Introduction

Scottie Smith
Canterbury School of Florida
St. Petersburg, Florida

One of the essential underpinnings of a course in environmental science is a basic understanding of ecology. The irony lies in the nature of the two courses. Environmental science is an introductory college course and is often a college student's first foray into the natural sciences arena. However, ecology is typically an upper-level course at most colleges and universities, requiring numerous introductory courses prior to enrollment. Ecology is the relationship between organisms—at the individual, species, population, community, and ecosystem level—and their environment. In order to understand environmental science, which is basically the human impact on these organisms and their interactions, one must grasp concepts that are actually quite difficult for the budding scientist. Therefore, a special focus devoted to ecology seemed prudent, particularly since both multiple-choice and free-response questions on the AP® Environmental Science Exam will directly and peripherally address concepts of ecology.

In this Special Focus publication, teachers will be provided with discussion and pertinent examples of numerous ecological precepts. The first section contains an introduction to energy, including photosynthesis, cellular respiration, and matter cycling and energy flow through ecosystems. This section is paramount to an understanding of AP Environmental Science and actually addresses one of the major themes of the course: Energy conversions underlie all ecological processes. Pertinent information is provided regarding trophic levels, food webs, and ecological pyramids. Another section discusses primary productivity because it potentiates the complex nature of the niche structure and therefore impacts the biodiversity of ecosystems. Special instruction is given to the terminologies used for species within various niche structures. An entire section is devoted to discussing the evolution, natural selection, adaptation, and interactions of species. The evolution section addresses another of the themes—that Earth is one interconnected system—upon which the AP Environmental Science course is based. Finally, there is a discussion of community interactions, including succession, disturbance, resilience, stability, edge effect, and island biodiversity. Numerous exercises have been produced for this Special Focus publication, including adaptation and natural selection labs, succession, primary productivity, and ecological footprint and Shannon-Weiner biodiversity index calculations.

Since students have traditionally had difficulty with the variety of calculations required on the AP Environmental Science Exam, many different types of calculations and exercises have been included in this guide. It is hoped that students will master and acheive confidence in their mathematical skills after they have sufficient practice to increase their proficiency. Calculations are required not only in the multiple-choice portion of a typical AP Environmental Science Exam; sometimes the free-response section incorporates several different calculations so that the questions can be answered fully.

Ecosystem Energy Flow: An Introduction to Energy and Laws of Thermodynamics

Carol Widegren
Lincoln Park High School
Chicago, Illinios

Although students entering an AP Environmental Science class have taken previous science classes, generally they do not have an understanding of the role that energy has in their biological environment.

In high school physics class, students are usually taught to define energy as the ability to do work, which might be expressed as a force moving through a distance. They are further taught that energy may be either kinetic (an energy associated with motion) or potential (an energy associated with position). They may encounter energy in mechanical, heat, light, and electrical form, among others. When studying kinematics, they learn that not all of the energy put into a system results in useful energy; some is converted to heat due, for example, to friction. This phenomenon leads to an understanding that energy cannot be created or destroyed but can be transformed from one form to another.

Often neither chemistry nor physics courses include a discussion about the energy necessary to hold together the parts composing atoms or the energy required by atoms to form molecules. Energy levels may be discussed in both courses, but often a conceptual understanding of energy is not achieved. It is with this background that students enter the AP Environmental Science class.

Thermodynamics, the principles that govern energy relationships, is very important to an understanding of our biological environment. Such energy relationships describe constraints on the generation of heat, the transformations of energy, and energy transfer within a system or to the surroundings. In other words, if energy is added to a system from its surroundings, it may return to the surroundings in a different form. The first law of thermodynamics states that energy is conserved when both a system and its surroundings are considered; that is, energy can neither be created nor destroyed but may be transformed from one form to another, including the exchange of energy with its surroundings. The second law is sometimes referred to as the law of entropy. To put it simply, in any energy transformation, some energy is lost as unusable energy in the sense that work cannot be performed.

Any discussion of energy in an environmental science class must investigate the two following questions: (1) Where does the energy needed for living organisms originate and (2) how is energy used by these organisms? At the onset of a discussion about energy relationships, it is important for students to think of the surface of earth as a system subject to the first two laws of thermodynamics. Most of the energy added to this system arrives on earth in the form of electromagnetic radiation from the sun. It has been estimated that 58 percent of the radiation directed toward earth is reflected or absorbed as heat by our atmosphere, that less than two percent of this remaining radiation is used by plants, and that the balance is transformed on earth's surface into heat. Other sources of energy that should be noted include energy released by geothermal and volcanic activity, as well as naturally occurring nuclear reactions.

Living organisms must conform to the laws of thermodynamics. Consider living organisms as temporary storage units for useful energy, whereby one organism can be used by another as a source of energy. In its transfer from one organism to another, useful energy is lost to the environment in the form of heat until the useful energy is ultimately consumed. As energy cannot recycle, there is a continuous requirement for new energy to enter the system. Photosynthesizing organisms use a series of oxidation-reduction reactions based on solar input to produce and store their own carbohydrates, which then become the energy source for other organisms.

Ecosystems and Energy

The food consumed by an organism will undergo a number of chemical reactions that are collectively referred to as metabolism. Materials in addition to water are transported across cell membranes. These processes are facilitated by carrier proteins embedded within the membrane. The detailed transformation of nutrients is beyond the scope of this discussion. Descriptions of these processes may be found by searching for information on the Krebs (citric acid) Cycle. Students should understand that organisms take in nutrients, the energy of which becomes available through oxidation and reduction reactions.

Extremophiles should be briefly considered in this course. These organisms live under severe conditions; some never receive sunlight or may be found clustered around underwater vents producing superheated boiling water. Their source of energy is through chemosynthesis, the process in which inorganic compounds such as nitrites, hydrogen sulfide, and hydrogen gas provide the necessary energy for these organisms to produce their own organic food. This information is sufficient to explain chemosynthesis without going into further detail.

Photosynthesis

Green plants are able to make food by producing ATP (a carrier for energy) and NADPH (a carrier for electrons used in the synthesis of glucose) in their chloroplasts, which then reduce carbon dioxide and water to form a carbohydrate (glucose) *only* in the presence of sunlight and chlorophyll. This process is actually a complex series of reactions where radiant energy is transformed into chemical energy. This series of reactions produces most of the oxygen in our atmosphere.

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

carbon dioxide | water light & chlorophyll | glucose | oxygen

Cellular Respiration

In this process, carbon dioxide, water, and available energy are produced by the oxidation of glucose. This series of chemical reactions occurs in all living cells. In aerobic organisms (those that can utilize oxygen). It is a process that requires oxygen and occurs at the cellular mitochondria; however, the first steps in the transformation of glucose take place in the cytoplasm rather than within the mitochondria and do not require oxygen. If the reaction never proceeds to the mitochondria, the organism has carried out anaerobic respiration, also known as fermentation. These first processes are known as glycolysis (glucose breaking). Although heat is released in this process, some of the energy is used to replenish the supply of ATP (a carrier for energy) and NADPH (a carrier for electrons used in the synthesis of glucose).

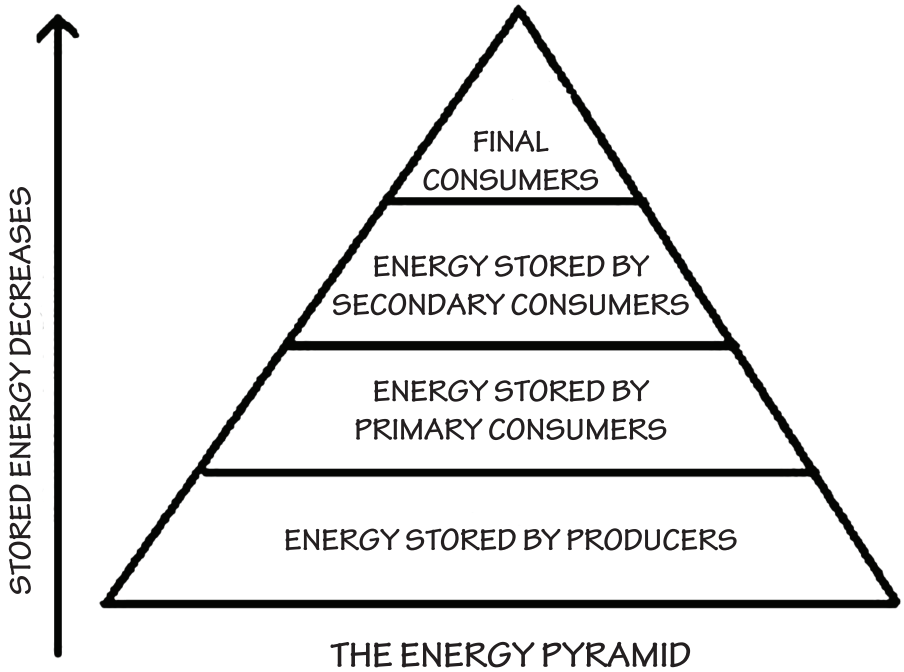
$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

glucose | oxygen | carbon dioxide | water

Trophic Levels

A producer, or autotroph, is an organism that makes its own food by either photosynthesis or chemosynthesis. A consumer, or heterotroph, is an organism that receives its energy from other organisms. Each step in the transfer of energy (autotroph to heterotroph and heterotroph to heterotroph) is known as a trophic level. The laws of thermodynamics apply to the energy flow through an ecosystem; therefore, less energy is available to organisms at each higher trophic level. This decreased amount of available energy at each trophic level is due to the amount of energy required by an organism to carry out the daily functions of living. It is estimated that only 10 percent of the energy at each trophic level is available to organisms at the next higher level.

Decomposers are often overlooked when considering trophic levels. These organisms receive their nutrients and energy while breaking down and recycling organic materials. Because their activity permits nutrients contained within deceased



THE ENERGY PYRAMID

organisms and waste products to be available to other trophic-level organisms, decomposers are important to the flow of energy and matter through the ecosystem

Food Chains and Webs

Energy flow through an ecosystem may be traced through its food chain; that is, by tracking down what feasts upon what, we can follow the flow of energy. At the lowest level of the food chain, we find the autotrophs—organisms that manufacture their food by either photosynthesis or chemosynthesis. Generally, herbivores eat autotrophs and are considered "primary consumers." Carnivores dine on the primary consumers and are designated as "secondary consumers." This, of course, is stated as the simplest food chain. In nature, as we are well aware, nothing is quite that simple. In an ecosystem, there are numerous food chains linked to each other to form a complex "food web."

Ecological Pyramids

The trophic structure of an ecosystem may be represented by an ecological pyramid. The base of the pyramid is composed of the producers, and each trophic level above the base represents consumers higher on the food chain.

Pyramids may be of three types: energy, numbers, and biomass. An energy pyramid shows a decreasing amount of energy available to each successive trophic level. This pyramidal shape is, of course, in accordance with the fact that only 10 percent of the energy at each trophic level is available to organisms at the next higher level. A pyramid based on the number of organisms at each trophic level also reflects energy loss, as does a pyramid based on biomass. Because only 10 percent of the energy at a given trophic level is available to the next higher level, food chains are usually short—usually not more than four or five links—and the number of organisms at each lower level must be greater than that of the organisms at the next higher level.

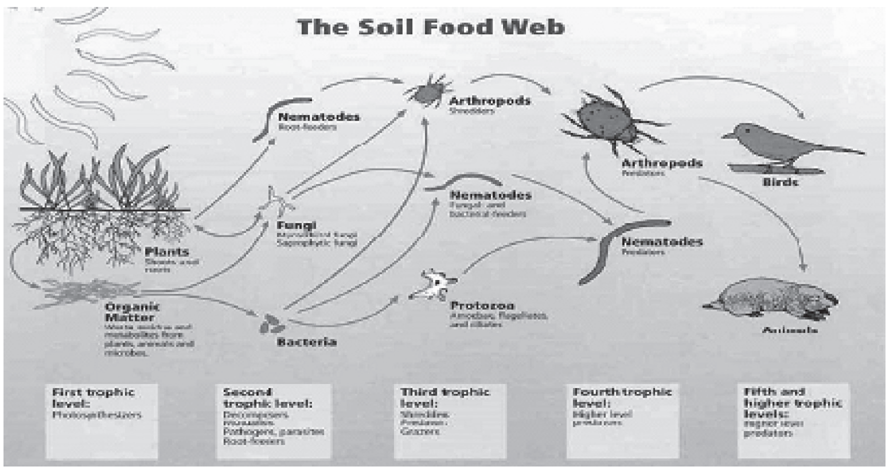


Image from:soils.usda.gov/…/soil_food_web.htm

An example of this could be found in a forest where green plants receive their energy from the sun. Primary consumers might include insects, mice, and rabbits. Secondary consumers could be birds and snakes, while tertiary consumers include wolves and owls. Note that owls are birds—a complex food web! Omnivores (like us) should be mentioned because omnivores circumvent the traditional notion of a food chain because they consume organisms from multiple levels.

Practice Questions:

1. How does the flow of energy through an ecosystem conform to the laws of thermodynamics? Be sure to discuss its origination, transformation, and utilization.

    Ecosystems conform to the laws of thermodynamics. The first law of thermodynamics states that energy is conserved; that is, energy cannot be created or destroyed, but it may be converted from one form to another. An ecosystem is a closed system that receives energy from outside sources; although there may be other sources, students have studied electromagnetic radiation from the sun. The organisms making up the ecosystem transform this energy into useful forms for storage and later utilization. Students study photosynthesis as a transformation process producing glucose (food), which may then be accessed as an energy source for the organism. The second law of thermodynamics states that some energy is lost as "useless" energy. Therefore, energy enters the system; is converted to food, which is stored by the organism; energy is used in normal metabolic processes; and energy is dissipated to the atmosphere during the normal living processes of the organism.

2. Green plants produce most of the oxygen in our atmosphere through a series of complex reactions. Name and describe this generalized reaction.

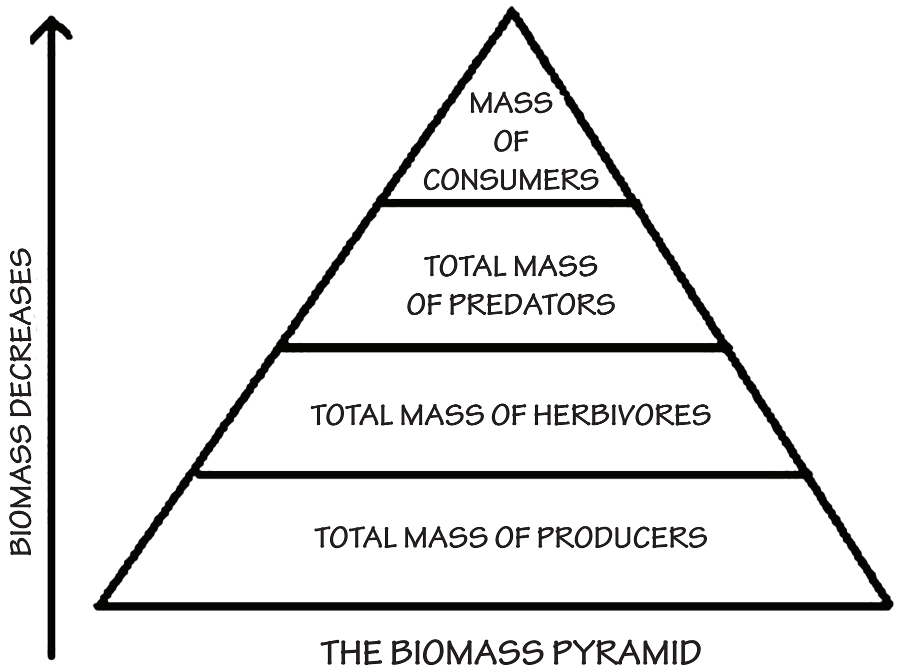
    Green plants produce most of the oxygen in our atmosphere by photosynthesis. The generalized reaction for this process is often referred to as "the light reaction."

$$\underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O} \longrightarrow \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2}$$

3. What is the role of ATP and NADPH in metabolism? What effect does the amount of light have on the metabolism of green plants?

    Green plants are able to make food by producing ATP (a carrier for energy) and NADPH (a carrier for electrons used in the synthesis of glucose) in their chloroplasts, which then reduce carbon dioxide and water to form a carbohydrate (glucose) only in the presence of sunlight and chlorophyll.

The amount of light available is critical for this process (photosynthesis) to occur.



4. Identify the structure shown above—be specific! What factors limit the steepness of the sides of this structure? Explain in detail.

   The diagram shown above may be a biomass, energy, or numbers pyramid by trophic level. As one moves higher on the pyramid, there is a decrease in biomass, energy, or numbers. Specifically, at the base level, stored energy, mass, or number of producers is greater than at the next level above. This decrease continues at each trophic level, culminating in the apex of the pyramid having the least biomass, stored energy, and/or quantity of individuals present.

5. A temperate deciduous forest contains the following organisms: oak tree, pine tree, grass, mouse, rabbit, crow, hawk, mushroom, dandelion, beetle, snake. Construct a food web using at least five of these organisms. If one of the organisms used in your web becomes unavailable, discuss what possible effect this would have on the web.

   There are numerous possibilities of a food web such as: grass-mouse-snake-crow-hawk. If one of the organisms becomes unavailable, the web changes to reflect the change. The most critical factor is at the lower levels of the food chain. If the producer (in this example, grass) becomes *unavailable, the next level (in this case, the mouse) will require another food source or a move to a different location. Otherwise it will starve.*

6. How would a food web differ in a different biome? To answer this part of question 5, select a different biome and create a food web.

   Different biomes have characteristic organisms present. You would not find a whale in a desert. It is important that the student name appropriate organisms for the selected biome and indicate a fitting food chain.

7. Each week, an owl must eat an average of five mice weighing 10 grams each in order to survive. How much plant material would each mouse have consumed? Solve this problem, and include set up and units. Explain how this scenario relates to trophic levels. Assume that energy and mass are proportional with the same constant of proportionality for each of these organisms.

   It is estimated that only 10 percent of the energy at each trophic level is available to organisms at the next higher level. It is given in the above question that an owl must consume five mice per week (one owl = five mice x 10 grams/each) in order to survive. Entropy occurs and not all of the grass is converted to biomass. Assuming that a 10-gram mouse would convert only 10 percent of the plant material, each mouse would have to consume 100 grams in order to survive. The mouse utilizes some of this grass for normal living functions, plus releases some as waste material.

$$\text{1 mouse} \times \frac{\text{10g(mouse)}}{\text{1 mouse}} \times \frac{\text{10g(grass)}}{\text{1g(mouse)}} = \text{100g(grass)}$$

   In this example, grass is at the producer level. It makes up the greatest biomass, it is the most numerous, and it has the greatest combined energy of the system. As herbivores, mice would make up the next trophic level, and have less biomass, fewer individuals, and less stored energy than the tropic level below it.

Bibliography

Lindemann, R. L. "The Trophic Dynamic Aspect of Ecology." *Ecology* 23, (1942) 399–418.

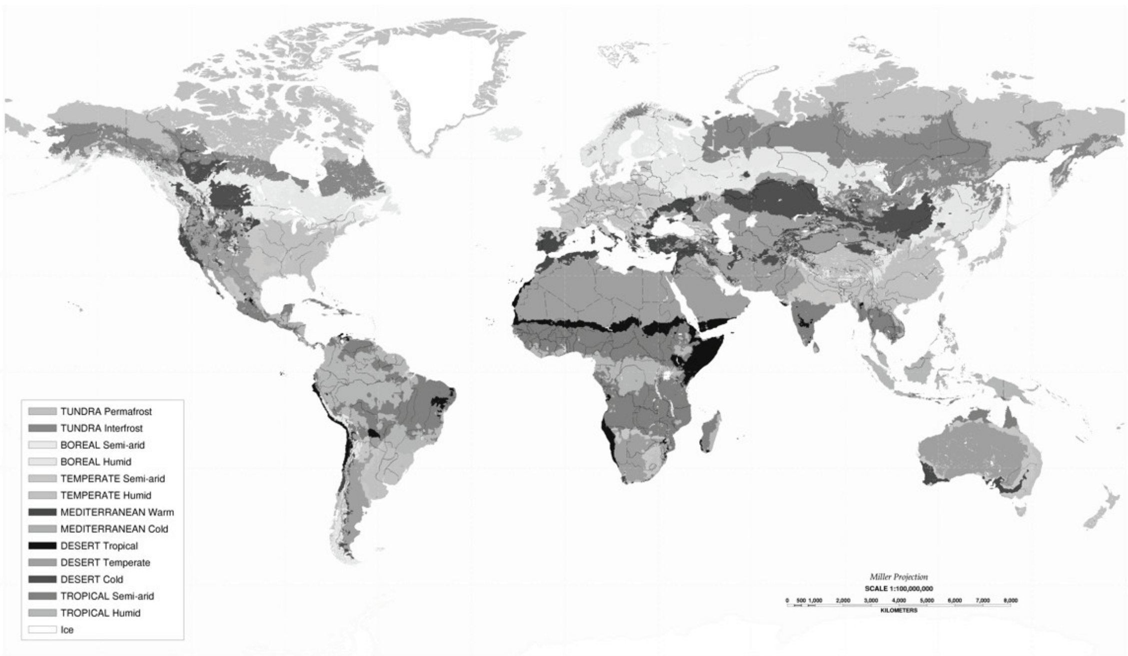
Miller, G. Tyler, Jr. *Living in the Environment.* Ontario: Brooks-Cole/Thompson, 2007.

Ecosystem Structure and the Role of Species Within Biomes

Kathryn Weatherhead
Hilton Head Island High School
Hilton Head, South Carolina

Introduction

A student of ecology should be familiar with the major biomes of the earth as illustrated below:



soils.usda.gov//use/worldsoils/mapindex/biomes

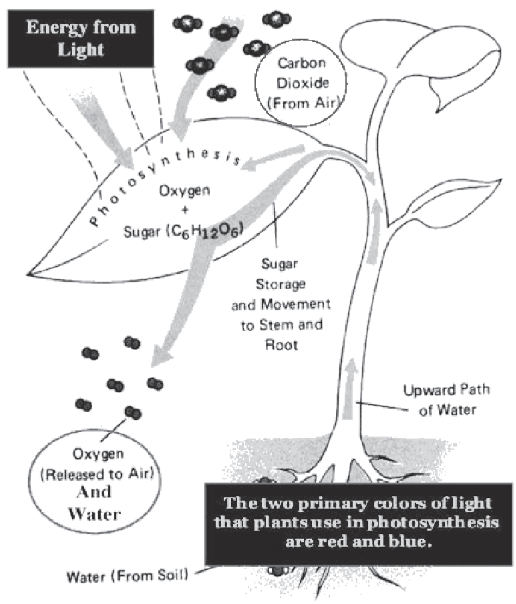
The main biomes include the polar regions of arctic tundra, taiga (boreal forests), temperate forests and grasslands deserts, and tropical forests and grasslands. There are also many different freshwater and marine biomes. For every biome there are unique abiotic and climactic conditions that support different organisms, from bacteria, fungi, and protists to plants and animals. The specific plants that can grow in a particular habitat are of utmost importance in determining what kinds of animals will be present as well, since the plant species support the animals.

Plants and animals interrelate in intricate and myriad ways. For example, plants may rely on animals, such as birds, insects, and rodents to carry pollen and fertilize seeds. The animals in turn use plants for shelter, nesting sites, and places to hide from predators or search for prey. Plant roots help hold soil moisture, nutrients, and particles against erosion, thereby reducing silting and fluvial deposits in streams and ponds whose turbidity would otherwise increase. This erosion control increases the depth of penetration of light, likely increasing the rate of photosynthesis and primary productivity.

Primary Productivity

Primary productivity is the fabrication of carbon compounds through photosynthesis or chemosynthesis by bacteria, protists, and plants. Such organisms contribute the sugars, lipids, and other building blocks for all other consumers in the trophic levels above the producers in a food web or energy pyramid. The organisms in a specific biome that support the rest of the organisms in this way are called *primary producers.*

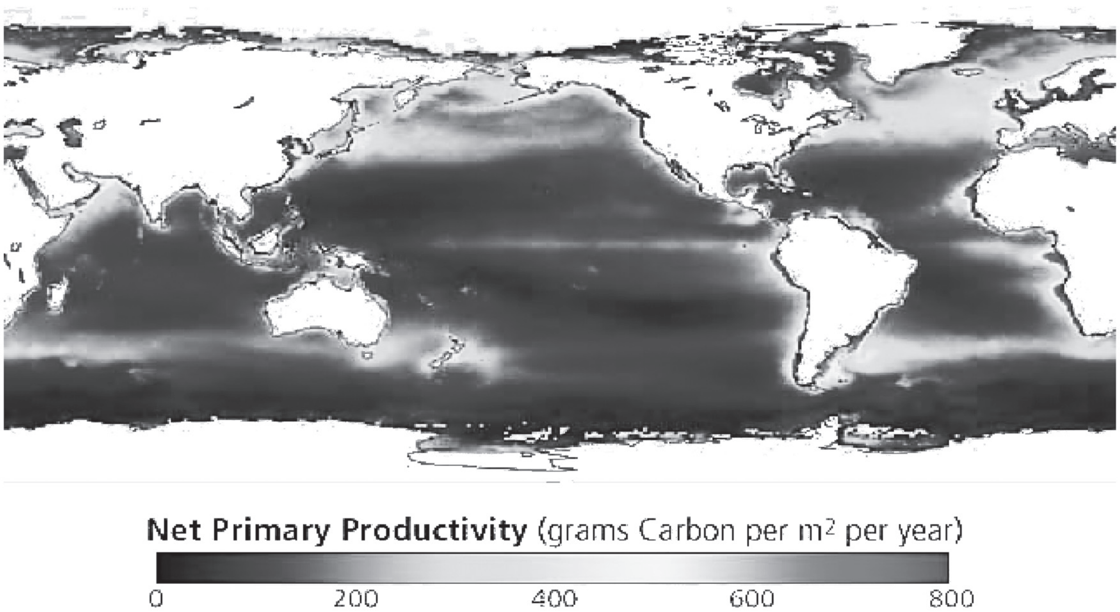
The ultimate source of the energy producing this organic fuel is sunlight. Raw materials of carbon dioxide gas and hydrogen from water combine to form the organic compounds, releasing oxygen from water into the atmosphere. *Gross primary productivity (GPP)* represents the rate at which producers can convert solar energy into biomass. *Net primary productivity (NPP)* represents the rate at which producers make and store photosynthetic products, but also takes into account the needs of the producers to use some sugar for their own energy requirements. Therefore, one must subtract the rate at which producers use some of their stored energy through aerobic cellular respiration. The general formula for calculating the available biomass in the form of high energy organic compounds is: *GPP - respiration rate = NPP.* These productivity values are often given in mg/L/day or may



www.nasa.gov

be expressed in energy units, such as kilocalories or kilojoules per day. Average net primary productivity in kcal/m^2/yr is sometimes referred to as *natural capital.*

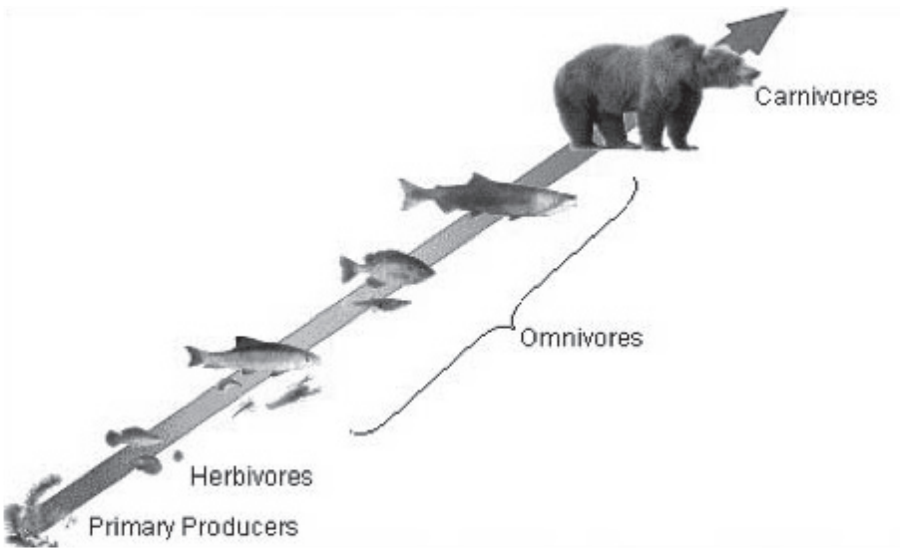
Various ecosystems and biomes of the earth show different rates of GPP and NPP. In terrestrial environments, tropical rainforests, swamps, and marshes have the most chlorophyll and other photosynthetic pigments that are often visible in satellite images and have the highest productivity rates, whereas deserts and polar regions have the lowest rates. In aquatic environments, salt marsh estuaries have the highest rates of NPP per square meter due to the nutrient-rich, detritus-filled waters that support dense *Spartina* grasses or mangroves. Oceanic productivity rates are the greatest overall, due to the fact that marine phytoplankton are efficient at various depths because of their different light-absorbing pigments and the vast number of these producers worldwide. Equatorial marine environments are often more productive than polar regions, and shallow coastal waters are more productive than deep, colder waters. Productivity is monitored by satellite images from which chlorophyll concentrations can be observed, as illustrated below.



seawifs.gfsc.nasa.gov

Roles of Species in Ecosystems

Within an ecosystem, certain *keystone species* play a crucial role in maintaining the biotic structure. Removal of the keystone species may have dramatic consequences for the overpopulation of herbivores, eventually decreasing the primary productivity of the ecosystem, resulting in overgrazing in certain terrestrial biomes. For example, in rocky intertidal zones sea stars feed on plankton-eating bivalve mollusks that would otherwise grow uncontrollably and cover the area. Because sea stars keep the population in check, a variety of other organisms like barnacles, anemones, and other invertebrates often flourish in the tidal area. A terrestrial example is the African elephant, which helps maintain the grasslands and savannahs. Without the elephants trampling the area and pulling up small trees and bushes for food or without some other animal to take on the elephants' role in this ecosystem, shrubs and bushes would create too much shade for the grasses to grow. The grasslands thrive in direct sunlight and help hold the soil with their roots. Normal grazing animals only eat the leaves and leave the roots intact. With fewer grasses, the organisms that eat the grass, such as antelope, die off due to lack of food reserves, ultimately affecting the number of predators, such as lions, who eat the grazers. Additionally, elephants are important in distributing seeds of trees they eat, and many trees species are lost when elephant herds are destroyed.



www.rcamnl.ws.usgs.org

Indicator species are those that provide information about overall equilibrium and health of an ecosystem. Birds are used as indicator species because they are found everywhere and respond quickly to environmental changes; this is one reason the canary was often used when miners went deep below the earth's surface to show the effects of toxic gases or decreased oxygen levels. Oysters play this role in a salt marsh environment because as filter feeders, any toxins in the water would likely build up in the tissues quickly, and populations of these organisms may rapidly decline due to fluctuations in salinity, temperature, and sediment turbidity. Even *Escherichia coli*

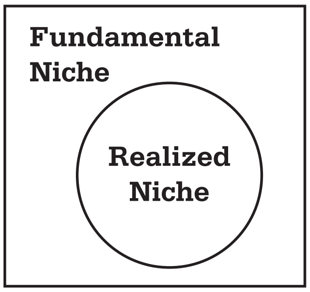
08-1453.AP.SF.EnvSciences.indd 14 8/15/08 4:21:05 PM

levels in aquatic ecosystems and soils can be considered indicator species and readily tested for and compared to EPA standards for water quality. *E. coli* is one of several bacterial species considered normal flora in the colon of mammals. In humans, it is necessary for the synthesis of vitamin K and proper digestion and excretion of bile salts. Some strains, however, are potentially lethal, and *E. coli* O157:H7 is a leading cause of food-borne illness. Clearly the levels of this microbe would signify the health of an area, particularly in the oyster populations in slow-moving tidal creeks that would have a propensity for filtering and collecting high levels of bacteria within their viscera. Another indicator species often used in terrestrial forest studies and pollution assays are lichens whose tissues are also quick to trap air and water-borne toxins and heavy metals.

Introduction of *exotic* or *nonnative* species has played a role in the exclusion of native species because they lack normal predator control or other limiting factors. These species are known by many descriptive terms including *nonindigenous, introduced, alien, transplants*, and *invasive.* Some exotics were introduced by wind, water, or other animals, but often they are brought to an area by humans. They can be devastating to the environment, degrading the normal habitats, reducing biodiversity, altering normal population genetics, and introducing alien diseases to the existing plants and animals, including humans. Not all nonnative species are harmful, and certain ornamental plantings may actually increase biodiversity, but the overall effects are usually detrimental. For example, zebra mussels introduced from Eastern Europe into the Great Lakes through the ballast of ships grow exponentially, clogging up waterways. Other common examples of introduced species that grow unchecked without natural predators include cane toads brought to Australia from Hawaii, kudzu vines from Asia, and armadillos and fire ants from Mesoamerica, which now thrive across much of the southeastern United States. Non-native species can be especially disruptive on island habitats with limited resources. This unchecked damage is certainly not a new phenomenon, and many historical accounts describe the deadly transmission of the measles virus and rodents by the early white settlers to Hawaii, as well as smallpox virus transmission to Native Americans by the Lewis and Clark expedition or by Pazzaro to the Incas, wiping out entire tribes and civilizations.

Niche Structure

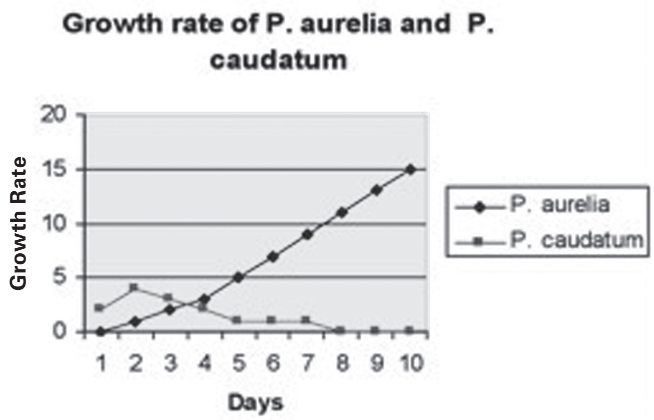
Individual species are usually adapted for a particular *habitat* and *niche* within a complex system. There are many abiotic and biotic *limiting factors* in species survival, including light, temperature, nutrients, gases, habitat space, water, wind, latitude, altitude, soil type, population size, and genetic diversity. The habitat refers to the specific geographical space in which an organism lives, including the limiting factors, while the niche represents the role of the organism in a community. In 1958 *G. E. Hutchinson* suggested that the niche could be modeled as an imaginary space with many dimensions. Each dimension or axis would represent the range of some environmental condition or resource that is required by the species. The niche of a plant might include optimum ranges of temperatures, light, humidity, and essential nutrients that it requires, while the niche of an animal could include the ranges of temperature, food sources, and predators. Different species can hold similar niches in different locations, such as the fact that seagulls along a beach and pigeons in a city both scavenge for food, or that different species of grass from grasslands of Australia or Africa provide the ground cover in North American prairies. Additionally, the same species may occupy different niches in different locations, organisms can assume a new niche when another organism dies out, or they take over a niche when introduced into a new habitat as in the case of nonnative species.



Niches may be categorized as either a *fundamental niche*, which is the full potential role of the organism and sometimes referred to as the "profession" of the organism; or a *realized niche*, which is the portion of the fundamental niche that is fully occupied by the organism when one takes into account interspecies competition and predation as illustrated.

Resource partitioning refers to evolutionary change in species in response to selection pressures from interspecies competition. Species may avoid competition by partitioning resources and habitats among themselves, and the degree of coexistence in the natural environment suggests that there is less competition in some areas. Common examples of resource partitioning include unique species of birds that forage on the same trees but obtain different foods such as berries and nuts or insects. These species often divide up the insects into different kinds by living at various vertical distributions in the same tree in a spatial microhabitat. In tropical rainforests, several different species of small anole lizards divide up the insect food population by living in different places within this same area.

Niche overlap occurs when resource requirements by at least two species are shared; however, when organisms do not partition their food, shelter, and other resources, natural selection pressures through competition or sexual selection may ultimately lead to the extinction of a species. This *competitive exclusion principle* of community ecology explains that two species that compete for the same resources cannot stably coexist when the conditions remain constant. One of the species will have an advantage over the other that either leads to its extinction or an evolutionary shift of the other species into a different or new niche in order to survive. A classic laboratory experiment of the competitive exclusion theory was conducted by the Russian biologist G. F. Gause, who grew two species of *Paramecium (aurelia and caudatum)* in individual cultures and then together. Both species grew exponentially and thrived when grown alone, but *P. aurelia* was the only successful species when the two were combined, thus illustrating the concept of exclusion as seen below.
A species' niche can be described as *generalist* or *specialist*. The generalist organism



rst.gsfc.nasa.gov

has the advantage of being able to eat a wide range of foods within a range of habitats, and its main problem is competition. The American alligator is an example of a generalist. A specialist has a very narrow range of habitat and diet, but often does not have as much competition. A giant panda is a specialist whose main concerns are predation and loss of habitat by human activities.

Finally, scientists often study the biodiversity of an area by conducting field sampling and using the Shannon-Weiner Index. The number of species in a biological community is termed *species richness, N*. For example, the number of species in a coral reef in Hawaii has greater species richness than grasslands of only a few species. *Species diversity* takes into account the abundance of a species as well. If a community is composed of very few species, or if only a few species are abundant, then species diversity is low. High species diversity indicates a complex community, with increased species interactions that have more energy transfer (food webs), predation, competition, and niches. *Evenness* is an expression that describes when species are equally abundant within the test area.

Activity 1: Introduction to habitats and species diversity

I. Purpose

The purpose of this investigation is to expose students to two different habitats that can be easily accessed, one having been regularly mowed and the other where the underbrush is heavy and diverse. Students should be able to understand the concepts of biodiversity within a small area while also learning field techniques to study different abiotic factors such as temperature and soil characteristics. Students will also design their own lab report or presentation of their results.

II. Procedure

Students should write a hypothesis about what they expect to see in the two different kinds of habitats before they go outside. Be sure to have students wear appropriate clothing, sunscreen, and bug repellent if needed.

Obtain the following: a meter square made from PVC pipe or a single meter stick to form a quadrant, soil temperature probe, soil pH meter, soil moisture meter, small trowel, bags or jars for collecting specimens, an insect/butterfly net, a camera if desired, clipboard, paper, and pencil. Field manuals of local vegetation and animals will be helpful.

Place the meter square in a "new field" that has been mowed regularly, and conduct the tests listed below. Then perform the same tests in an "old field" that has been permitted to grow for several seasons. Around a school the soccer or football field works nicely for a new field, and an area near a ditch or under a power line easement can usually be found nearby to serve as the old field.

Record the following:

- types of plants
- average height of the plants (measure a representative sample and take the average)
- three soil temperature readings and average
- three soil pH measurements and average
- three soil moisture readings and average