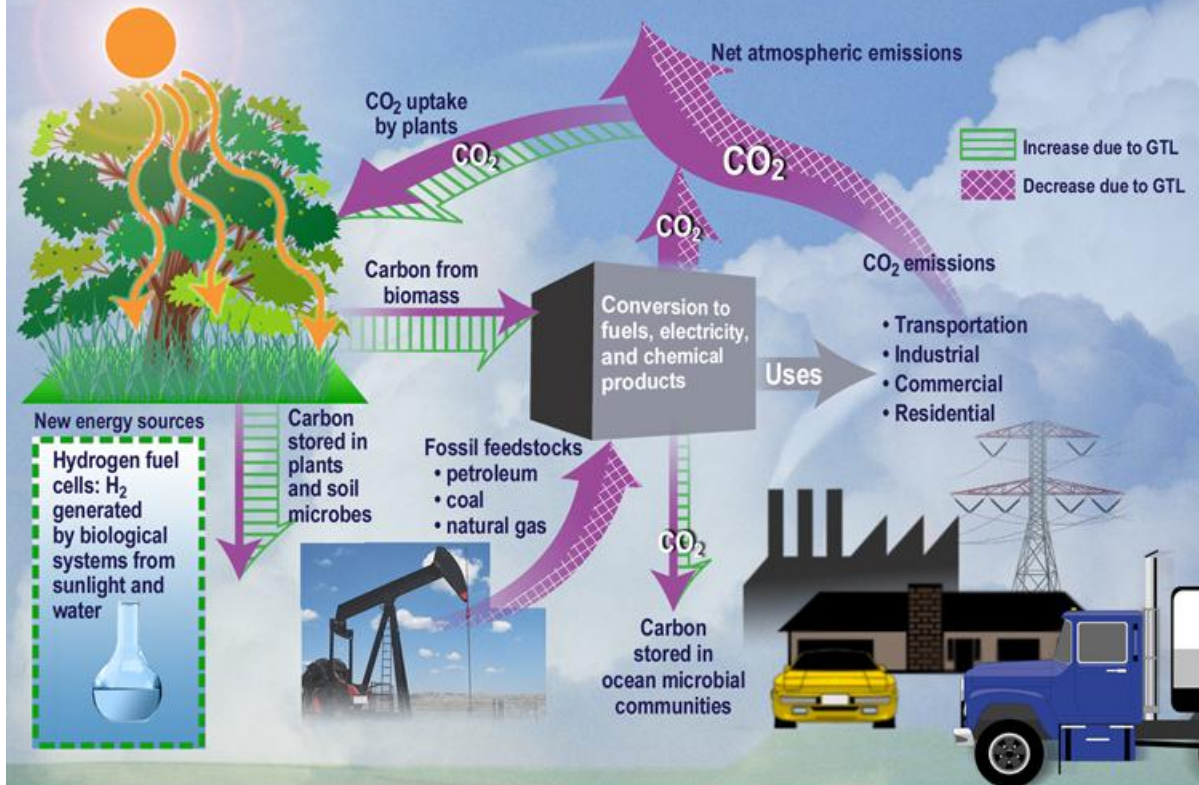
What to look out for:

The systems diagram above shows how both energy and inorganic nutrients flow through the ecosystem. We need to define some terminology first. Energy "flows" through the ecosystem in the form of carbon-hydrogen bonds. When respiration occurs, the carbon-hydrogen bonds are broken and the carbon is combined with oxygen to form carbon dioxide. This process releases the energy, which is either used by the organism (to move its muscles, digest food, excrete wastes, think, etc.) or the energy may be lost as heat. The dark arrows represent the movement of this energy. Note that all energy comes from the sun, and that the ultimate fate of all energy in ecosystems is to be lost as heat. Energy does not recycle!! Be careful of which way the arrows point. They point in the direction that energy is flowing!



The other component shown in the diagram is the inorganic nutrients. They are inorganic because they do not contain carbon-hydrogen bonds. These inorganic nutrients include the phosphorous in your teeth, bones, and cellular membranes; the nitrogen in your amino acids (the building blocks of protein); and the iron in your blood (to name just a few of the inorganic nutrients). The movement of the inorganic nutrients is represented by the open arrows. Note that the autotrophs obtain these inorganic nutrients from the inorganic nutrient pool, which is usually the soil or water surrounding the plants or algae. These inorganic nutrients are passed from organism to organism as one organism is consumed by another. Ultimately, all organisms die and become detritus, food for the decomposers. At this stage, the last of the energy is extracted (and lost as heat) and the inorganic nutrients are returned to the soil or water to be taken up again. The inorganic nutrients are recycled; the energy is not.

Systems Diagram



Vocabulary:

- Autotroph: (auto = by itself; trophikos = to feed) – a self-feeder. Does not need to eat other organisms for food.
- Biodiversity: The different kinds of organisms in a specific ecosystem or on the planet as a whole.
- Biogeochemical cycle: A circuit or pathway by which a chemical element moves through both living and non-living components of an ecosystem, including the Earth as a whole.
- Biomass: The total amount of living tissue within a described system (e.g., an organism, a trophic level).
- Carnivore: kill and eat other animals
- Chemosynthesis: bacteria harness chemical energy from inorganic molecules (such as hydrogen sulfide) to produce carbohydrates
- Consumer: Organisms that rely on other organisms for energy and nutrients.
- Decomposer: “feed” by chemically breaking down organic matter.
- Denitrification: The process by which soil bacteria convert nitrates into nitrogen gas that enters the atmosphere.
- Detritivores: feeds on detritus and often decomposers
- Ecological pyramid: show the relative amount of energy or matter contained within each trophic level in a given food chain or food web.
- Energy transfer: The movement of energy from one location to another.
- Energy transformation: Change of energy from one form to another.
- Environment: Natural surroundings, including living and nonliving components. May also refer to a region or to all natural systems on planet Earth.
- Food chain: a series of steps in which organisms transfer energy by eating and being eaten.
- Food web: a network of feeding interactions.
- Food web: The complex eating relationships among species within an ecosystem. In a diagram of a food web organisms are connected to the organisms they consume by arrows representing the direction of energy transfer.
- Fossil Fuel: A substance that can be burned for heat energy, such as coal, oil, or natural gas, formed from the decayed remains of prehistoric animals and plants.
- Herbivore: eat plant material
- Heterotroph: consumers - must acquire energy from other organisms, typically by ingesting them.

- Input: The addition of matter, energy, or information to a system.
- Invasive Species- A non-native species
- Limiting Factors- Components that control the growth of a population.
- Nitrogen Fixation: The process of converting nitrogen gas into ammonia that plants absorb and use.
- Omnivore: eat both plant and animal material
- Output: Matter, energy, or information that flows out of a system.
- Photosynthesis: uses light energy to convert carbon dioxide and water into oxygen and energy-rich carbohydrates
- Phytoplankton: floating algae = primary producers in many aquatic food chains.
- Precipitation: Any product of the condensation of atmospheric water vapor deposited on Earth's surface, such as rain, snow, or hail.
- Primary producer: (autotrophs) – are the first producers of energy-rich compounds that are later used by other organisms.
- Scavenger: consume the carcasses of other animals that are already dead.
- Secondary Consumer: An organism that eats primary producers. (Example: A grasshopper eats a leaf.)
- System: An assemblage of interrelated parts or conditions through which matter, energy, and information flow.
- Trophic level: Each step in a food chain or a food web
- Zooplankton: small swimming animals that feed on marine algae

Content Standard “B” (9-11 LS2B)	Student Performance Expectation
Students know that:	Students are expected to:
Living organisms have the capacity to produce very large populations. Population density is the number of individuals of a particular population living in a given amount of space.	<ul style="list-style-type: none"> • <i>Evaluate</i> the conditions necessary for rapid <i>population growth</i> (e.g., given adequate living and nonliving resources and no disease or predators, <i>populations</i> of an <i>organism</i> increase at rapid rates). • Given <i>ecosystem</i> data, calculate the <i>population density</i> of an <i>organism</i>.*a

In other words:

- Population density = # of organisms/area they live in.
- Given unlimited resources, populations will grow very rapidly. Resources include space, food, water, mates, lack of predators, lack of diseases, etc.

Important notes:

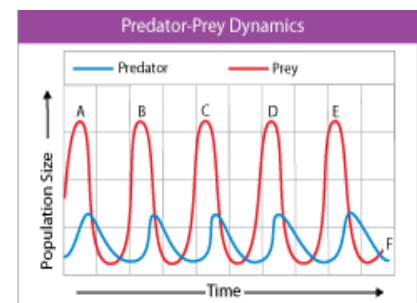
- **Conditions necessary for rapid population growth**

-Abiotic factors include

- Temperature, humidity, hours of light and dark, water resources, etc.

-Biotic factors include

- Adequate food, mates, places to live, places to raise young, etc.
 - Competition can occur both among members of the same species (**intraspecific** competition) and between members of different species (**interspecific** competition)
- Predator vs. Prey Relationships: can affect both the size of prey populations in a community and determine the places prey can live and feed. Note in a predator-prey diagram the population growth of the predator lags behind the population growth of the prey.
 - Diseases are considered predators. Don't forget them!
 - Herbivores (plant eaters) can affect both the size and distribution of plant populations in a community and determine the places that certain plants can survive and grow.



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- **Ecologists study the following about populations:**

- geographic range (where they live in one area, or where they live throughout the world)
- density and distribution (are they all clumped together in one spot, or evenly spread out, or is distribution random)
- growth rate (see below)
- age structure (e.g., how many old critters are there compared to young critters).

- **Population size** is affected by birthrate, death rate, and the rate at which individuals enter (immigration) or leave (emigration) a population. See above right.

- **Exponential growth?**

- Under ideal conditions with unlimited resources, a population will grow exponentially. (Reproduce as fast as bunny rabbits!)
- Organisms that are introduced to new environments can grow exponentially for a time and change an ecosystem. This is especially true of invasive species.

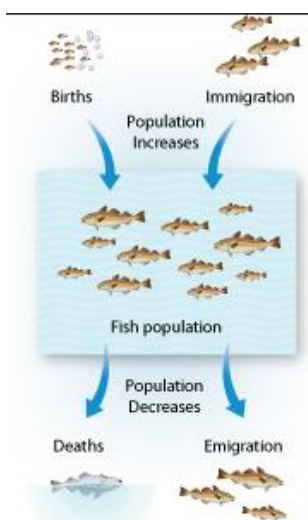
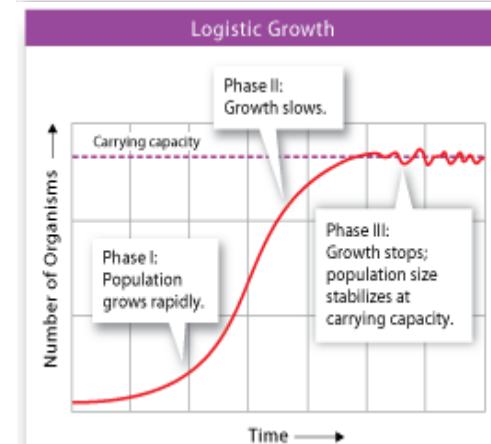
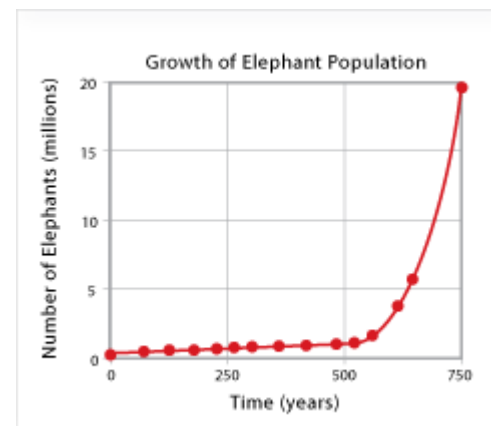
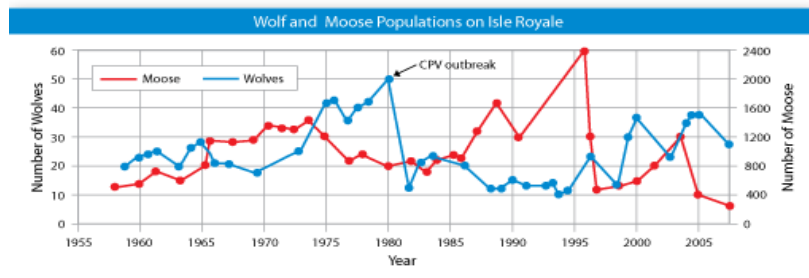
- **Logistic growth?**

- This occurs when a population's growth slows and then stops, following a period of exponential growth. This occurs because the numbers of organisms begin to exhaust the resources of the environment. The resources become "limiting factors." They limit how much the population can grow. When the population gets to the size where it is in equilibrium with its resources, the population growth stops and has finally reached "Carrying capacity." The capacity of the land to support ("carry") a number of organisms of that species.

- **Population density** is an often reported and commonly compared statistic for places around the world. Population density is the measure of the number per unit area. It is

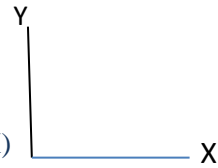
commonly represented as people per square mile (or square kilometer), which is derived simply by dividing...total area population / land area in square miles (or square kilometers)

- For example, Canada's population of 33 million, divided by the land area of 3,559,294 square miles yields a density of 9.27 people per square mile. While this number would seem to indicate that 9.27 people live on each square mile of Canadian land area, the density within the country varies dramatically - a vast majority lives in the southern part of the country. Density is only a raw gauge to measure a population's disbursement across the land.



What to look out for:

- Be sure you understand how to interpret graphs
- Be sure you know how to calculate the population density of a defined area.
- Rules for graphing:
 1. Title
 2. 'x' axis: time, independent variable or manipulated variable (MIX)
 3. 'y' axis: rate, dependent variable or responding variable
 4. You will be asked to interpret data and recognize patterns. It is most useful to develop a mathematical equation that fits the data. This then allows us to calculate the value of the dependent variable at any value of the independent variable. For example, if the plot of the data gives a straight line, we can say that the dependent variable (plotted on the y-axis) is *directly proportional* to the independent variable (plotted on the x-axis). In that case, we can then fit the data to the equation for a straight line, $y = mx + b$, where m is the slope of the line and b is the y-intercept.



Vocabulary:

- Carrying Capacity- the largest number of individuals of a particular species that a particular environment can support.
- Habitat: An ecological or environmental area that is inhabited by a particular species. It is the natural environment in which an organism lives or the physical environment that surrounds (influences and is used by) a species population.
- Invasive Species- A non-native species
- Limiting Factors- Components that control the growth of a population.
- Niche: The position of a species or population in its ecosystem. A shorthand definition of niche is how and where an organism makes a living.
- Open system: A system in which matter may flow in and out, as opposed to a closed system in which matter may not flow in or out.
- Population density: The number of individuals of a particular population living in a given amount of space.
- Population growth: The rate at which the number of individuals in a population increases. Usually applies to a given ecosystem, but could refer to a region or the entire Earth.
- Population: The collection of organisms of a particular species that can breed and reproduce.

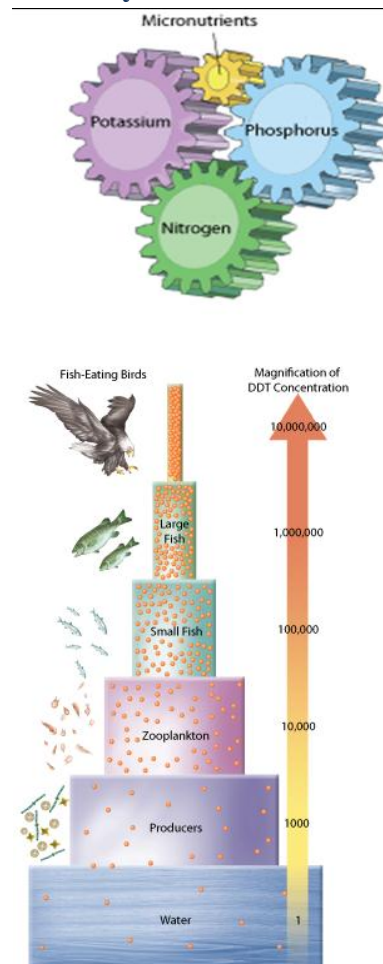
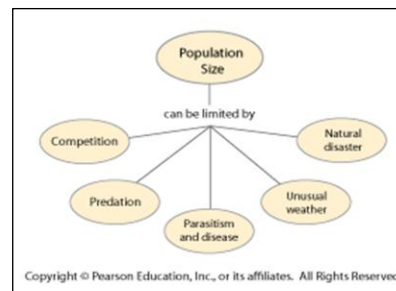
Content Standard “C” (9-11 LS2C)	Student Performance Expectation
Students know that:	Students are expected to:
Population growth is limited by the availability of matter and energy found in resources, the size of the environment, and the presence of competing and/or predatory organisms.	• <i>Explain factors, including matter and energy, in the environment that limit the growth of plant and animal populations in natural ecosystems.</i>

In other words:

- *No interpretation needed. The Standard and Performance Expectation are clear.*

Important notes:

- **Limiting factors determine carrying capacity of a species.** Limiting factors can act separately or together.
 - **Density-dependent limiting factors** mean factors that will not be much of a threat to a species if the population is small. But if the population becomes large, the factors start to limit how many of the species can survive. Examples: competition for food and nutrients (see below), predation, herbivory, parasitism, diseases, and stress from overcrowding.
 - **Density –independent limiting factors** affect all populations in similar ways, regardless of population size and density. Unusual weather such as hurricanes, droughts, or floods and natural disasters such as wildfires, volcanic eruptions, and huge earthquakes can act as density-independent limiting factors. That is, it doesn’t matter what the size of the population is, all are affects. Some of these factors may cause a population to “crash”.
- **Nutrient availability is a limiting factor that affects the productivity of an ecosystem.**
 - Limitations in soil-All nutrient cycles work together like gears to provide nutrients. When one nutrient is in short supply, it causes the overall system to slow down or get stuck reducing overall productivity.
 - Open oceans are nutrient poor compared to most land areas and nitrogen is the limiting factor of the oceans.
 - In streams, lakes and freshwater environments, phosphorus is the limiting nutrient. For example, run off from a heavily fertilized crop may result in an algae bloom. This is caused from an increase in nutrients to the primary producers (algae). Excessive algae growth can cover the water’s surface and reduce photosynthesis to other organisms.
- **Primary sources of water pollution**
 - The primary sources of water pollution are industrial and agricultural chemicals, and residential sewage and nonpoint sources.
 - **For Example:** Biomagnification occurs if a pollutant, such as DDT (a long lasting chemical used to control agricultural pest and disease carrying mosquitoes) enters a stream from rain water run-off and is consumed by organisms, but not broken down. The DDT is passed up the food chain from producers to consumers. As the DDT enters the tropic levels, its concentration becomes more concentrated, causing damage to larger species at the top of the food chain.
 - **This is also an example of a closed system.** A system in which matter (DDT) may circulate, but may not enter or leave.



What to look for:

- Be sure you understand what a limiting factor is. Know the differences between a density-dependent and density-independent limiting factor.
- Biomagnification is a big deal. Understand the principle.

Vocabulary:

- Limiting Factor: determines the carrying capacity of an environment for a species. A balance between extinction and overcrowding the planet.
- Competition: When populations become crowded, individuals compete for food, water, space, sunlight, and other essentials.
- Predation: The effect of a predator on its prey. Most predator-prey relationship populations' cycle up and down over time like the graph above shown the wolf and moose on Isle Royale.
- Human predation: Humans can limit the supply of certain populations by catching/hunting/harvesting more than can be put back causing the population steadily decline toward extinction.
- Closed system: A system in which matter may circulate, but may not enter or leave.

Content Standard "D" (9-11 LS2D)	Student Performance Expectation
Students know that:	Students are expected to:
Scientists represent ecosystems in the natural world using mathematical models.	<ul style="list-style-type: none"> • Draw a <i>systems</i> diagram to illustrate and <i>explain</i> why introduced (nonnative) <i>species</i> often do poorly and have a tendency to die out, as well as why they sometimes do very well and force out native <i>species</i>. *a, *b

In other words:

- Because ecosystems are typically large and/or complex and/or change over long periods of time, it is usually best to understand them using a mathematical model.
- Invasive species are a good topic to introduce this concept of modeling.

Important notes:

- An introduced species is synonymous with *non-native*. These species are usually introduced to an area by humans for a variety of reasons. E.g.,
 - By mistake (e.g., Norway rats hitchhiking aboard sailing ships).
 - To control other non-native species that are reproducing out of control, and needing to be limited without using a herbicide (plant killer). NOTE: In the process of controlling non-native species, these introduced species can choke out the native vegetation as well and themselves become an invasive species
 - From human carelessness and/or ignorance. E.g., releasing your python pet into the Everglades.
- Non-native species can
 - increase the biodiversity of an ecosystem
 - cause such an imbalance that the area in which it has been introduced becomes overcrowded, nutrient poor and prone to disease.

What to look for:

- You will probably be asked to draw a systems diagram and represent it mathematically. Chances are the math will be no more than calculating population density at different times as populations change due to an invasive species. See the example on this and the next page.

EXAMPLE: Mouse populations are tallied every 10 years in Central City, NO (Nowhere), a fictitious city in a fictitious state, for the sake of an example. The droppings, urine, and saliva of deer mice in particular can carry the Hantavirus, a rare but serious virus. To curtail the virus, the city decided to bring in one of the deer mouse's worst enemy, the barn owl. Barn owls eat many other types of food, including rats, frogs and small birds (called "LBJs, or "little brown jobbies" since they are so hard to identify), although deer mice are their favorite. Following are data that were collected by Central City naturalists from the year 1950 to 2010.

Year: 1950	Species					
Area Surveyed = 1000 sq. hectares	Deer Mice	Rats	Moles	Frogs	LBJs	Barn Owls
Count	500	50	30	100	300	30

Year: 1960	Species					
Area Surveyed = 1000 sq. hectares	Deer Mice	Rats	Moles	Frogs	LBJs	Barn Owls
Count	450	45	30	90	200	34

Year: 1970	Species					
Area Surveyed = 1000 sq. hectares	Deer Mice	Rats	Moles	Frogs	LBJs	Barn Owls
Count	250	45	30	80	100	50

Year: 1980	Species					
Area Surveyed = 1000 sq. hectares	Deer Mice	Rats	Moles	Frogs	LBJs	Barn Owls
Count	100	45	30	70	100	60

Year: 1990	Species					
Area Surveyed = 1000 sq. hectares	Deer Mice	Rats	Moles	Frogs	LBJs	Barn Owls
Count	100	45	30	60	100	60

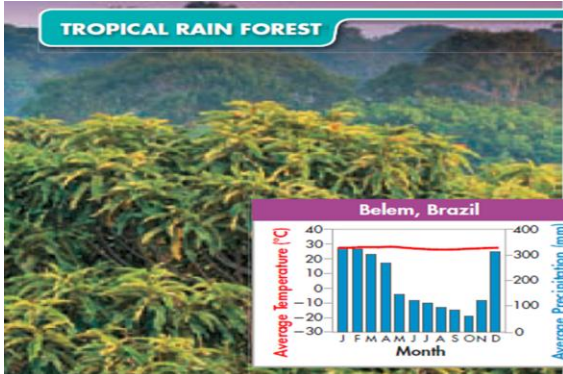
1. Draw a graph that represents the above data. **Describe the effect** the introduction of barn owls has had on each of its prey. Give a **possible reason** for each effect.
2. Draw a systems diagram showing the inputs, process, and outputs. Use population densities as your measurement tool.

Vocabulary:

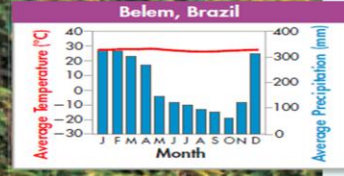
- Non-native (Introduced): Species that have become able to survive and reproduce outside the habitats where they evolved or spread naturally.
- Native Species: defined as natural to a given region or ecosystem if its presence in that region is the result of only natural processes, with no human intervention.
- Invasive Species: those introduced species that spread-widely or quickly, and cause harm, be that to the environment, human health, other valued resources or the economy.

Content Standard “E” (9-11 LS2E)	Student Performance Expectation
Students know that:	Students are expected to:
Interrelationships of organisms may generate ecosystems that are stable for hundreds or thousands of years. Biodiversity refers to the different kinds of organisms in specific ecosystems or on the planet as a whole.	<ul style="list-style-type: none">Compare the biodiversity of organisms in different types of ecosystems (e.g., rain forest, grassland, desert) noting the interdependencies and interrelationships among the organisms in these different ecosystems.
In other words:	
<ul style="list-style-type: none">No interpretation needed. The Standard and Performance Expectation are clear.	
Important notes:	
<ul style="list-style-type: none">Terrestrial Biomes:<ul style="list-style-type: none">Earth has 6 major biomes and each biome is defined by its climate and by the plant communities that live there.<ul style="list-style-type: none">The abiotic factors that affect climate are primarily temperature, precipitation, and latitude. NOTE: latitude may be “mimicked” by altitude, as in hiking up a tall mountain.Each biome has its own climate diagram.Biodiversity is most affected by humans altering habitats, hunting, introducing invasive species, releasing pollution into food webs, and contributing to climate change.	
<ul style="list-style-type: none">Below is a comparison between a tropical rainforest and northwest coniferous forest.	

TROPICAL RAIN FOREST



Belem, Brazil




Month	J	F	M	A	M	J	J	A	S	O	N	D
Average Temperature (°C)	28	28	28	28	28	28	28	28	28	28	28	28
Average Precipitation (mm)	300	300	300	300	300	300	300	300	300	300	300	300

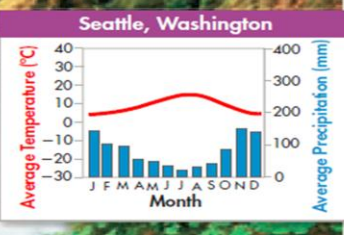
Tropical rain forests are home to more species than all other biomes combined. As the name suggests, rain forests get a lot of rain—at least 2 meters of it a year! Tall trees form a dense, leafy covering called a **canopy** from 50 to 80 meters above the forest floor. In the shade below the canopy, shorter trees and vines form a layer called the **understory**. Organic matter on the forest floor is recycled and reused so quickly that the soil in most tropical rain forests is not very rich in nutrients.

- Abiotic factors** hot and wet year-round; thin, nutrient-poor soils subject to erosion
- Biotic factors**
 - Plant life:** Understory plants compete for sunlight, so most have large leaves that maximize capture of limited light. Tall trees growing in poor shallow soil often have buttress roots for support. Epiphytic plants grow on the branches of tall plants as opposed to soil. This allows epiphytes to take advantage of available sunlight while obtaining nutrients through their host.
 - Animal life:** Animals are active all year. Many animals use camouflage to hide from predators; some can change color to match their surroundings. Animals that live in the canopy have adaptations for climbing, jumping, and/or flight.

NORTHWESTERN CONIFEROUS FOREST



Seattle, Washington



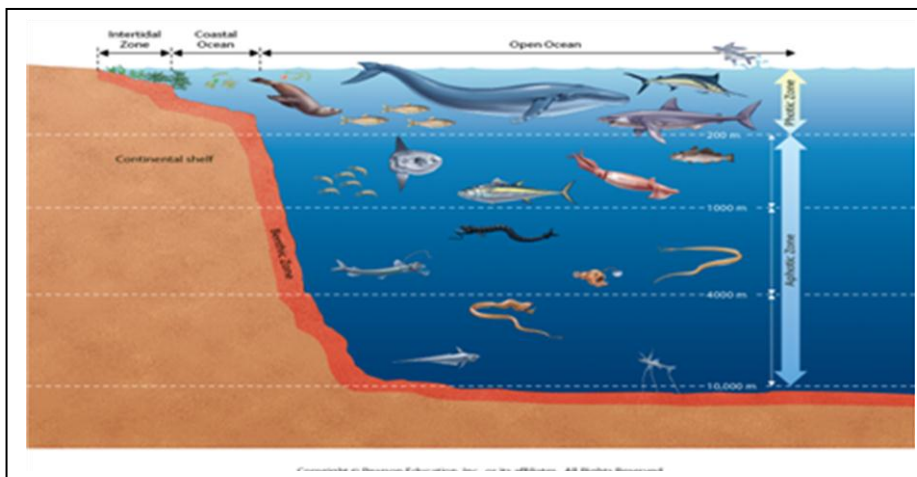
Month	J	F	M	A	M	J	J	A	S	O	N	D
Average Temperature (°C)	5	6	7	9	12	15	17	16	12	8	5	4
Average Precipitation (mm)	150	150	150	150	150	150	150	150	150	150	150	150

Mild moist air from the Pacific Ocean influenced by the Rocky Mountains provides abundant rainfall to this biome. The forest includes a variety of conifers, from giant redwoods to spruce, fir, and hemlock, along with flowering trees and shrubs such as dogwood and rhododendron. Moss often covers tree trunks and the forest floor. Because of its lush vegetation, the northwestern coniferous forest is sometimes called a “temperate rain forest.”

- Abiotic factors** mild temperatures; abundant precipitation in fall, winter, and spring; cool dry summers; rocky acidic soils
- Biotic factors**
 - Plant life:** Because of seasonal temperature variation, there is less diversity in this biome than in tropical rain forests. However, ample water and nutrients support lush, dense plant growth. Adaptations that enable plants to obtain sunlight are common. Trees here are among the world’s tallest.
 - Animal life:** Camouflage helps insects and ground-dwelling mammals avoid predation. Many animals are browsers—they eat a varied diet—an advantage in an environment where vegetation changes seasonally.

- **Aquatic ecosystems**

- Aquatic organisms are affected primarily by the water's depth, temperature, flow, and amount of dissolved nutrients.
- **Zones of Aquatic Ecosystems:**
 - **Photic zone:** the sunlit region up to 200 meters deep. This may be only a few inches deep in rivers or streams depending on the amount of silt that clouds the water.
 - **Aphotic zone:** below the photic zone, where photosynthesis does not occur.
- **Freshwater ecosystem categories**
 - Freshwater ecosystems can be divided into three main categories: rivers and streams; lakes and ponds; and freshwater wetlands. Only 3% of the Earth's surface water is fresh water, but that small percentage provides terrestrial (land) organisms with drinking water, food and transportation.
 - Wetlands support a large amount of plant and aquatic life and are one of the most important for their role in filtering pollutants and to prevent flooding by absorbing large amounts of water.
- **Estuaries are where freshwater rivers dump into saltwater.**
 - Estuaries serve as spawning and nursery grounds for many ecologically and commercially important fish and shellfish species.
- **Marine ecosystems.** The ocean can also be divided into zones based on depth and distance from the shore.
 - **Intertidal Zone:** organisms are submerged in seawater at high tide and exposed to air and sunlight at low tide.
 - **Coastal Ocean:** extends from low tide to the outer edge of the continental shelf.
 - **Open Ocean:** begins at the edge of the continental shelf and extend outward. More than 90% of the ocean is Open Ocean Zone.
 - **Organisms that live in each marine zone have unique adaptations that enable them to live in each of these zones.**



What to look for:

- Biodiversity is considered by most as a “good thing.” The more diverse the kinds of organisms are that live in an area; the better able to ecosystem is able to support itself if something goes wrong with one species. Remember that the greatest threat to biodiversity is humans due to habitat destruction.
- Remember that biomes are defined mostly by temperature, precipitation, and latitude...and plant type.

Vocabulary:

- Aphotic Zone- This area is considered the dark zone and extends just below the photic zone to the bottom of the ocean. Food webs here are based on which organisms fall from the photic zone above “marine snow” or on the chemosynthetic organism.
- Benthic Zone- environment on the ocean floor in the Aphotic Zone where organisms are exposed to high pressure, frigid temperature or extremely hot deep-sea vents that support chemosynthetic primary producers.
- Climate: Encompasses the temperatures, humidity, atmospheric pressure, winds, rainfall, atmospheric particle count, and numerous other meteorological elements in a given region over long periods of time.
- Ecosystem: A natural unit consisting of all plants, animals, and microorganisms (biotic factors) in an area functioning together with all of the nonliving physical (abiotic) factors of the environment.
- Global climate: The average temperature, humidity, rainfall, and other meteorological measures of Earth as a whole over a long period of time (usually taken to be about 30 years).
- Photic Zone- The surface most layer of water that receives the most sunlight and conducts the most photosynthesis. The photic zone is nutrient poor, but because it is so massive, it supports a large number of small species such as phytoplankton.
- Temperature: A physical property that determines the direction of heat flow between two objects placed in thermal contact. If no heat flow occurs, the two objects have the same temperature; otherwise, heat flows from the hotter object to the colder object.

Content Standard “F” (9-11 LS2F)	Student Performance Expectation
Students know that:	Students are expected to:
The concept of sustainable development supports adoption of policies that enable people to obtain the resources they need today without limiting the ability of future generations to meet their own needs. Sustainable processes include substituting renewable for nonrenewable resources, recycling, and using fewer resources.	<ul style="list-style-type: none">• Explain how scientific concepts and findings relate to a resource issue currently under discussion in the state of Washington (e.g., removal of dams to facilitate salmon spawning in rivers; construction of wind farms).* a,*b,*c.• Explain how the concept of sustainable development may be applied to a current resource issue in the state of Washington.*a,*b,*c.

In other words :

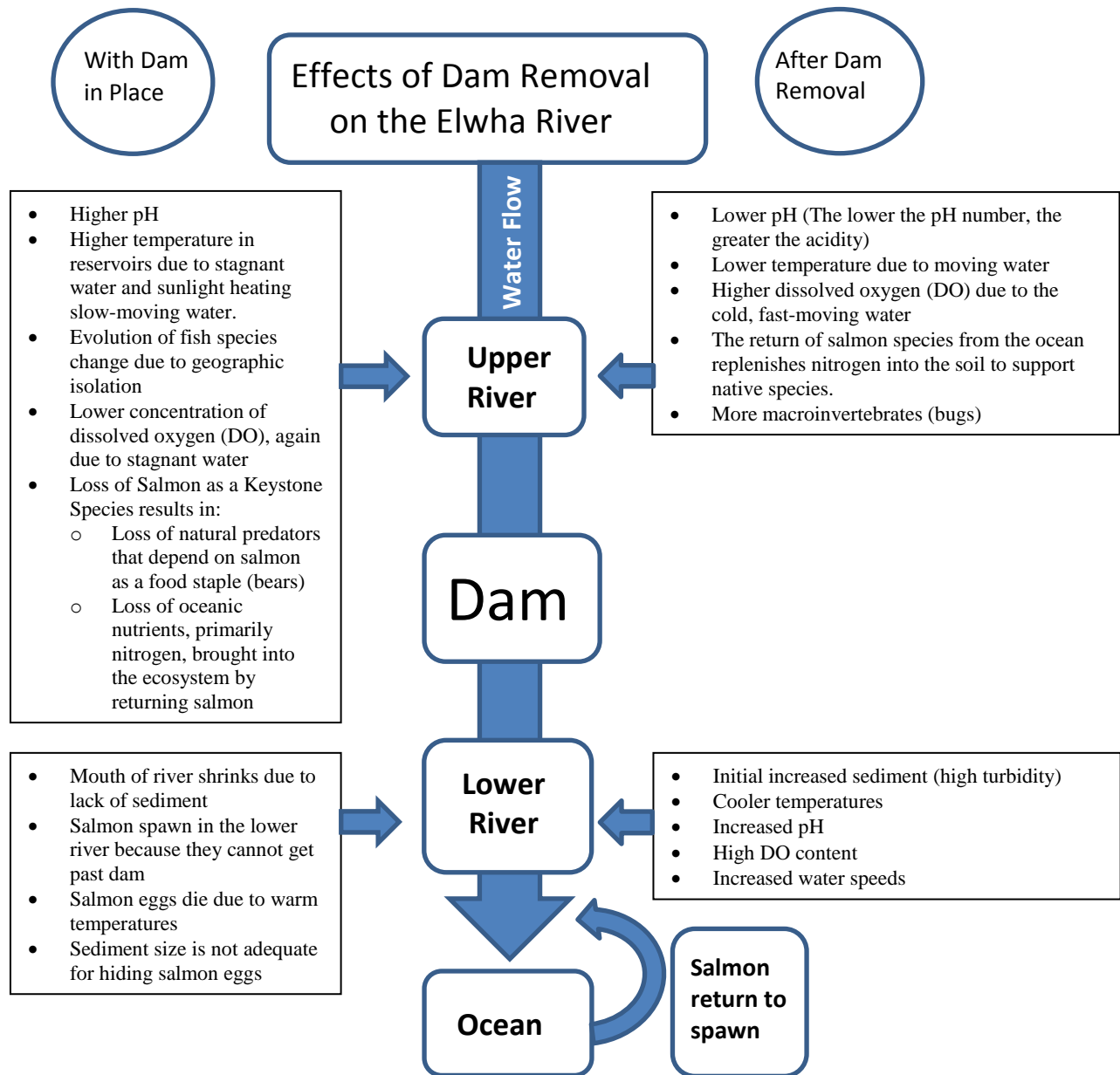
- *No interpretation needed. The Standard and Performance Expectations are clear.*

Important Notes:

- It is important to familiarize yourself with resource issues applicable to the Pacific Northwest. These include, but are not limited to
 - Salmon populations
 - Crop rotation
 - Crop irrigation
 - Reforestation issues after clear-cutting
 - The succession occurring at Mt. St. Helens
 - Construction of wind farms along the Columbia Gorge.
 - Non-point source pollution of Puget Sound
- Be able to demonstrate your knowledge of a resource issue using a systems diagram to show the interdependency among organisms within an ecosystem.

What to look for: Don't be too over-simplistic with these questions.

Figure F: Elwha Dam Removal



Vocabulary:

- Sustainable development:** Policies that enable people to obtain the resources they need today without limiting the ability of future generations to meet their own needs.

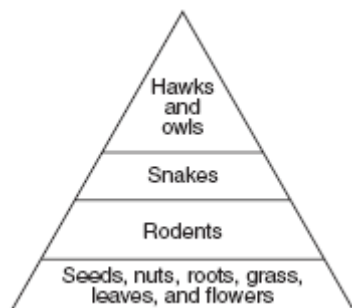
SAMPLE TEST QUESTIONS – Taken from several tests, so the numbers are not in order.

1. The table below contains information about animal diets.

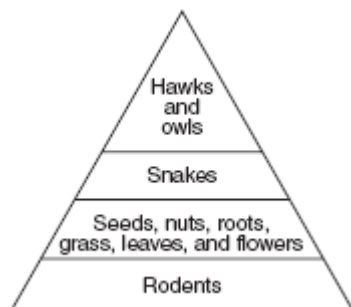
Animals	Diet
Snakes	Squirrels, chipmunks, gophers, and mice
Hawks and owls	Rodents and reptiles
Rodents	Seeds, nuts, roots, grass, leaves, and flowers

Which energy pyramid *best* represents the data in the table?

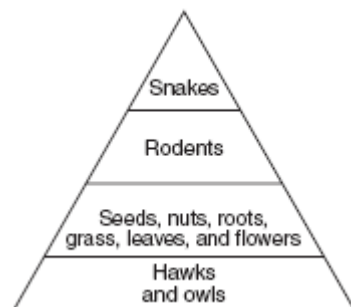
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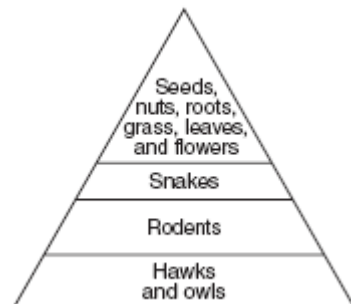
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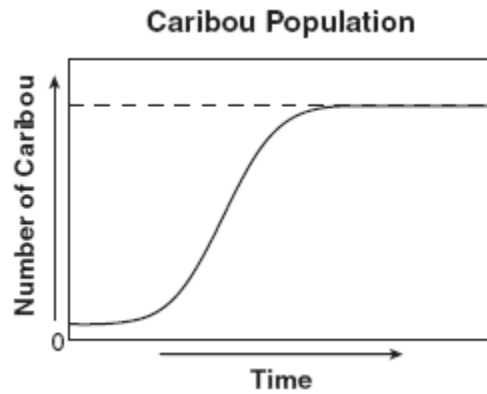
c.



d.



2. The graph below shows changes in a caribou population over time.



Based on the graph, which of the following is a possible explanation for the stabilization of the caribou population?

- a. an equal number of deaths and births
 - b. an unequal number of deaths and births
 - c. an equal number of immigrants and births
 - d. an unequal number of immigrants and deaths
3. Before modern fertilizers were introduced, farmers regularly allowed certain amounts of their land to grow wild in order to renew the soil before planting crops again. This increased the output of the farm by doing which of the following?
- a. decreasing the average yield per crop
 - b. decreasing the amount of carbon in the soil
 - c. increasing the amount of usable nutrients in the soil
 - d. increasing competition between crops and wild plants
4. Which of the following is an example of a relationship between a consumer and a producer?
- a. mice eating seeds
 - b. snakes eating mice
 - c. humans eating mushrooms
 - d. plants taking nutrients from the soil
5. Which of the following sets of organisms would be found in a wetland ecosystem?
- a. tortoise, lizard, fly
 - b. salamander, mosquito, frog
 - c. moose, seal, lemming
 - d. lion, giraffe, beetle
6. Nitrogen-fixing bacteria help cycle nitrogen through ecosystems. How do they do this?
- a. They change nitrogen into forms usable by plants.
 - b. They convert water and carbon dioxide into sugar.
 - c. They release the chemical energy in nitrogen for respiration.
 - d. They convert sunlight into chemical energy stored in nitrogen.

7. The five Great Lakes make up 95% of the United States' fresh water supply. Chemicals, pesticides, and herbicides from the agriculture industry and toxic wastes from factories have polluted the Lakes. Higher temperatures and reduced precipitation have contributed to lower water levels, leading to costly efforts to dig out harbors and to open shipping lanes.

A hard freeze that affected Lakes Superior, Huron, and Erie during the winter of 2003 forced ships carrying industrial products to delay shipments or risk being trapped in the 2-foot-thick ice.

A scientist who believes that the dropping water levels in the Great Lakes are the result of global warming would be *most likely* to study ways to reduce

- a. oil spills.
- b. acid rain.
- c. fossil fuel use.
- d. recycling of paper.

8. Complete burning of plant material returns carbon primarily to the

- a. herbivores.
- b. water.
- c. vegetation.
- d. atmosphere.

9. The greatest mass in any ecosystem is usually found in

- a. parasites.
- b. producers.
- c. consumers.
- d. decomposers.

10. Rabbits introduced into Australia over 100 years ago have become a serious pest to farmers. Rabbit populations increased so much that they displaced many native species of plant eaters. What is the *most* logical explanation for their increased numbers?

- a. Rabbits have a high death rate.
- b. There are few effective predators.
- c. Additional rabbit species have been introduced.
- d. There is an increase in rabbit competitors.

11. Which of these organisms would *most likely* be found at the top of an energy pyramid?

- a. clams
- b. sardines
- c. sharks
- d. kelp

Refer to the text below to answer questions 12 through 15.

A form of lake succession called eutrophication occurs when a lake fills with inorganic and organic debris and eventually becomes a field. Water draining into a lake carries nutrients and organic compounds, which stimulate growth of algae and microorganisms. This growth forms an opaque mat on the lake's surface and lowers the level of dissolved oxygen produced by plants in the lake. Over time, the algae and microorganisms become so dense that the oxygen becomes depleted, killing the fish in the lake. Decaying fish bodies and other sediments accumulate on the lake bottom, until gradually the lake becomes land.

12. A biologist claims that during lake succession, fish such as trout are slowly replaced by fish such as bluegills. How must these fish be different for this claim to be TRUE?
- Bluegills must require less oxygen than trout.
 - Bluegills must have a greater population size.
 - Bluegills must require less nitrogen than trout.
 - Bluegills must have a higher carrying capacity.
13. Which of the following explains why algae and microorganisms reduce the level of dissolved oxygen?
- Plants below the lake's surface do not have cell walls.
 - Plants below the lake's surface cannot undergo mitosis.
 - Plants below the lake's surface cannot undergo meiosis.
 - Plants below the lake's surface cannot undergo photosynthesis.
14. There is much eutrophication taking place in Lake Mitchell, but in Lake Sarah there is relatively little. You read that this is partially due to the runoff of the different kinds of forests surrounding each lake. Which of the following would have to be true in order to support this claim?
- The trees are taller around Lake Sarah than around Lake Mitchell.
 - The trees are taller around Lake Mitchell than around Lake Sarah.
 - The forests around Lake Sarah lose their leaves in fall; those around Lake Mitchell do not.
 - The forests around Lake Mitchell lose their leaves in fall; those around Lake Sarah do not.
15. After a volcanic eruption has covered an area with lava, which of the following is the most likely order of succession in the repopulation of the area?
- lichens ----> grasses ----> shrubs ----> trees
 - mosses ----> grasses ----> lichens ----> trees
 - grasses ----> trees ----> mosses ----> lichens
 - shrubs ----> grasses ----> trees ----> lichens

16. *Read the article below and answer questions 16 and 17.*

Burning Man

People have been altering the climate since the days of the woolly mammoth.

Humans are constantly manipulating their environment: we now plow over forests to make space for parking lots and giant malls, fill in marshland for seaside condominiums, and muddy the air with car exhaust and industrial pollutants. In the bargain, mankind has altered local ecosystems, raised global temperatures, and perhaps even influenced the patterns of rainfall and the strength of hurricanes (see "Rainmakers" in *Discover*, November 1998). But all this inadvertent tinkering with climate and the environment is nothing new. According to geologist Gifford Miller of the University of Colorado at Boulder, it has been going on for many thousands of years.

Miller believes that the systematic burning of vegetation in Australia by early Aboriginal peoples, beginning about 50,000 years ago, caused an irrevocable shift in the flora and the climate of the entire continent. Today, the vast interior of Australia is an arid and desolate place, with nutrient-poor soils and sparse plant life. It was not always so; at many times in the past, the entire continent abounded with lush vegetation and large inland lakes.

Before humans came along, nature alone controlled these changes. According to fossil and other evidence, Australia cycled through long periods of dry and wet conditions from at least 150,000 years ago until about 40,000 years ago. These climatic shifts correspond to a variation in Earth's orbit around the sun, called the Milankovitch cycle, which changes the amount of solar radiation that reaches the planet. The Milankovitch cycle is responsible for the waxing and waning of glaciers in the Northern Hemisphere.

Controlled burning of vegetation by early Australians, Miller thinks, transformed the flora of northern Australia from drought-resistant plants to grassland. The altered landscape influenced the climate and ultimately led to the desertification of the continent's interior. "Such a shift would have dramatically reduced the recycling of moisture between land and atmosphere," says Miller.

Used by permission of Discover-Science News.

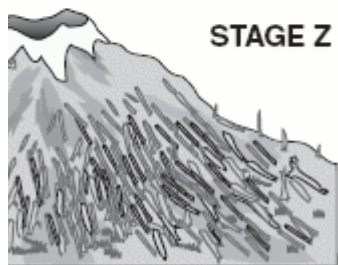
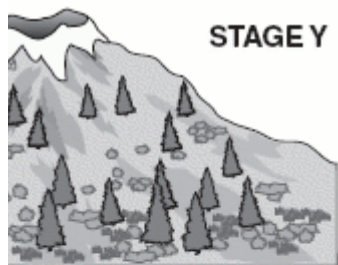
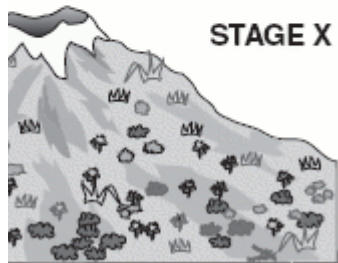
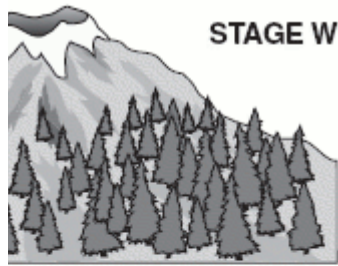
16. The central claim of the article is which of the following?

- a. The Milankovitch cycle has strongly influenced human cultures.
- b. Only with modern technology has humanity begun to alter the environment.
- c. Manipulating the environment is acceptable because people have always done it.
- d. People have been altering the environment much longer than previously believed.

17. In paragraph 4, the transformation of flora is an example of which process?

- a. recycling
- b. predation
- c. succession
- d. fossilization

18.



18. When the Mount St. Helens volcano erupted, the blast covered much of the surrounding area with ash. Based on the diagram above, which list shows the sequence of secondary succession that followed that eruption?

- a. X, Y, Z, W
- b. Z, X, Y, W
- c. W, Y, X, Z
- d. Z, Y, W, X

19. Why does the nitrogen cycle limit the carrying capacity of some ecosystems when Earth's atmosphere is 78% nitrogen?

- a. Only ultraviolet light can bond nitrogen with nonpoisonous elements.
- b. Very few organisms can fix nitrogen into biologically useful compounds.
- c. Only animals can use nitrogen in chemical reactions that give them energy.
- d. Compared with solids, gases have such a low density that nitrogen is still scarce.

20. Which of these is a negative side effect of using pesticides on crops?

- a. Crop pests are destroyed.
- b. The crop takes longer to mature.
- c. The size of the crop is reduced.

The characteristics of some organisms are listed below.

Algae - *producers*

Osprey - *carnivorous bird*

Largemouth bass - *carnivorous fish*

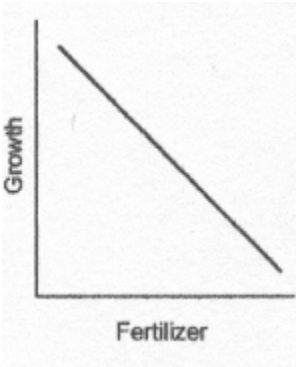
Daphnia - *herbivorous crustacean*

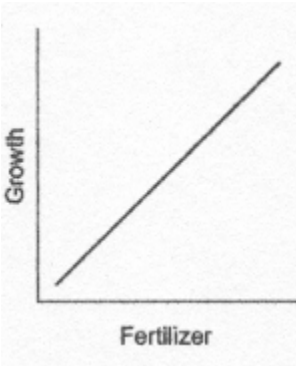
Minnow - *omnivorous fish*

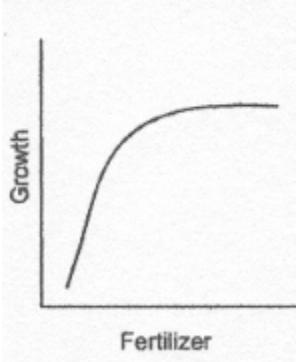
21. Based on the information given above, which of the following food chains is possible?

- a. largemouth bass → osprey → algae → daphnia → minnow
- b. algae → minnow → daphnia → osprey → largemouth bass
- c. osprey → largemouth bass → minnow → daphnia → algae
- d. algae → daphnia → minnow → largemouth bass → osprey

22. Fertilizers help plants grow faster. However, as more and more fertilizer is added, the plants may stop growing and begin to die. Which graph best illustrates this pattern?

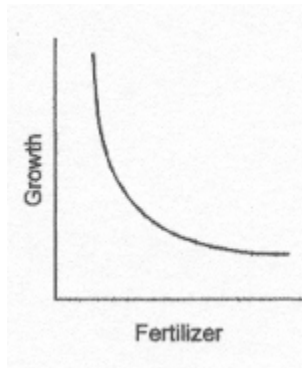
- a. 

A line graph with 'Growth' on the vertical y-axis and 'Fertilizer' on the horizontal x-axis. The line starts at a high point on the y-axis and slopes downward to the right, ending at a lower point on the y-axis.
- b. 

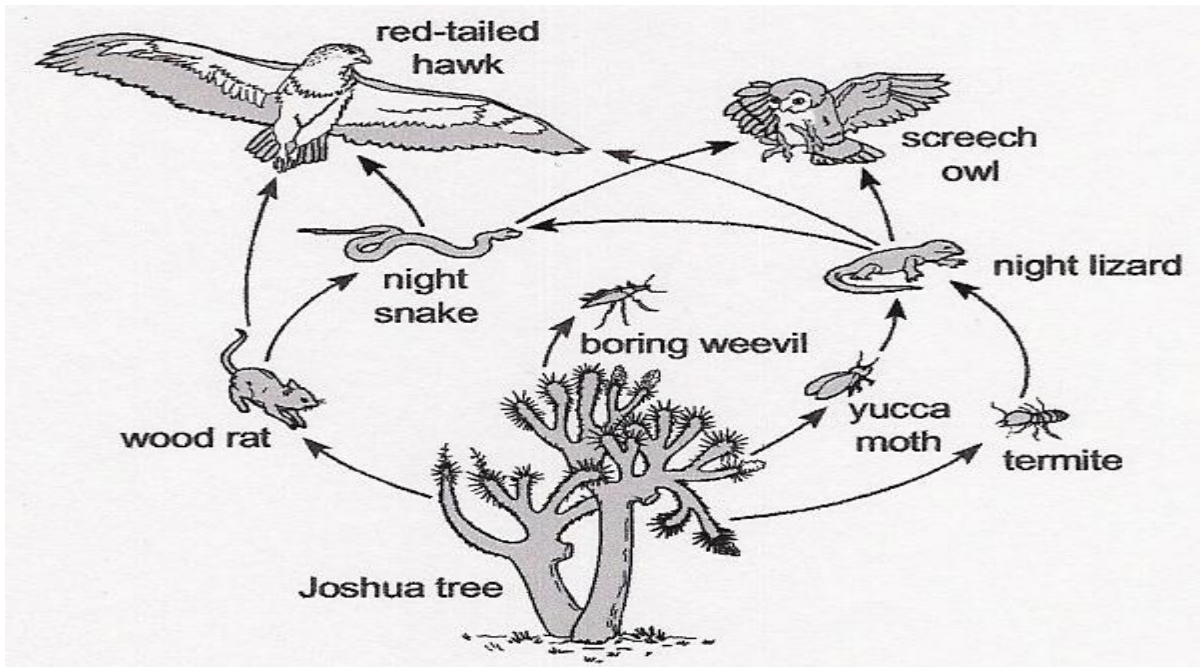
A line graph with 'Growth' on the vertical y-axis and 'Fertilizer' on the horizontal x-axis. The line starts at a low point on the y-axis and slopes upward to the right, ending at a higher point on the y-axis.
- c. 

A line graph with 'Growth' on the vertical y-axis and 'Fertilizer' on the horizontal x-axis. The curve starts at the origin (0,0) and rises steeply, then gradually levels off as it moves to the right, approaching a horizontal asymptote.

d.



Study the diagram below of a *partial* desert food web. Then do Numbers 23 through 25.



23. What do the arrows in the diagram represent?

- a. the flow of energy in a food web
- b. evolution from less to more complex organisms
- c. symbiotic relationships among desert organisms
- d. the movement of desert organisms at night

24. The night snake population might increase as the result of

- a. an increase in the screech owl population
- b. an increase in the yucca moth population
- c. a decrease in the night lizard population
- d. a decrease in the wood rat population

25. The night lizard might be called a "secondary consumer" because

- a. it feeds on a plant-eating animal.
- b. it is eaten by another animal.
- c. it eats the remains of other animals.
- d. it comes out to feed after the night snake.