(c)

Chapter 1.5 - 1.10

1.5

Ecology

Have you ever been stung by a wasp? The unpleasant experience is not soon to be forgotten! Organisms that cause problems for humans, like wasps, are often categorized as **pests** (**Figure 1**). Why don't scientists work to eliminate pests rather than just control their numbers?

Imagine a world without biting flies, mosquitoes, termites, caterpillars, or weeds. At first thought that world might seem very appealing, but consider how other organisms might be affected. For example, some fish and amphibians rely on mosquito larvae for food. The elimination of mosquitoes would have a devastating effect on lakes. In addition, adult mosquitoes are an important food source for swallows, robins, and other small birds.

Some other insect "pests" are needed by plants. Most plants rely on insects for pollination. Plants also benefit from insects like the wasp that help decompose tissues of dead plants and animals, returning nutrients to the soil. Many of the insects we call pests also dig around plants, loosening the soil and allowing more oxygen to get to plant roots.

Even garden weeds like crab grass serve an important purpose. Outside the garden these rapidly growing plants are an important source of food for many animals. Eliminate wild grasses and cattle, sheep, and other grazing mammals would soon become extinct. The long and fibrous roots of these hardy, fast-growing plants also pump nutrients back to the soil's surface, where they can be used by more delicate domestic plants. The greatest benefit of these plants might be their ability to grow along cliffs and in other precarious locations. Here they anchor the soil, preventing erosion.

Figure 1
Humans categorize mosquitoes as pests, but some birds and other insects would categorize them as food.

Organisms Interact Within Ecosystems

To better understand living things, scientists must put aside the idea of the pest, and examine organisms within their natural setting. Ernst Haeckel, a German biologist, first coined the word **ecology** in 1866 to describe the study of how organisms interact with each other. Ecology combines the Greek words *oikos*, meaning "the place where one lives," with *logos*, meaning "study of."

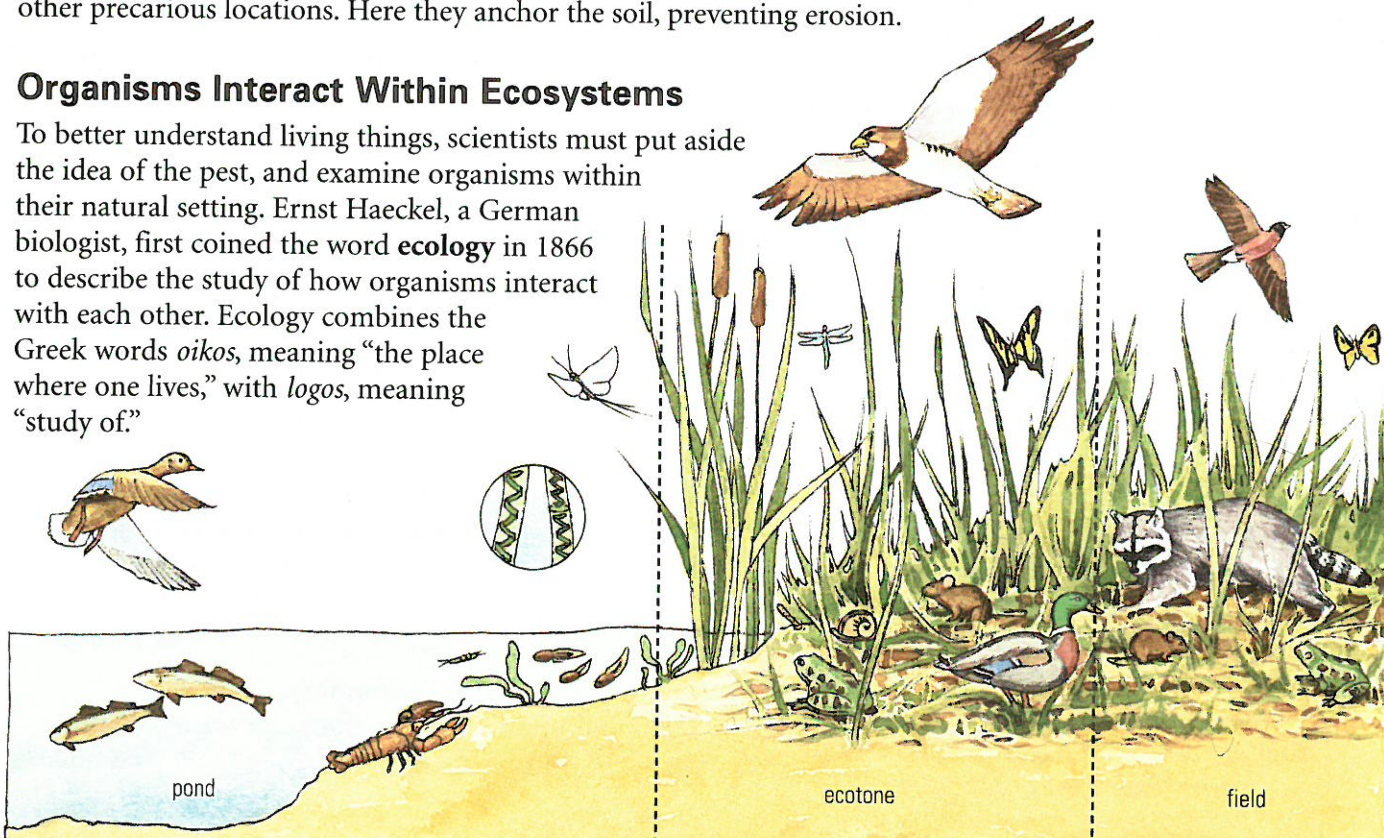


Figure 2
In the ecotone between the pond and the field, species from both ecosystems meet.

Ecological studies can begin at the level of a single organism. Investigations might be designed to determine how the individual interacts with its environment, and how factors in the environment affect its growth, feeding habits, and reproduction. Non-living factors or influences on organisms, such as amount of sunlight, temperature, and strength and direction of wind are called **abiotic**. Factors caused by the presence and roles of other living things are called **biotic**.

Organisms do not live in isolation. Organisms usually group with others of the same species. All of the members of the same species, living in the same ecosystem or habitat, are referred to as a **population**. For example, all the pike in a lake form a population.

Since there is usually more than one species in an ecosystem, there is also more than one population. The collection of all the populations of all the species in an ecosystem or habitat is called the **community** of organisms. The community in the lake might include populations of pike, perch, tadpoles, mosquito larvae, and algae, among others.

When studying a community, an ecologist would study how biotic factors affect each population. For example, an ecologist studying a forest community might examine the interactions between different types of plants and animals in the area.

Ecologists can extend their study beyond the community of organisms to the physical environment. When they do so they begin investigating ecosystems. An ecosystem includes the community of living things and its physical environment. For example, in studying a forest ecosystem, an ecologist could examine how much sunlight reaches the forest floor, and what affect it has on the plants and animals that live in the ecosystem.

Ecotones and Biodiversity

Ecosystems rarely have sharp boundaries, and organisms can move back and forth from one ecosystem to another. There is often a grey area between ecosystems where organisms from both ecosystems interact with each other. These transition areas or **ecotones** (Figure 2) contain species from both bordering ecosystems, so they often contain greater biodiversity (more species) than either ecosystem.

Ecosystems with greater biodiversity tend to be less fragile. For example, if a predator has to rely on a single species as a food source, its very existence is tied to the survival of the prey. In ecotones and other diverse areas there are more species, and a predator may have an alternative if something happens to the population of its main prey. It should come as no surprise that the ecotones, by providing alternative food sources, guard against extinction.

Understanding Concepts

1. In your own words, define the term "ecology."
2. List four biotic and four abiotic factors in:
   (a) a freshwater ecosystem, such as a lake
   (b) a terrestrial ecosystem, such as a forest
3. Describe how a population differs from a community, using your own examples.
4. Describe how an ecosystem differs from a community, using your own examples.
5. Predict whether you would find more species in a forest, an open field, or the forest-grassland ecotone between them. Explain your prediction.
6. **Figure 3** shows changes in the size of the populations of *paramecia* (single-cell organisms) placed in three different beakers.
   (a) Compare the growth of Species 1 in Beaker A with the growth of Species 2 in Beaker B.
   (b) What evidence suggests that the populations of *paramecia* affect each other?
   (c) Suggest a conclusion that can be drawn from the population changes in Beaker C.

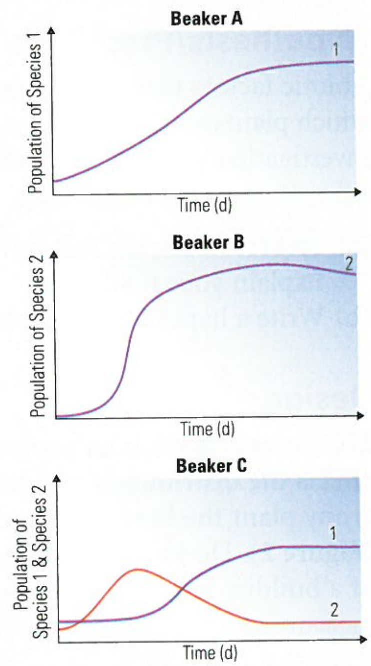


Figure 3
Graphs showing changes in populations of *paramecia* in three beakers

Challenge

1 An understanding of how abiotic factors affect communities is a good basis for understanding ecosystems. What abiotic factors must be controlled to ensure ideal playing conditions for golfers?

1.6 Investigation

INQUIRY SKILLS MENU

- ○ Questioning
- ● Hypothesizing
- ● Predicting
- ○ Planning
- ● Conducting
- ● Recording
- ● Analyzing
- ● Evaluating
- ● Communicating

A Schoolyard Ecosystem

To gain a better understanding of the impact of environmental change on living things within ecosystems, you do not have to go far. You can begin by investigating your schoolyard, and how living things there respond to local biotic and abiotic factors (**Figure 1**).

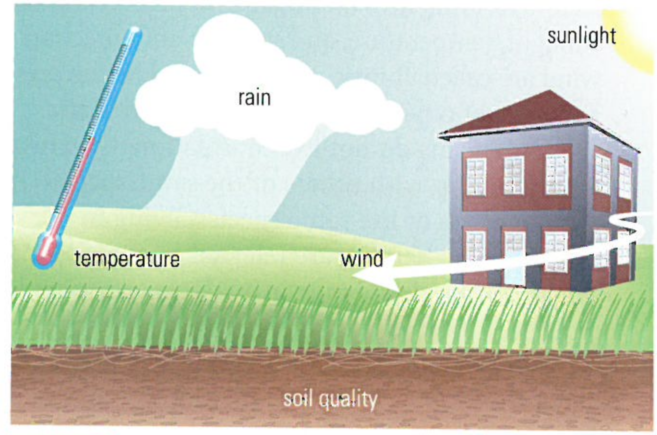


Figure 1
Some of the abiotic factors that affect living things in a schoolyard

Question

How do abiotic factors affect the distribution of weeds?

Hypothesis/Prediction

Abiotic factors play an important role in determining which plants can succeed in a given area. In this investigation you will study sites on the north and south sides of your school building.

(a) Predict which site will contain the most weeds. Explain your prediction.
(b) Write a hypothesis to explain your prediction.

Design

This investigation is an exploration of how location affects the distribution of common weeds. A weed is any plant the human caretaker does not want (**Figure 2**). Do more weeds grow on the north side of a building or the south side of the building? You will measure abiotic factors in each location.

(c) Identify the abiotic factors being studied in Part 2.
(d) You will have to choose two study sites. Before beginning, suggest some controls you could identify to make sure the sites are as similar as possible, except in the abiotic factors being studied.

Part 1: Distribution of Weeds

Materials

- string
- metre stick or measuring tape
- 8 Popsicle sticks
- notebook

(Note: If you have access to a computer with a spreadsheet program it will help you analyze your observations.)

Figure 2
Common weeds

Procedure

1 Set up equal study sites on the north and south sides of the school. Using string and 4 Popsicle sticks mark off each study site as shown in **Figure 3**. Make sure you push the Popsicle sticks completely into the ground. Calculate and record the area of each study site.

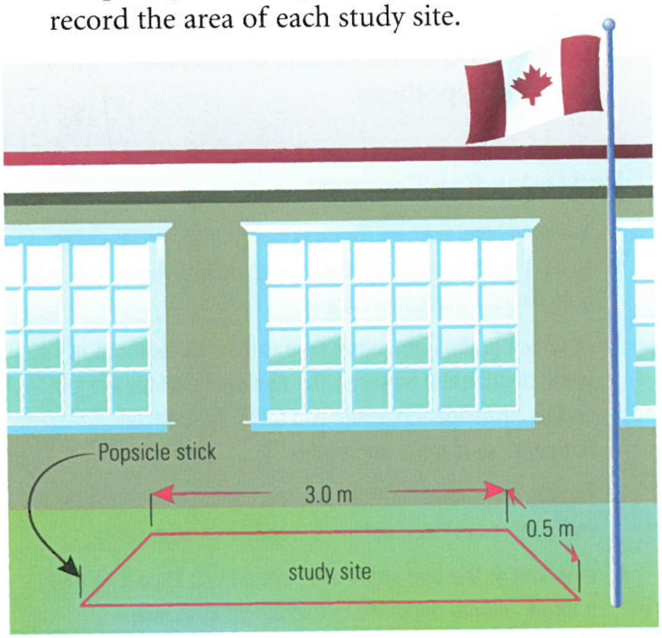


Figure 3

2 Survey each study site by counting and recording the number and type of weeds in each site. Use the photos in **Figure 2** as references. Record your data in a table such as **Table 1**.

Table 1 **Incidence of Weeds in North Study Site**

Type of weed	Number of plants	Diameter of plant (cm)	Area covered (cm^2)
dandelion			
plantain			

3 Within each of the study sites, record the coverage by each type of weed. Use a measuring tape or a metre stick to measure the diameter of each of the larger weeds in the study area. Record your measurements in your table.

4 Calculate the area covered by each weed using the formula

$$\text{area} = \frac{\pi d^2}{4}$$

For small weeds such as crabgrass, you can measure the entire area covered by a grouping of weeds rather than the area covered by each individual plant.

Part 2: Measuring Abiotic Factors

Materials

- plastic bottle cap
- light meter
- thermometer
- thread
- tape
- Ping-Pong ball
- protractor

Procedure

5 Toss a plastic bottle cap into a study site. Using the light meter, determine the amount of light reaching the soil next to the bottle cap. Repeat the procedure at least twice more. Record your observations in a table similar to **Table 2**.

(e) Why was the bottle cap tossed before light readings were taken?

Table 2 **Light Readings**

Measurement	North study site (lux)	South study site (lux)
1		
2		
3		
mean		

6 Repeat the light measurements in the second study area. Calculate the mean for each set of measurements.

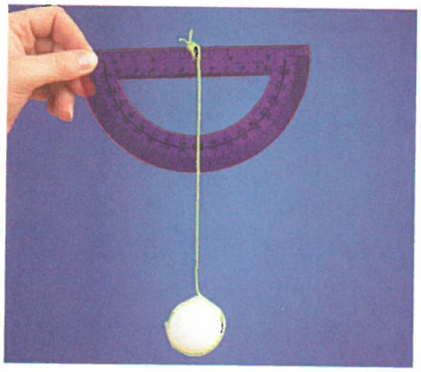
7 Using a thermometer, measure soil temperatures in the north and south study sites. Throw the bottle cap, as in Step 5, to choose measurement locations. Record your observations in a table such as **Table 3**.

Table 3 **Soil Temperature**

Measurement	North study site (°C)	South study site (°C)
1		
2		
3		
mean		

8 Construct an anemometer (a device to measure wind speed), as shown in **Figure 4**.

Figure 4
An anemometer



9 Make sure you are not blocking the wind. Point the thin edge of the anemometer into the wind. To measure wind speed, record how many degrees from vertical the thread is at the edge of the protractor. Take three readings in each study site and record them in a table as in **Table 4**.

Table 4 **Anemometer Readings**

Measurement	North study site (°)	South study site (°)	Wind speed (km/h)
1			
2			
3			
mean			

10 Using the conversion scale in **Table 5**, convert the degree readings to wind speeds.

Table 5 **Conversion from Degrees to Wind Speed**

Angle (°)	90	85	80	75	70	65	60
Wind speed (km/h)	0	9	13	16	19	21	24
Angle (°)	55	50	45	40	35	30	25
Wind speed (km/h)	26	29	32	35	38	42	46

Analysis and Evaluation

(f) Calculate the density of each kind of weed in the north and south study sites using the following formula:

$$\text{Density} = \frac{\text{Number of weeds}}{\text{Area of the study site}}$$

(g) Determine the total number of weeds in each study site.

(h) Calculate the area covered by weeds in each study site.

(i) Was your prediction correct? Explain why, or why not, based on your observations.

(j) Which abiotic factor do you think is most (K3) important for the growth of dandelions? Use your observations to create a hypothesis, and design an experiment that would allow you to test your hypothesis.

Understanding Concepts

1. You may have noticed that there are more weeds close to a building than in the open field. How would wind help explain that difference?
2. How would the light meter help explain differences in weed distribution between the two study areas? Based on this investigation, could you tell if light or soil temperature is more important?
3. Explain why unfavourable growing conditions for grass could increase the number of weeds in a study area.
4. In which of the two study sites would you expect to find a larger animal population? Explain your answer.

Making Connections

5. How do humans affect the distribution of weeds in your study areas?
6. Examine a map of a new housing development. Provide some reasons that help explain the difference in selling price between two lots that are the same size, but on different sides of the street.

Exploring

7. One biotic factor that affects distribution of plants is competition between plants. Design an experiment that would determine how competition from other plants affects the area covered by dandelions.

Reflecting

8. You made several measurements and calculations in this investigation, including the density of each type of weed. Why would it be important for an ecologist to calculate the density of plants in an ecosystem?

Challenge

1,2 **In this investigation you created biotic maps and collected data on abiotic factors. How would a map of your study area help in your Challenge?**

SKILLS HANDBOOK: (K3) Developing the Prediction and Hypothesis

Karin Banerd

Science Teacher

Karin Banerd does not promote a traditional approach to life. For her, life is about making exciting choices and helping her students realize that there are many different paths people can take to find fulfillment.

Karin has always loved animals and nature. While she was growing up, her parents encouraged these interests by allowing her to keep many pets, including fish, birds, hamsters, gerbils, and a rabbit!

She also liked science and math, although she sometimes struggled with them. Her parents were supportive of these interests, even when her math grades were a little low. She appreciates their support for her interest, since it helped her to keep believing in herself, rather than giving up on something she enjoyed.

When she finished high school, she entered the three-year forestry program at Sault College, eventually focusing on fish and wildlife technology. Karin spent her summers working in unspoiled areas such as Foleyet, Chapleau, and Kapuskasing. She fondly remembers the experience of trekking through the Northern Ontario bush.

She eventually wanted a career that didn't require wearing insect repellent everyday but that still enabled her to follow her interests. As a result, Karin took part-time courses at Algoma University College (Nipissing University) in Sault Ste. Marie and correspondence courses from the University of Waterloo. She acquired a liberal science degree, then went to teacher's college at Ottawa University.

Now a high school teacher for grades 9, 10, and 11, Karin wants to share her love of science and math, especially when she remembers how she and other women were discouraged from taking these subjects in the past.

Karin considers her teaching job an interpretive one, in which she translates the information in textbooks so that students can best understand it. She sets up labs and activities to spark students' interest in different aspects of science and wants to impress upon them the fact that science is all around us. Karin feels that "there is a lot of science misinformation, and if students could leave high school thinking critically about all the information that is out there..." her job would be well done.

When she sets up labs, Karin mixes chemicals ahead of time, testing the experiments to make certain that they are effective. She shares ideas and expertise with other teachers, learning from them in those areas where her background is not strong.

She uses her science background in other aspects of her life, too. Not only does she breed canaries, finches, and parrots, but she also writes magazine articles about them. Karin's is a pretty convincing case for flexibility in building a career path.

Making Connections

1. What other experiences might lead to teacher's college?
2. Choose an area of study (e.g., insects) and investigate three different kinds of jobs that are related.

Work the Web

Research the schools Karin attended by visiting www.science.nelson.com and follow the links from Science 10, 1.7. Report on what kinds of specialized learning are offered at each school.

1.8 Case Study

Comparing Ecosystems

Your schoolyard, local parks, farms, and managed forests are artificial ecosystems. An **artificial ecosystem** is planned or maintained by humans. Lakes, rivers, forests, deserts, and meadows can all be classified as natural ecosystems. In a **natural ecosystem**, the living community is free to interact with the physical and chemical environment. However, this does not mean that the area is untouched by humans: humans are a natural part of many ecosystems. Natural ecosystems haven't been planned or maintained by humans. In this case study, you will compare a meadow (natural) and a park (artificial).

Change within a park is limited because of human interference. Although the trees grow, most parks look somewhat the same from year to year. Humans manage change. Natural ecosystems undergo subtle changes as one plant or animal species gradually replaces another. In natural ecosystems, only plants suited for the environment flourish. In an artificial ecosystem, plants selected by humans have an advantage.

(a) List some reasons humans would select one plant over another in a park.

Weeds and Artificial Ecosystems

Plants can be classified in many different ways. Ecologists classify them based on structure. However, gardeners and park workers have an overall classification: weeds and nonweeds. This is a subjective grouping — the classification is not based on structure, size, or reproductive capacity. Weeds are naturally occurring plants that have fallen out of favour with humans.

(b) Suggest some reasons a plant might be categorized as a weed.

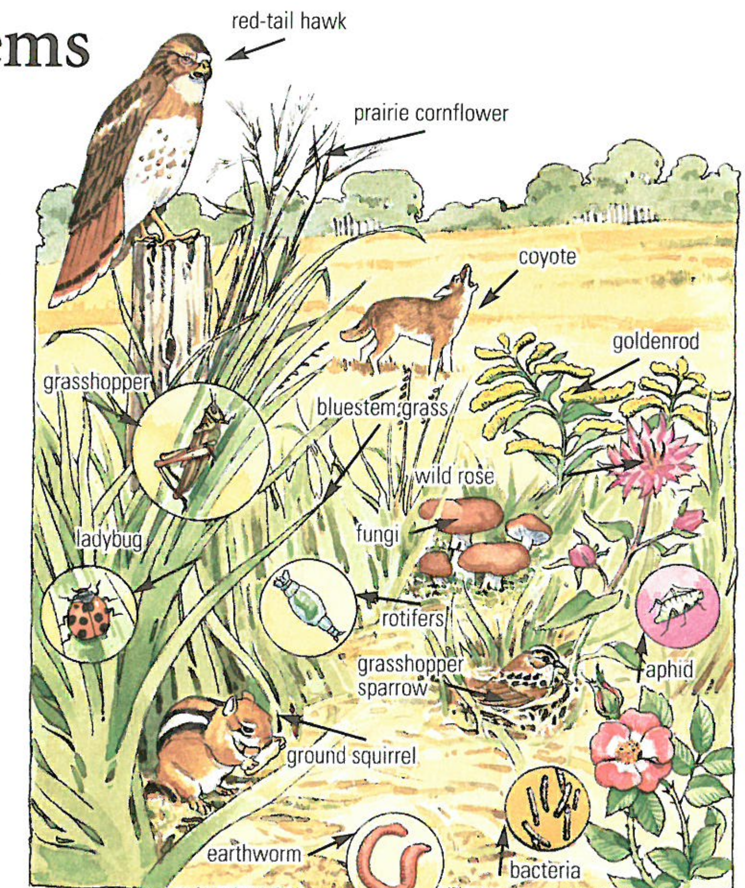


Figure 1
A meadow

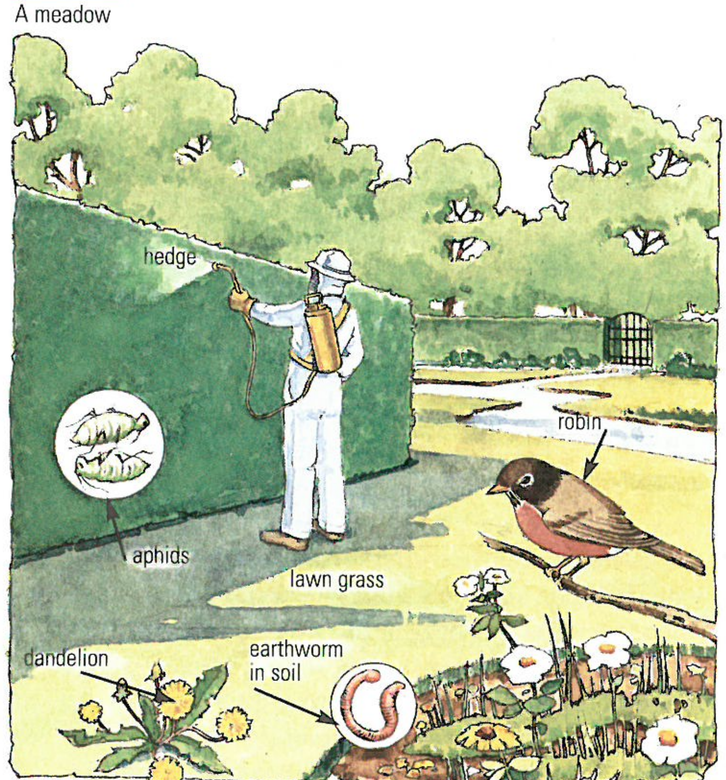


Figure 2
A park

Comparing Biotic Factors

Study **Figures 1** and 2.

(c) What human activities prevent the artificial ecosystem of the city park from changing?
(d) Which ecosystem demonstrates the greater biodiversity? Explain your conclusion.
(e) Speculate about why grasshopper sparrows, found in the meadow, are less likely to be found in a city park.
(f) Speculate about why coyotes are not common in city parks.

Comparing Environmental Factors

Table 1 provides data collected from a city park and a meadow. All measurements were taken on the same day at the same times.

Relative humidity is a measure of the percentage of water vapour in a mass of air, compared with the maximum amount of vapour that could be held at that temperature.

Evaporation rate measures the volume of water lost from soil in one day. Soil litter is a measure of the mass of decomposing organic matter found above the ground. Fallen leaves, twigs, and dead grass make up most of the soil litter.

(g) Why is it important to take measurements on the same day and at the same time?
(h) Speculate about why the wind velocity at ground level differs in the two ecosystems.
(i) Speculate about why temperatures tend to be higher in the park than in the meadow.
(j) Present an explanation that accounts for differences in the evaporation rate in the two ecosystems.

Table 1 Abiotic and Biotic Factors in Two Ecosystems

Abiotic factors	City park	Meadow
temperature (maximum)	28°C	26°C
temperature (minimum)	12°C	10°C
wind speed at ground	22 km/h	15 km/h
evaporation rate	10 L/day	3.5 L/day
relative humidity	85%	64%
light at ground (% of sunlight available)	95%	91%
soil nitrogen rating	very high	low
soil phosphorus rating	high	low
Biotic factor		
soil litter	56 g/m^2	275 g/m^2

Understanding Concepts

1. (a) List abiotic factors of the city park and meadow.
   (b) Explain how human interference influences each of the factors.
2. Which of the two ecosystems, the meadow or the park, would provide a better habitat for a fox? Give reasons for your answer.
3. Not all natural ecosystems have more biodiversity than all artificial ecosystems. Give two examples of an artificial ecosystem that might have more biodiversity than a natural ecosystem. Provide an explanation of each example.
4. **Tables 1** and **2** provide some data on two ecosystems. What additional data would be useful in making a comparison of an artificial and a natural ecosystem?

Exploring

5. Some animals, such as the raccoon and the tree squirrel, do very well in artificial ecosystems. What special adaptations or behaviours make these two animals successful in human-dominated environments? Report on the results of your research.

Table 2 provides detailed counts for some species in the two ecosystems.

(k) Speculate about why goldenrod is found in the meadow but not the city park.
(l) Provide a hypothesis that explains why more earthworms are in the meadow than the park.
(m) Why are more spiders found in the meadow?

Table 2 Inventory of Species in 10 m x 10 m Study Areas

Types of organism	City park		Meadow	
	Number of species	Population of all species	Number of species	Population of all species
grass	1	100 000/m^2	3	40 000/m^2
goldenrod	0	0	1	51
weeds	3	6	17	459
earthworms	1	25	8	210
beetles	4	7	22	39
spiders	1	2	2	13
birds	3	10	11	39
rodents	0	0	3	45

INQUIRY SKILLS MENU
- ○ Questioning
- ○ Hypothesizing
- ● Predicting
- ○ Planning
- ● Conducting
- ● Recording
- ● Analyzing
- ● Evaluating
- ● Communicating

A Natural Ecosystem

Lakes, rivers, forests, deserts, and meadows can be classified as natural ecosystems. Natural ecosystems are places that haven't been planned or maintained by humans, although humans may live in them. Natural ecosystems do not need to be large, but they do need to hold a community of living things. A very small ecosystem is called a microecosystem.

Question

How does the top of a fallen log differ from the bottom of the log?

Hypothesis/Prediction

If the abiotic factors on top of a fallen log differ from those below the log, then the community in the top of the log will differ from the community in the bottom of the log.

(a) Predict what differences you will find between top and bottom when you examine a log. Explain your prediction. (K3)

Design

You will explore the relationships between the abiotic environment and living things in a fallen log.

Materials

- gloves
- several fallen logs at various stages of decay (one per group)
- hand lens or dissecting microscope
- field guide to insects/arthropods
- field guide to fungi
- metal spoon
- plastic bags or small jars with screw caps
- tweezers
- labels
- spade

Procedure

1 Use **Table 1** to describe the stage of decomposition of your group's log.

Table 1 Ratings Chart for Decomposing Logs

A rating:	Log is firm. Bark remains on log even when pressure is applied to the log.
B rating:	Log is less firm. Bark is easily pulled away when pressure is applied, but log maintains shape.
C rating:	Log feels spongy. The log breaks when pressure is applied. Wood begins to crumble.
D rating:	The last stage of decomposition. Log shows evidence of crumbling even before any pressure is applied.

2 Observe the outer surface of your log for signs that animals have burrowed into or out of the log. Record your observations.

(b) What kind of animals do you think made the marks or holes in your log?

3 Examine the outside of the bark for mosses and other plants. Look also for fungi. (White or yellow threads also indicate the presence of fungi.) **Figure 1** may help you with your identification. Draw a diagram of the outer surface of the log, indicating the position of the organisms you identify. (M1)

(a) moss **(b)** bracket fungi

Figure 1
Some plants and fungi commonly found on logs

SKILLS HANDBOOK: (K3) Developing the Prediction and Hypothesis (M1) Qualitative Evidence

4 Using a spoon, remove a small section of the bark and look for insect larvae and eggs, centipedes, millipedes, ants, and wood-boring beetles. Record your observations. You may wish to take a small sample of the bark back to the laboratory for later study, using tweezers and a plastic bag or a jar. Be sure to label each bag with the location from which the sample was taken.

5 Using a spade as a lever, carefully roll the log over. Feel the underside. Compare the amount of moisture on top and underneath the log. Record your observations.

6 Repeat steps 3, 4, and 5 for the underside of the log. Record your observations.

7 Return the log to its original position.

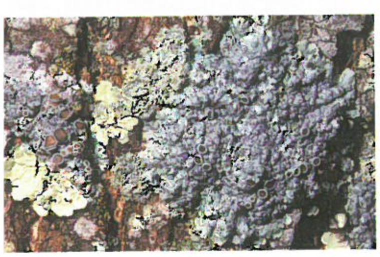
8 Wash your hands.

Analysis and Evaluation

(c) Using a table such as **Table 2**, compare the abiotic factors that influence life on the top and the bottom of the log you studied.

(c) mushrooms

(d) puff balls



(e) lichen

(f) mould

Table 2 **Abiotic Factors**

Abiotic factor	Top of log	Bottom of log
1. sunlight		
2. moisture		
3. wind		
4. temperature		

(d) Using a table similar to **Table 3**, categorize the members of the biotic communities you studied.

Table 3

Biotic community	Top of log	Bottom of log
1. producer		
2. consumers		
a. carnivores		
b. herbivores		
3. decomposers		

(e) Prepare a report for this investigation. In your report, include a conclusion about the hypothesis and your prediction — were there really two microecosystems and two communities in your log?

Understanding Concepts

1. Provide a hypothesis that explains why bracket fungi are often found on top of a log, but mould is more common under a log.

2. In what ways are the microecosystems under a log and inside a running shoe similar?

3. Based on your observations, explain why fallen trees are important in the ecosystem of the forest.

Exploring

4. Use the observations collected by other groups to compare logs at different stages of decay. Examine the drawings and the samples taken from the other logs and compare the microecosystems. For example, which log has the greatest number of fungi? On the basis of your class observations, create diagrams showing how the community in a log changes as it decays. Accompany your presentation with explanations for the changes in the community.

Reflecting

5. In this investigation you worked in a group to collect data. Explain some advantages of working in a group.

Q Lab Reports

Energy in Ecosystems

The source of all energy for ecosystems is the Sun. It lights and warms the surface of our planet. It gives the energy needed to evaporate water from the oceans and lakes, to form rain and snow. Sunlight also provides the energy used by green plants to make the compounds that maintain their lives and serve as food for all other organisms.

The Sun acts like a distant nuclear fusion reactor, radiating energy out into space. Of the energy released by the Sun only about one billionth reaches Earth — after a journey of about 150 million kilometres. Much of the energy that reaches Earth's atmosphere is filtered out before it reaches the surface. Harmful high-energy cosmic rays, gamma rays, X rays, and ultraviolet radiation are all either reflected or absorbed by chemicals in the atmosphere.

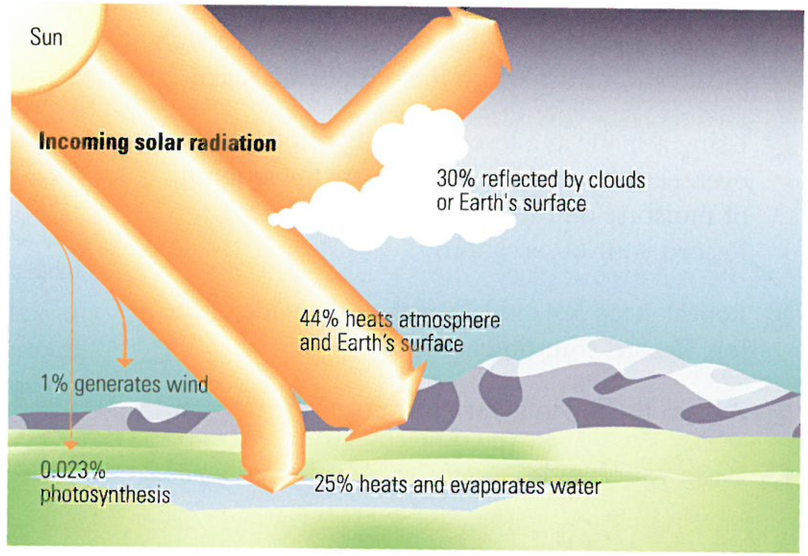


Figure 1

A model of the flow of energy from the Sun, to Earth, and back into space.

Of the energy that penetrates into the lower atmosphere, 30% is reflected by clouds or the Earth's surface. The remaining 70% warms the surface of the planet, causing water to evaporate, and generating the water cycle and weather. Only a tiny portion, approximately 0.023%, is actually used by green plants for photosynthesis (**Figure 1**). **Photosynthesis** is the process by which green plants use sunlight energy to produce carbohydrates (sugars).

Many gases found in the atmosphere actually trap thermal energy rising from the surface and direct it back to Earth. These gases permit energy from the Sun into Earth's ecosystems, but act as a barrier preventing the energy from leaving.

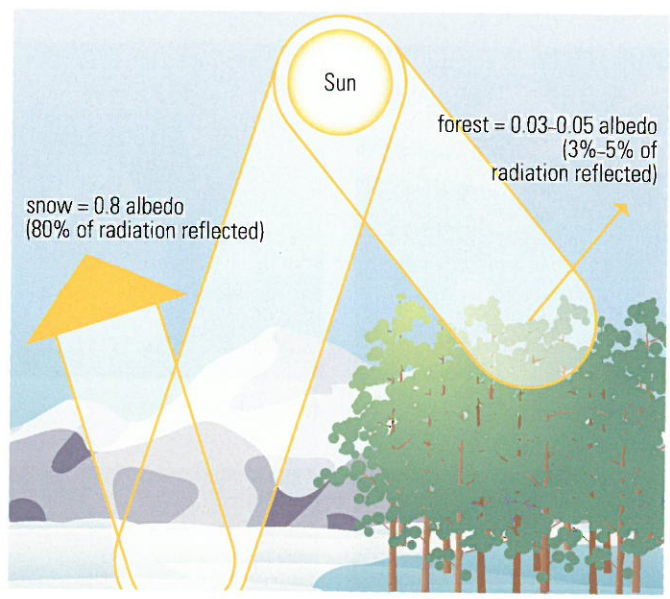


Figure 2

Most of the radiation that reaches snow is reflected, and cannot be used to warm the surrounding air. Forests have a much lower albedo. Most of the radiation that falls on dark green leaves is absorbed, and can be used to warm the surrounding air.

The Albedo Effect

When sunlight strikes an object, some of the energy is absorbed, and some is reflected. Some materials reflect sunlight better than others. **Albedo** is a measurement of the percentage of light that an object reflects. The higher the albedo, the greater the object's ability to reflect sunlight. For the Earth, the higher its overall albedo, the less energy will be absorbed and available for maintaining the global temperature. For example, you've probably noticed how bright snow is when sunlight is falling on it — snow has a high albedo (**Figure 2**). Snow contributes to the low temperatures of winter by reflecting energy from the Sun back into space. Snow also delays warming in the spring. Other light-coloured (high-albedo) areas of the Earth's surface, such as sand, pale rocks, and areas without forest, have a similar effect.

Cloud cover also increases the albedo of the Earth. If there is more water vapour, or more dust for water vapour to condense on, there will be more cloud. Higher temperatures cause more water to evaporate. Industrial activities release dust.

Understanding Concepts

1. Why is sunlight important for the biosphere?
2. Make a pie graph showing what happens to the energy from the Sun that penetrates into Earth's atmosphere. Label each piece of the pie.
3. In your own words, describe the albedo effect.
4. **Table 1** provides data collected following the eruption of four volcanoes. The average summer temperature declined following each eruption.

Table 1 Volcanoes and Lower Temperatures

Volcano	Year of eruption	Period of low average temperature
Mt. Asama (Japan)	1783	1784–91
Mt. Tamboro (Indonesia)	1815	1816–20
Mt. Krakatoa (Indonesia)	1883	1884–90
Mt. St. Helens (United States)	1980	1981–82

(a) Write a hypothesis that explains why temperatures (K3) become lower following a volcanic eruption.

(b) Design a controlled experiment that could test this (K4) hypothesis. In your description, include the independent and dependent variables.

(c) On the basis of the data, predict which was the largest eruption. Explain your prediction.

(d) At most times, a volcano is erupting or about to erupt somewhere on Earth. If no more volcanic activity occurred, predict how world temperatures would be affected. Explain your prediction.

5. Albedo is not the only factor that determines temperature. **Table 2** includes data collected from grassland and forest ecosystems in Ontario. Air temperatures were measured simultaneously at the two study sites, which were in the same general area.

Table 2 Soil Temperature vs. Depth

Distance above the surface of the soil (cm)	Temperature in field (°C)	Temperature in forest (°C)
200	24	22
100	25	22
50	26	22
25	27	22
0	29	21
–10	23	18
–20	14	9
–30	10	9

(a) Use data in the table to plot a graph showing the (V) relationship between temperature and distance from the surface of the earth.

(b) List biotic and abiotic factors that might explain the difference in the data gathered from the two study sites.

(c) Explain why the difference between above-ground and surface temperatures is greater in the open field.

(d) For each site, explain the pattern in changes of temperature below the surface.

(e) Using only the information presented within the study, explain why more burrowing animals are found in grassland ecosystems than forest ecosystems.

Making Connections

6. Describe low-albedo and high-albedo areas around your school or home. What could you do to make the high-albedo areas absorb more sunlight? What could you do to make low-albedo areas absorb less sunlight?

SKILLS HANDBOOK: (K3) Developing the Prediction and Hypothesis (K4) Creating the Design (V) Graphing

1.11

Following Energy Movement in Ecosystems

You can begin to understand energy flows by categorizing living things by their **trophic level** in their ecosystem, according to how they gain their energy. The term "trophic" comes from a Greek word meaning "feeder."

Organisms that can make their own food from basic nutrients and sunlight or some other non-living energy source are placed in the first trophic level (**Figure 1**). Not surprisingly, these organisms are also referred to as producers or **autotrophs** (from Greek words meaning "self-feeders"). Plants, algae, and some types of bacteria are in the first trophic level.

The second trophic level contains organisms that feed on the producers. These organisms are referred to as **primary consumers**. Primary consumers rely on autotrophs directly for their source of energy.

Secondary consumers are animals in the third trophic level. They rely on primary consumers for their source of energy, but they are still dependent on the autotrophs in the first trophic level. Although a wolf eats other animals, it still relies indirectly on the photosynthesis of plants for energy. The deer the wolf eats has eaten the buds of a spruce tree or grass.

Consumers, at whatever trophic level, are sometimes called **heterotrophs**. Heterotrophs cannot make their own food, and so must obtain their food and energy from autotrophs or other heterotrophs. Human beings are heterotrophs.

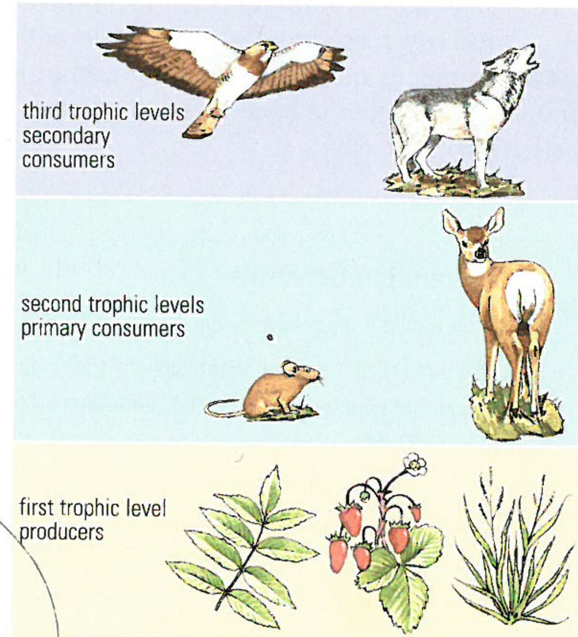


Figure 1
Trophic levels, showing producers and consumers. An ecosystem may contain more than three trophic levels.

Energy and Food Chains

Every organism within an ecosystem provides energy for other organisms. Food chains are a way of showing a step-by-step sequence of who eats whom in an ecosystem. The sequence in **Figure 2** shows a one-way flow of energy in a simple food chain from producer to secondary consumer. The deer does not make its own energy; instead it relies on the spruce tree. The deer is a heterotroph. Since the deer receives its energy two steps away from the original source (sunlight) it is in the second trophic level. Using the same reasoning, the wolf, also a heterotroph, is a member of the third trophic level.

Consumers are placed in categories based on their trophic level in a food chain. A carnivore directly feeding on a primary consumer is a secondary consumer. However, if the carnivore eats a secondary consumer (another carnivore), it is now a tertiary consumer — it is at the fourth trophic level. The final carnivore in any food chain is called a top carnivore. Top carnivores are not eaten by other animals (at least, while they are alive). In the example above, the wolf is both a secondary consumer and a top carnivore, since it obtains its energy from the deer and no other animal eats the wolf.

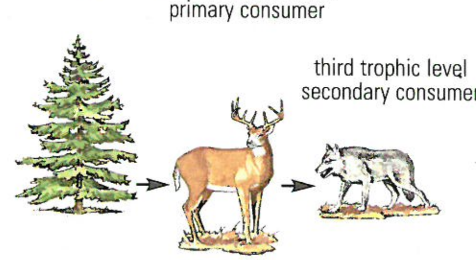


Figure 2
In this food chain, energy flows from a producer (the spruce tree) to a primary consumer (the deer), to a secondary consumer (the wolf).