TwoOldGuys™ Study Guides
BI114 Biological Concepts for Teachers
Chapter 5. Ecology, Basics
5.4. EcoSystem, Energy Flow

Based on Indiana's Academic Standards, Science, as adopted by the Indiana State Board of Education, Nov 2000.

Numbers refer to the age-appropriate grade-level for the content.

Review

Ecosystem, energy flow

The Ecosystem is generally defined as all of the plant and animal communities of the same geographic site, plus all of the physical environmental factors at the site. Equally important to understanding the ecosystem concept is all of the relationships between the elements of the system. The simplest of the relationships within an ecosystem are those which are related to the movement of energy and materials through the system. This subsection deals with energy flow while the next subsection involves the movement of material. The more complicated relationships within the ecosystem are not included in this text.

grades 1: to 3:

Animals eat plants or other animals as food

Animals, like humans, have to eat food to stay healthy. For some animals, their food is plants. For example, white-tailed deer in the wild ate small trees and bushes, but in agricultural areas may have switched to soybeans and corn. Wild eastern cottontail rabbits do not eat carrots, but eat leaves of various weeds. Other animals eat animals as their food source. For example, red foxes, red-tailed hawks, and red-shouldered hawks all eat eastern cottontail rabbits and other small plant eating animals.

Animals also use plants and animals for shelter and nesting

Animals need places to nest and to rest where they can avoid being eaten. Often, this means hiding within the plants of the site. A few animals live among the hair, feathers or scales of other animals, but these particular animals also feed on the same animals where they live, usually by eating the skin or drinking the blood.

Plants need a place to live too. For plants, this refers to the soil type, amount of soil moisture, amount of sunlight or shade, and other factors in the physical environment.

grades 4: to 6:

Animals eat to get energy (and materials for growth)

It takes energy for an animal to run around, to fly, or even to walk. All living things even use energy just staying alive, without doing anything. For all animals, this energy comes from the food they eat. The only time that animals do not need to eat is when they hibernate, but then they must survive on the fat they stored last summer while eating. If hibernating animals run out of fat, they have to wake up and go in search of food.

An interesting problem faced by predators, such as red fox and coyote, is that it costs extra energy to chase and catch prey, such as rabbits. The predator has to get more energy from the prey than the amount of energy spent to catch the prey. Imagine what would happen if you spent more energy eating than the energy you got from eating – you would get hungrier every time you ate!

Plants get their energy from sunlight

Most plants do not eat. Some plants, such as the Venus Flytrap, seem to catch and eat flies. Scientists have, however, not been able to prove that these plants actually eat the flies; but we have no idea what is happening if the Venus Flytrap is not eating. All plants still need energy to live, whether they eat or not. The green color in plants is a chemical which collects energy from sunlight to convert carbon dioxide to sugar. The plants then 'burn' the sugar to release the energy as needed to support life.

A few plants, however, are not green, but white [or grey]. Such plants cannot collect sunlight, so must live either by digesting dead plants [as mushrooms do] or by attaching themselves [as a parasite] to green plants so they can take some of the sugar from the host plants.

grades 7: to 8:

Energy flows through ecosystems from trophic level to trophic level

- solar energy
- producer trophic level [plants]
- primary consumer trophic level [herbivores]
- secondary consumer trophic level [carnivores]
- top carnivore

Ecosystems require large amounts of energy since each plant and animal requires energy. As a rough estimate of the amount of energy involved, the 'average' American human being is expected to consume approximately 1,000 kilocalories [kilocalories are also called 'dietary Calories'] per day to maintain a body mass of 75 – 80 kilograms [165 – 176 lbs], or about 13 kilocalories per kilogram per day [6 kilocalories per pound per day]. Assuming this number to be typical of warm-blooded animals, the total weight in kilograms of all birds and mammals in the ecosystem times 13 kcal/kg-day is the energy required for the warm-blooded animals. The total weight in kilograms of all of the reptiles, amphibians, insects and spiders would have to be multiplied by the appropriate kilocalories per kilogram to get the energy needed for cold-blooded animals. The same calculation would also have to be performed for the plants to get a complete accounting of the energy consumed by an ecosystem per day.

The ultimate source of the energy for the ecosystem is the Sun. With the Earth 149.6 million kilometers [93 million miles] from the Sun, light energy from the Sun takes 8 minutes 18 seconds to reach the Earth. The Sun is considered to be a reasonably infinite source of energy, although it may burn out as soon as 15 billion years in the future. Until then it is a fairly reliable source of energy, varying by only a few percent over geological time. If a square target, one meter [39.37 inches] on a side, were positioned perpendicular to the suns rays at noon, approximately 9,000 kilocalories of energy from the sun would hit the target per day.

Not all of the solar energy is used to support the energy demands of the ecosystem. A portion of the incoming solar energy is used to drive weather. Weather systems are needed by the ecosystem, because they provide the precipitation, and therefore soil moisture, required by the plants in the ecosystem. Some of the solar energy is used by plants to maintain their life. All photosynthetic organisms in the ecosystem are referred to as the producer trophic level. The word 'trophic' means 'feeding level' in this context. Another portion of the solar energy is used to support growth of the producer trophic level; either as growth in size of the individuals or as growth in numbers of the population. As a result of this growth, there is energy stored in the plants.

Those animals which eat mostly plants are the primary consumer trophic level. When a plant is eaten by an animal, all of the stored energy of the plant is transferred to the animal. A portion of this energy is used to maintain the life of the animals. As for plants, another portion of the energy from the plants is used to support growth of the primary consumer trophic level, resulting in energy being stored in the animals' bodies. Animals which eat mostly animals are the secondary consumer trophic level. Energy is again transferred to this trophic level. some of the energy is used to maintain life, while some is used to support growth. Most ecosystems also have one more trophic level: the top carnivore.

grades secondary: to college:

Trophic efficiency equals approximately 10%

Solar energy arrives at the Earth at the rate of about 9,000 kilocalories per square meter per day. Some of this energy is absorbed by the atmosphere, and powers the wind and weather. Some is absorbed by the ground, and powers the daily temperature cycle. Some is absorbed by plants, and powers life and growth of the plants. Based on research on various breeds of corn, the efficiency of plants in converting sunlight to plants averages about 10% [8 – 12% depending on breed]. One study of herbivore efficiency involved white-faced hereford cows eating hay, with an efficiency in converting plants to animals equal to about 10%. A carnivore study fed meat-based dog food to german shepard dogs. The efficiency of animals in converting animals to other animals is also equal to about 10%. As a result of these studies, it has been suggested that we use the simplifying assumption that all energy transfers between trophic levels occur with 10% efficiency. This produces the Trophic Pyramid, as follows:

energy source	amount	efficiency
solar	9,000	
producer	900	10%
primary consumer	90	10%
secondary consumer	9	10%
top carnivore	0.9	10%

Another way to visualize this is to consider the area necessary to supply sufficient food supply to meet a 1,000 kilocalorie diet [the expected 'minimum' for American human beings].

trophic level	area
solar	1. m^2 10.8 ft^2
producer	10. m^2 107.6 ft^2
primary consumer	100. m^2 1,076.4 ft^2
secondary consumer	1,000 m^2 10,763.9 ft^2
top carnivore	

One square meter [a square 3 ft 4 in (3' 4") on a side] will supply enough sunlight to meet a 1,000 kilocalorie 'diet' for a producer. It would take over 10 square meters [a square 10' 4" on a side] to supply enough plants to meet a 1,000 kilocalorie diet for a primary consumer. The 1,000 kilocalorie diet for a secondary consumer would require the animals from 100 square meters [a square 32' 10" on a side]; and for a top carnivore, the animals from 1,000 square meters [a square 103' 9" on a side].

Detritus-based ecosystems

Plants periodically lose leaves, and occasionally other parts such as twigs and limbs. Animals shed skin and feathers or hairs. All of these plant and animal parts together are called detritus. The detritus also includes dead bodies of various plants and animals. The detritus is decomposed to compost by bacteria and fungi [decomposer trophic level]. The decomposing bodies, bacteria and fungi are eaten by animals [scavenger trophic level]. As for the producer-based ecosystem system, the detritus-based ecosystem moves energy from organism to organism.

The energy source for the detritus-based ecosystem is the 'left-over' energy from the producer-based ecosystem. This left-over energy is the energy which was not passed on to the next higher trophic level in the producer-based ecosystem. Any 'left-over' energy from the detritus-based ecosystem eventually becomes fossil fuels.