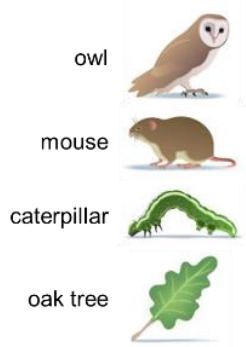
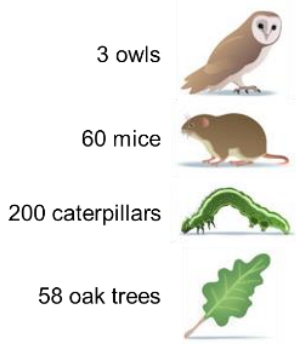
2A Species Richness and Diversity

2. Community Ecology

The structure of a community is measured and described in terms of: species composition and species diversity.

Species Richness	Species Diversity
The **species richness** of a community is a listing of the species within a community; it does not reveal the relative abundance of organisms. ● For example, a coniferous forest has a different composition from a tropical rain forest in species of plants and animals.	**Species diversity** of a community includes not only a listing of the species in the community, but also the abundance of each species. ● The greater the diversity, the greater the number and the more even the distribution of the species.





Simpson's Diversity Index—

$$\text{Diversity Index} = 1 - \Sigma\left(\frac{n}{N}\right)^2$$

n = the total number of organisms of a particular species

N = total number of organisms of all species

The Simpson's DIversity Index is one way to measure richness and diversity

Using the above example, we will have a total of 321 organisms and 4 different species. We start by calculating the sum -
$(3 \text{ owls}/321)^2 + (60 \text{ mice}/321)^2 + (200 \text{ caterpillars}/321)^2 + (58 \text{ oak trees}/321)^2 = 0.46$

Diversity index = 1-0.46= 0.54

How to interpret the Diversity Index: The index returns the probability that two individuals taken at random from a community (with replacement) will be different species.

Think counting and probability**.** If I pick a card out of a deck of cards and it is a Queen, then return the card to the deck and pick another card at random. What is the probability that this card will be a Queen (same species)? For the first pick, the probability is 4/52 (there are 4 Queens in a deck of 52 cards). We put the card back, so the probability of picking another Queen out of the deck is again 4/52. So the probability of picking up 2 Queens (2 of the same species) is 4/52 x 4/52 or 1/13 x 1/13 = 1/69. The probability of me **NOT** picking 2 Queens will be 1-1/69 or 68/69.

Now, let's make this more interesting. What is the probability that I **DO NOT** pick 2 cards of the same value (Kings, 2's, 10's, etc.). I calculated the probability of picking up 2 Queens, now I have to calculate the probability of picking up 2 two's, 2 three's, etc. (every "species" of card). Then I

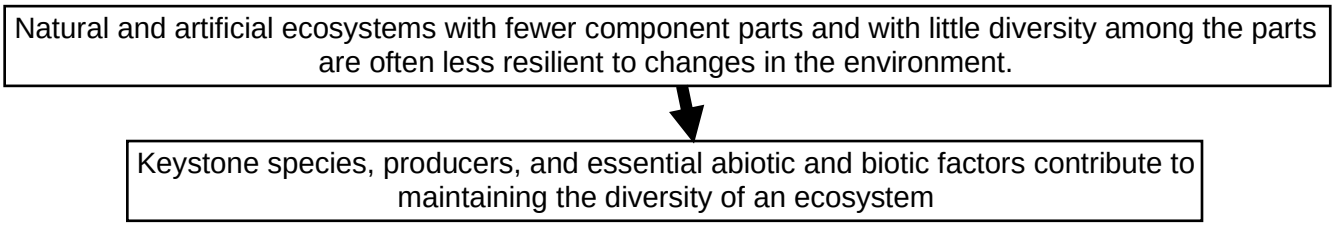
ADD these probabilities because I can get 2 identical cards by picking up 2 two's OR 2 Kings OR 2 Jacks, etc. Remember AND means addition in probability. Once I add up all the probabilities, I subtract them from 1 (100%) to get the probability of NOT picking up 2 identical cards.

Because the index is probability of randomly picking 2 organisms of 2 DIFFERENT species, the higher the value, the more diverse the community is. In the above example the probability of picking 2 different species is 0.54 or 54%.

Impact of Diversity

Diversity of species within an ecosystem may influence the stability of the ecosystem.

- Ecosystems with little species diversity are often less resilient to changes in the environment
- Keystone species, predators, and essential abiotic and biotic factors contribute to maintaining the diversity of an ecosystem



Keystone Species

A keystone species is an organism that plays a unique and crucial role in the way an ecosystem functions. Without keystone species, the ecosystem would be dramatically different or cease to exist altogether.

- The effects of keystone species on the ecosystem are disproportionate relative to their abundance in the ecosystem
- A small number of keystone species can have a large impact on the environment
- When they are removed from the ecosystem, the ecosystem often collapses.

Keystone species include (based on niche):

- Predators
- Prey
- Plants
- Links (e.g. pollinators)
- Ecosystem engineers (those that create or modify habitats, or can affect nutrient cycling

A keystone species if often (but not always) a predator.

- A single mountain lion can roam an area of hundreds of miles.
- The deer, rabbits, and bird species in the ecosystem are at least partly controlled by the presence of the mountain lion. Their feeding behavior, or where they choose to make their nests and burrows, are largely a reaction to the mountain lion's activity. Scavenger species, such as vultures, are also controlled by the activity of the mountain lion.

Examples of Keystone Species

Removal of the keystone sea otter : sea urchins overgraze kelp and destroy the kelp forest community.

Sea otters in the Pacific Northwest

- Sea otters feed on sea urchins, controlling their population.
- If the otters didn't eat the urchins, the urchins would eat up the habitat's kelp.
- Kelp, or giant seaweed, is a major source of food and shelter for the ecosystem. Some species of crabs, snails, and geese depend on kelp for food. Many types of fish use the huge kelp forests to hide from predators.
- Without sea otters to control the urchin population, the entire ecosystem would collapse.

Elephants in Africa

- African elephants help to maintain suitable habitats for many other species in savanna and forest ecosystems
- Elephants directly influence forest composition and density, and can alter the broader landscape
    - In tropical forests, elephants create clearings and gaps in the canopy that encourage tree regeneration
    - In the savannas, they can reduce bush cover to create an environment favorable to a mix of browsing and grazing animals

- Many plants species also have evolved seeds that are dependent on passing through an elephant's digestive tract before they can germinate
    - It is calculated that at least a third of tree species in west African forests rely on elephants in this way for distributions of their future generations
- Source: Nunez, Martin A., and Romina D. DiMarco. "Keystone Species." *Encyclopedia of Sustainability.* Berkshire Publishing Group, 2012, pp. 226-230.
- Source: World Wildlife Fund (WWF). (2011). African elephant. Retrieved December 27, 2011 from http://www.worldwildlife.org/species/finder/africanelephants/africanelephant.html

Watch the following video: How Wolves changed rivers

You can also go to YouTube and type in How wolves change rivers, this will take you to the video.

QUESTIONS:

1. The number of species in a community is referred to as the
    A. keystone species
    B. ecosystem productivity
    C. species diversity
    D. species richness

Modified from Maerna Kauffman

2. Removal of a _____ from a community affects community structure significantly.
    A. keystone species
    B. niche
    C. competitor
    D. predator

3. The more component parts and more diverse parts, the more healthy the ecosystem.

    A. True B. False

4. In the Video about the reintroduction of wolves in Yellowstone it was said that the presence of wolves changed the course of the rivers. Briefly explain how that is possible.

2B Species Interactions

2. Community Ecology

How species and populations interact with each other affect the distributions and abundance of populations. We can also call these "community interactions."

Types of Interactions

<table>
<tr><th colspan="2">Name of Interaction</th><th>Description</th></tr>
<tr><td colspan="2">Competition</td><td>● More than one organism uses a resource at the same time, or wanting/needing to use the resource simultaneously
● Example resources:
○ Food
○ Living space/territory
○ Mates (if same species)
● Niche partitioning (see below)
Two kinds
Intraspecific Competition
● Between members of the same species
 
Bighorrn sheep fighting over mates
Interspecific Competition
● Between members of different species
 
Cheetahs & hyenas fighting over food</td></tr>
<tr><td colspan="2">Predation</td><td>● One organism feeding on another
● Typically refers to animals</td></tr>
<tr><td rowspan="3">Symbiosis
Any long-term & close relationship between two or more species</td><td>Mutualism</td><td>● Benefits both members of the relationship (+ / +)
● Obligate symbionts – both organisms entirely depend on each other for survival</td></tr>
<tr><td>Commensalism</td><td>● Benefits one organism, the other organism is not affected (+ / 0)</td></tr>
<tr><td>Parasitism</td><td>● Benefits one organism, harms the other organism (+ / -)
● The organism that benefits is called the parasite
● The organism that is harmed is called the host</td></tr>
</table>

Niche Partitioning

- Competing species use the environment differently in a way that helps them coexist
- **Competitive exclusion**: no two species can indefinitely occupy the same niche at the same time
  - Over time, either one population replaces the other or the two species evolve to occupy different niches
- If it appears two species occupy the same niche, there must be slight differences
  - E.g. two species of paramecium coexisted if one fed on bacteria at the bottom of the test tube and the other fed on suspended bacteria

- **Resource partitioning**: when species shift niches; they no longer directly compete
    - Results in character displacement (two populations diverge in morphological, ecological, behavioral, or physiological characters)

Do you know any examples of symbiosis? List them here

Name the Symbiosis:

Name the symbiotic relationship which is described in the scenario. You may use + and - or the actual term. Example +/+ of mutualism.

Scenario:

1. An egret hangs out with cattle. The cattle graze and eat grass. The cattle's grazing disturbs the insects and other animals living in the grass. This disturbance makes it easier for the egret to catch and eat these insects for food.

Type of symbiosis _____

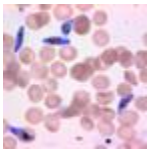
2. A kind of plant grows harmlessly on a tree in the rainforest. The plant gets physical support from the tree.

Type of symbiosis _____

3. The Squid and Vibrio fischeri bacteria you encountered in the Quorum sensing TED talk, glowing bacteria helps the squid not casting a shadow and escaping predators, the bacteria gets food while inside the squid.

Type of symbiosis _____

4. Plasmodium - a unicellular eukaryote, requires a human liver and blood cells to reproduce. When the organism lives in a human, it causes disease, malaria.



Type of symbiosis _____

Modified from Maerna Kauffman

5. A crustacean has to attach itself to a substrate in order to live. The crustacean attaches itself to a whale. By living on the whale, it has a place to settle and can filter food by passing water. The whale is not affected.

Type of symbiosis _____

6. Termites have an organism called metamonads living in their guts. Termites require the metamonads to digest the wood that they eat, and the metamonads get a place to live.

Type of symbiosis _____

Watch this video https://www.youtube.com/watch?v=vMG-LWy
or Go to YouTube and search for Body Invaders, National Geog

1. What kind of symbiotic relationship did you just observe? Explain how each organism is affected.

Watch Crash Course Mind controlling parasites

or go to YouTube and search for Crash Course, Mind Controlling parasites

2. Why is Toxoplasma Gondii's ability to control rodent's brains an evolutionary adaptation? Explain how this increases the fitness of the parasite.

Invasive Species

- **Invasive species** – organisms that are introduced, by human action, to an area where they do not naturally live and where they do not naturally breed
    - They often have *no competition or predation* to control their population (imagine a population with very few limiting factors!)
    - The plants and animals in that area have no adaptations to protect themselves from the new species
- They often devastate ecosystems where they are introduced
- Why invasive species are successful
    - No natural predators, parasites, pathogens
    - Little limitation on resources
    - No environmental inhibitors (e.g. pollutants)
    - Available niche not occupied by any other species, hence no successful competitors
    - Prey lack effective defense mechanism against introduced species
    - Appropriate environmental conditions (e.g. rainfall, temperature)
- Do you know any examples of invasive species? List them here:

Examples of Invasive Species

Brown tree snake

- Stink bugs in United States
- Burmese python in Florida
- Brown tree snake in Guam
    - Caused extinction of many native species in Guam (an island in the Pacific)
        - Before the introduction of the brown tree snake, Guam had 12 species of native forest birds
        - Today 10 of those are extinct on Guam, and the other two species have fewer than 200 individuals
        - Having so few birds impacts seed dispersal affects many parts of the ecosystem
    - Tried many ways to eliminate the species, but nothing has been successful
- Kudzu in eastern United States (including Virginia)
    - Along Virginian roadways and agricultural fields
    - Out-competes and eliminates native plant species

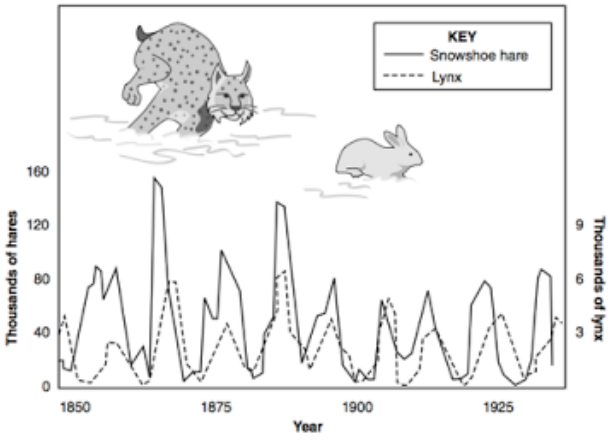
Kudzu

Kudzu range

Predator/Prey Population Changes

Often a graph of predator-prey population densities shows regular peaks and valleys with the predator population lagging slightly behind the prey. Two reasons are possible:

1. The biotic potential of the predator may be great enough to overconsume the prey; the prey population declines and the predator population then follows
2. Or the biotic potential of the prey is unable to keep pace and the prey population overshoots the carrying capacity and suffers a crash



Note in the snowshoe hare and Canadian lynx populations in the graph to the right. The predator (lynx) population size lags slightly behind that of the prey (hare) population,

QUESTIONS:

Modified from Maerna Kauffman

1. Non-native species like kudzu, zebra mussels, and nutria experience _____ outside their native area due to a lack of natural predators and their ability to compete more successfully than native species for resources.
    A. environmental resistance
    B. extinction
    C. resource partitioning
    D. exponential growth

2. _____ is when one living organism feeds on another.
    A. Competition
    B. Predation
    C. Parasitism
    D. Mimicry

3. When one living organism feeds on another, the organism serving as the food source is called the ___.
    A. prey
    B. predator
    C. consumer

4. When the population density of prey increases, ____.
    A. the population density of the predators increases as well, but lags slightly behind that of the prey
    B. the predator numbers exceed those of the prey
    C. predators are less likely to encounter the prey
    D. lack of food for the predator may cause a cycling effect

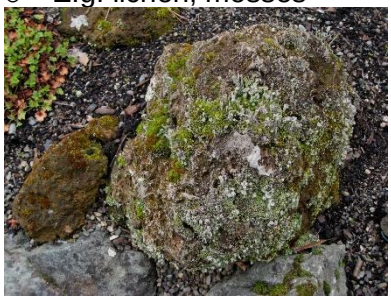
5. Resource partitioning commonly results in all of the following EXCEPT:
    A. Character displacement
    B. Allows different species to coexist in the same habitat
    C. Less competition
    D. More niche overlap between species

Community change resulting from disturbances sometimes follows a pattern, **Ecological succession** describes predictable and orderly changes in the composition or structure of an ecological community. It could be initiated by:

- Formation of a new, unoccupied habitat (like a lava flow or severe landslide)
- Some form of disturbance of an existing community (e.g. fire, logging)

Some important terms:

- **Pioneer species** – the first species to appear during succession
  - E.g. lichen, mosses

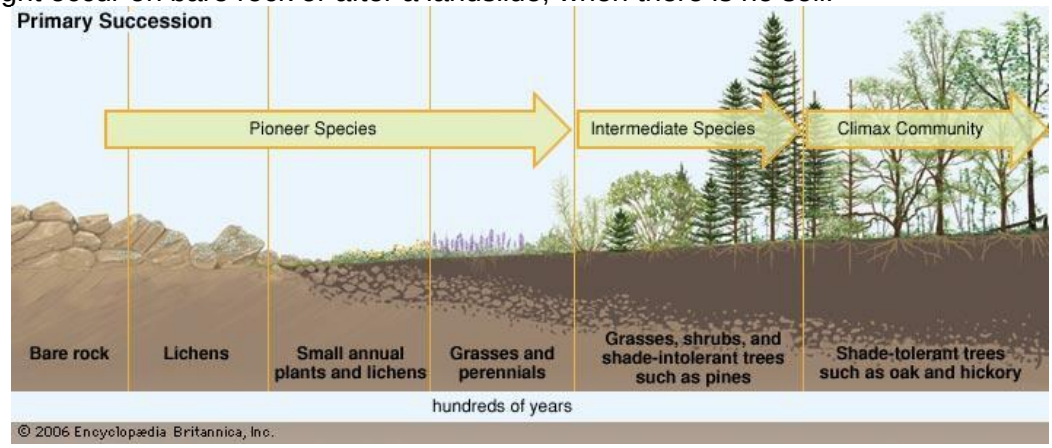


- **Climax community** – the stable, mature community where there is little change in the composition of species

Primary Succession

This type of succession occurs where there is no soil already established.

- This might occur on bare rock or after a landslide, when there is no soil.

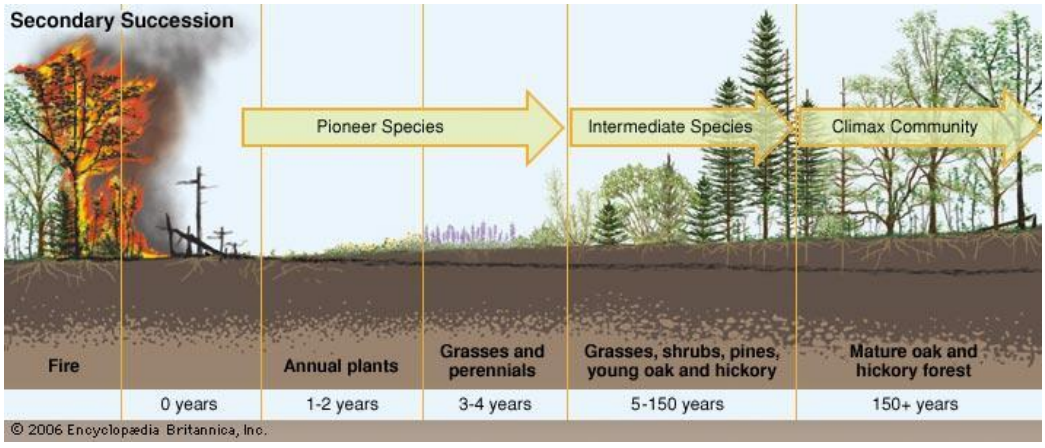


Secondary Succession

This type of succession occurs when there is a disturbance but the soil is still intact.

- This might occur after a fire, flood, or logging.

This is actually healthy for the ecosystem because it prevents any one species from overcrowding the forest. It also returns nutrients to the soil.

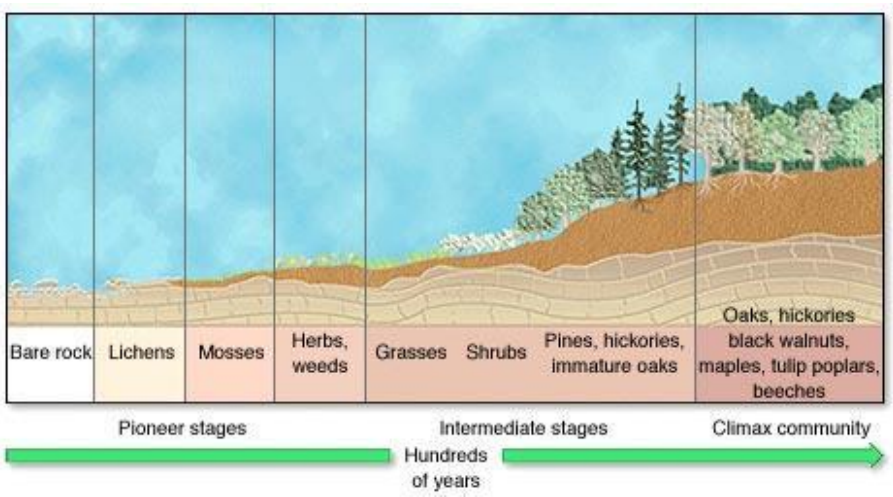


Modified from Maerna Kauffman

Order of Organisms in Succession

You might've heard of the term "mature forest" before. This refers to the types of plants and producers found in the forest. You can tell the general age of the forest by what types of plant can be found there.

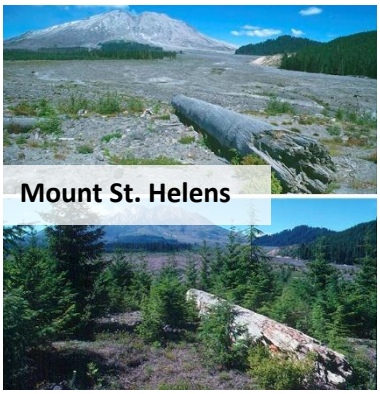
- Pioneer: grow from windblown spores, help develop soil
  - Lichens
  - Mosses
  - Herbs, weeds
- Intermediate: sprout from seeds blown in from nearby areas or carried in by animals
  - Grasses,
  - Shrubs,
  - Pines, hickories, immature oaks (think: evergreen trees dominate)
- Climax community: "mature" forest
  - Oaks, hickories, black walnuts, maples, tulip poplar, beeches (think: deciduous trees dominate)



By altering soil properties, pioneer plant species can facilitate colonization by new plant species during succession.

Examples

- Yellowstone Park had massive fires in 1988, but we have seen the community return.
- Mount St. Helens erupted in 1980, destroyed the entire ecosystem below it. The ecosystem has since recovered.



QUESTIONS:

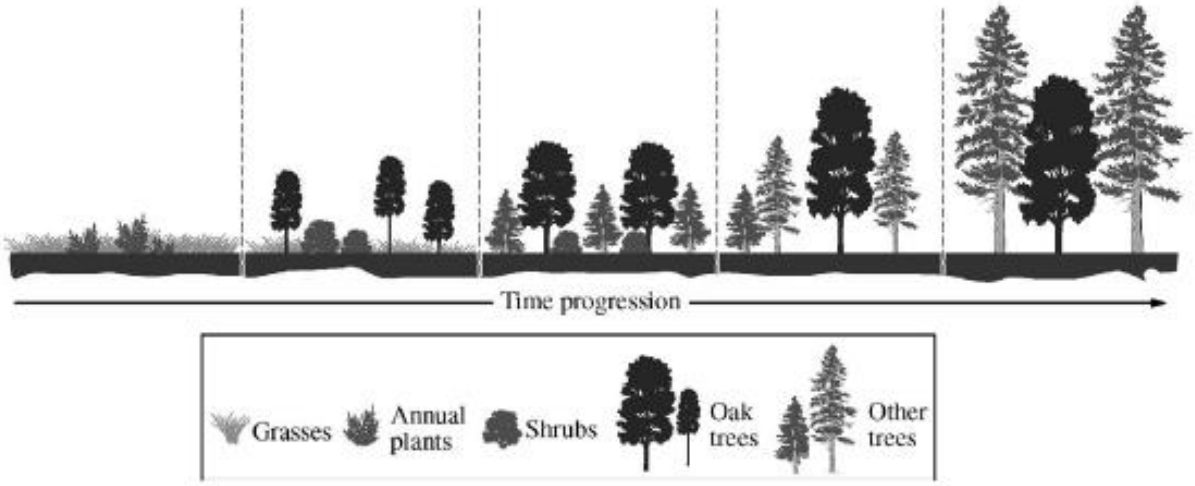
1. Looking at the examples of Yellowstone and Mount St. Helens, which type of succession best fits each ecological event?
   A. Yellowstone – primary succession; Mount St. Helens – primary succession
   B. Yellowstone – primary succession; Mount St. Helens – secondary succession
   C. Yellowstone – secondary succession; Mount St. Helens – primary succession
   D. Yellowstone – secondary succession; Mount St. Helens – secondary succession

2. After a forest fire, secondary succession occurs in an ecosystem. Which of the following statements **BEST** explains why pioneer species are replaced by other "climax" trees?
   A. The fast growing trees and other pioneer species absorb environmental pollutants more quickly than the "climax" trees and die off, leaving space available for the "climax" trees.
   B. The "climax" trees eventually grow taller than the fast growing trees and other pioneer species and shade out the fast growing trees beneath them.
   C. The pioneer species change the chemical composition of the soil in a way that favors the growth of grasses and perennials.

Modified from Maerna Kauffman

D. The roots of the woody pioneers spread through the soil and inhibit the fast growing trees ability to obtain essential nutrients.

3. What is the main *difference* between primary and secondary succession?
   A. Primary succession usually occurs faster.
   B. Primary succession occurs after a mature community is disturbed.
   C. Secondary succession takes place on intact soil.
   D. Secondary succession can result in a climax community.



4. The diagram above shows the progression of ecological events after a fire in a particular ecosystem. Based on the diagram, which of the following best explains why the oak trees are later replaced by other trees?
   A. Eventually the other trees grow taller than the oak trees and form a dense canopy that shades the understory.
   B. Oak trees alter the pH of the soil, making the forest better suited for shrubs and other trees.
   C. Roots of shrubs proliferate in the soil of the forest and prevent the oak trees from obtaining water.
   D. Oak trees succumb to environmental pollutants more readily than do either the shrubs or the other trees.