Key Terms
ecological niche
bog
predator
prey
mutualism
parasite

2.2 Interactions Among Species

Resource needs and abiotic factors are not the only influences on population growth and size. All organisms interact with other species in multiple ways, and these interactions can have positive and negative effects on a population. Recall, from Chapter 1, that predation, competition, and symbiosis are the major types of interactions among species. These interactions, along with the limiting factors introduced in the previous section, restrict populations to particular places, roles, and sizes in the ecosystems they occupy.

ecological niche the way that an organism occupies a position in an ecosystem, including all the necessary biotic and abiotic factors

A Species' Ecological Niche

Species spend most of their time doing two things: surviving and reproducing. They do not have "jobs" in the familiar sense—having obligations or responsibilities to their ecosystem. As they pursue their daily activities, however, they consume food and interact with other species. Thus, they have jobs in the sense of providing benefits to their ecosystem. The resources that are used by an organism, the abiotic limiting factors that restrict how it can survive, as well as the biotic relationships that it has with other species all make up an organism's **ecological niche**. For the big brown bat shown in **Figure 2.9**, the biotic niche factors include all the insects that it eats, its competitors, such as the common nighthawk, and its predators. The abiotic niche factors include the places it uses for roosting and hibernation, the time of night it hunts for food, the airspace it flies through when hunting, and the temperature range it can tolerate.

Different species provide many different services to their ecosystems by occupying their ecological niches. These services may include the regulation of population sizes of other organisms, as well as specific services related to matter cycling or energy flow. For example, one likely ecological service provided by the big brown bat is the regulation of insect populations. Cave-dwelling bats also regulate insect populations, but another service they provide is to support many cave-dwelling organisms. The food webs that support these organisms are dependent on nutrients that are brought into the caves through bat droppings.

No two species can occupy the exact same ecological niche or provide the exact same services to their ecosystem, because no two species live in exactly the same way.

Figure 2.9 The space this brown bat takes up while sleeping in the cave is part of its ecological niche.

Occupying Ecological Niches

There are millions of species on Earth. Thus, there are millions of niches, all with particular services to provide. One common Canadian ecosystem with many niches is a type of wetland known as a **bog**. If you have ever seen a bog, you may have thought that it looked like a great place for plants to grow. Bogs have a lot of water and sunlight, which are two things that plants need. The water and soil, however, are acidic and deprived of nutrients, such as nitrogen, due to poor water flow. As a result, most bog plants are adapted to occupy niches that are limited by these conditions.

Most plants get nutrients by absorbing them from the soil and water through their roots. If the soil and water in bogs are nutrient-poor, bog plants must have another way to get nutrients for survival. How can bog plants import nutrients into a nutrient-poor environment? They are carnivorous. By consuming insects, bog plants are able to get the nutrients they need to survive. **Figure 2.10** shows some of the different ways that carnivorous bog plants trap insects, including drowning them in pitcher-shaped leaves filled with water and trapping them on sticky leaves.

By consuming insects, bog plants are meeting their survival needs. In the process of doing this, they are also bringing relatively rare nutrients into their ecosystem by digesting the insects. The niches of carnivorous plants are very particular, and carnivorous plants are well adapted to live in these niches. Carnivorous plants do well as bog specialists, but they could not thrive in other environments.

bog a type of wetland in which the water is acidic and low in nutrients

Sense of Value

The pitcher plant *Sarracenia purpurea* is found throughout Newfoundland and Labrador, and is its official flower. In 1954, the pitcher plant was chosen as a symbol of this province's natural beauty, and of its people's strength of character.

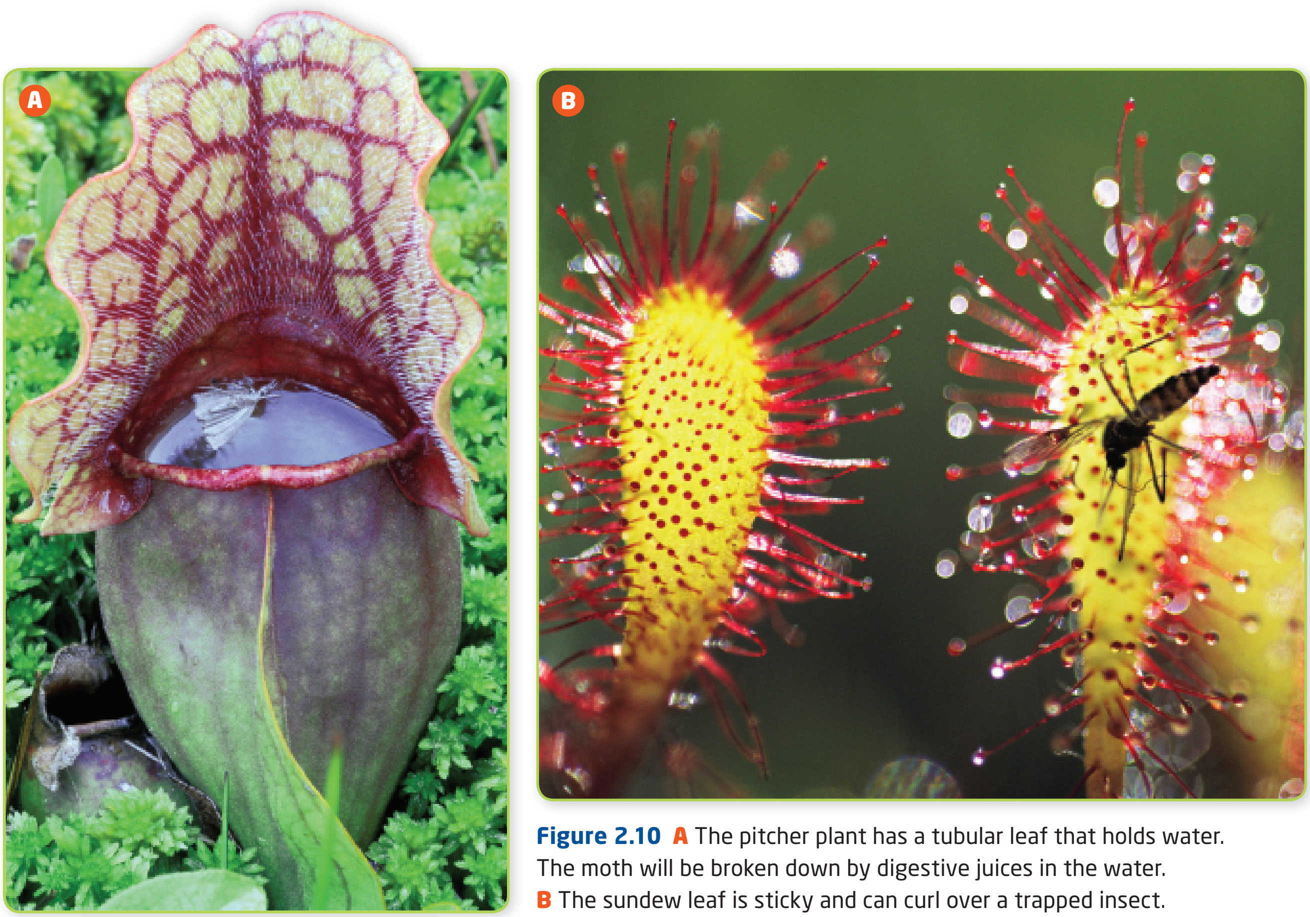


Figure 2.10 **A** The pitcher plant has a tubular leaf that holds water. The moth will be broken down by digestive juices in the water. **B** The sundew leaf is sticky and can curl over a trapped insect.

Predation and Population Size

predator an organism that kills and consumes other organisms

prey an organism that is eaten as food by a predator

In a sense, the carnivorous plants in bogs are **predators** because they capture and consume **prey**—the insects they eat to survive. You may be more familiar with examples of animal predators, such as lions, sharks, and owls. In fact, most predators are animals.

Bottom-Up Population Regulation

Predators and their prey influence one another, especially in terms of population size. There are two ways that predator-prey interactions can influence, or regulate, population size. Think about the following example. A plant-eating species, such as a grasshopper, is the prey for a predatory carnivore, such as a shrew. If the grasshoppers consume too many of the plants they eat for food, their numbers may eventually decline due to lack of food to support the population. If the population size of the grasshoppers decreases, there will be less food for the shrews. As the food that the shrews eat decreases, the number of shrews will eventually decrease too. What happens in this example is known as *bottom-up population regulation*. A shortage in the plant resource at the base of the food chain causes declines in the animals in the higher trophic levels.

Top-Down Population Regulation

Now consider another example. A population of prey, such as rabbits, increases in number. With more rabbits to eat, the population of predators, such as coyotes, will also increase in size. As the coyote population increases, the coyotes consume more rabbits, leading to a decrease in the rabbit population. This situation is known as *top-down population regulation*. Eventually, the number of coyotes will decrease as well.

The graph in **Figure 2.11** shows how the population sizes of lynx and snowshoe hares are influenced by their predator-prey relationship. Lynx prey on snowshoe hares. Notice that the rise and fall of both populations occurs about every 10 years. Scientists have found that a combination of factors affects this repeating cycle. These factors include the availability of food for the hares and the interactions between the hares and other predators, such as foxes, coyotes, and wolves.

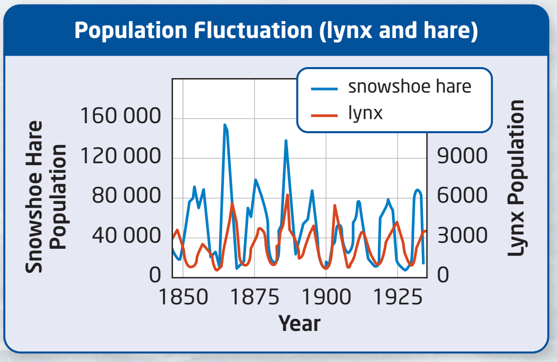


Figure 2.11 As the number of hares increases, the number of lynx increases. When the number of hares decreases, the population of lynx also decreases.

Do Wolves Affect Moose Numbers?

In Canada's boreal forest, the largest herbivore is the moose, and the top predator is the wolf. Wolves eat moose, as shown in **Figure 2.12**. The predator-prey relationship between moose and wolves has been extensively studied. Some research projects have been relatively simple, focussing on moose as the only large prey and wolves as the only predator. Other research projects have been more complex, also studying other large prey, such as caribou, and other predators, such as bears or humans that hunt.

Although the research does not point to one simple conclusion, the number of moose seems to be regulated more by other factors than by the number of wolves. The number of wolves, however, is significantly influenced by the number of moose. On Isle Royale, an island in Lake Superior, the predator-prey relationship between moose and wolves has been studied since 1958. The graph in **Figure 2.12** shows that sometimes predation by wolves affects the moose population, but exceptionally cold winters and tick infestations, which can affect the health of the moose, may also be factors that lead to periodic moose population declines.

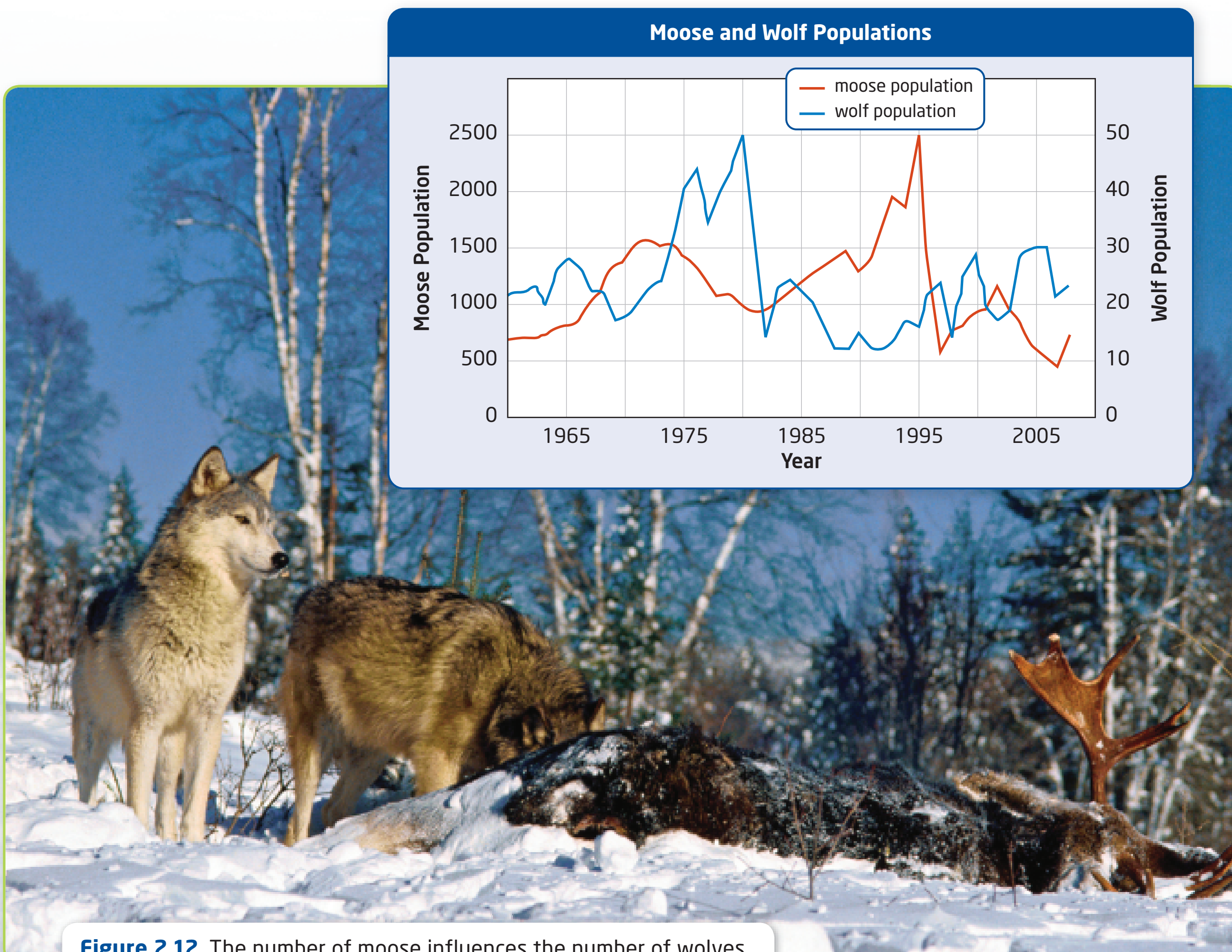


Figure 2.12 The number of moose influences the number of wolves, the top predator. The extent or significance of this influence remains uncertain, however.

Activity 2-3

What Was for Dinner?

Owl pellets are regurgitated clumps of the indigestible parts of the prey–mostly bones, feathers, and fur. What can you find out about an owl's niche by examining a pellet?

Safety Precautions

- Wash your hands when you have completed this activity.

Materials

- owl pellet
- paper towel
- forceps, tweezers, or probe
- magnifying glass
- identification key

Procedure

1. Place the owl pellet on a paper towel. Using forceps, tweezers, or a probe, carefully break apart the pellet. Then separate out all the smaller pieces.
2. Use the identification key to identify and describe each item you were able to separate out from the pellet. Be as specific as possible.
3. Clean up as your teacher directs, then wash your hands.

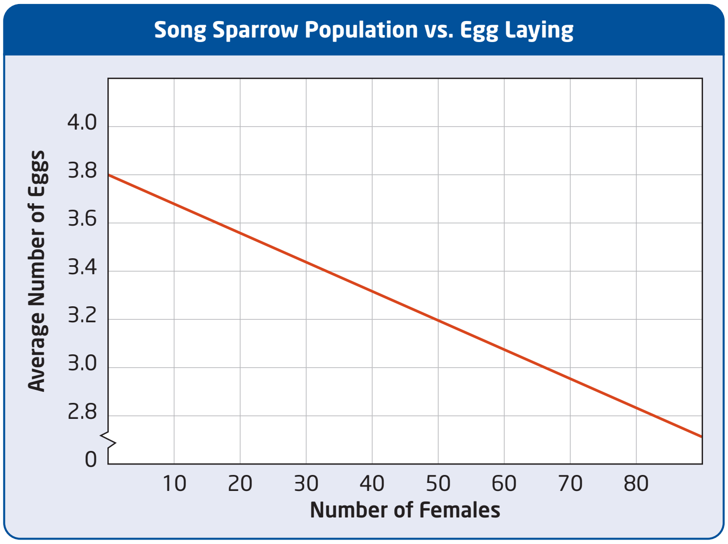
Questions

1. List the prey of an owl. What inferences can you make about the ecological niche of an owl based on its prey?
2. What is the most common prey identified in the class? Infer why this prey is the most common in the owls' diet.
3. In southern Ontario, screech owls catch fish. What would you expect to find in a screech owl's pellet that would reflect this?

Competition

Recall, from Chapter 1, that competition occurs when two or more organisms compete for the same resource, such as food or space, in the same place at the same time. Competition can limit the size of a population. The more energy an organism spends competing, the less energy it has for growth and reproduction. Competition can also influence the ecological niche of an organism.

Figure 2.13 As competition for food increased due to increased population, the average number of eggs laid by female song sparrows decreased.



As the population of a species increases, the competition for resources also increases. The result can be a decrease in the birth rate of the population. For example, consider the graph in **Figure 2.13**. As the size of a population of female song sparrows increases, the average number of eggs laid decreases. Scientists performed an experiment to test the hypothesis that competition for food leads to a decline in the reproductive output in these birds. In the experiment, female song sparrows living among an increased population of birds were given extra food. These birds did not show a decrease in the number of eggs laid.

Competition and Stickleback Fish

An example of how competition influences an organism's ecological niche can be seen in the stickleback fish that live in northern Ontario lakes. The stickleback is a small freshwater fish with spines along its back. The male stickleback uses vegetation to build an underwater nest in which the female lays her eggs. The male then protects the nest. Some northern Ontario lakes have brook sticklebacks, while others have both brook sticklebacks and nine-spine sticklebacks. Both species favour shoreline habitats, where they consume a variety of invertebrates, including larval insects.

Careful studies have shown that the areas of a lake in which brook sticklebacks look for food vary, depending on whether the second species is also present in the lake. In a lake with just brook sticklebacks, they can be found feeding along the bottom, among the vegetation growing from the bottom, and in the shoreline waters above the vegetation. When they share a lake with the nine-spine sticklebacks, however, they are only found on the bottom, as shown in **Figure 2.14**. The nine-spines are found in the water above the vegetation.

Patterns like this, in which species that compete for a resource divide the resource into two parts, have been reported for many organisms. The best explanation is that when there is no competition, a species can occupy a broad niche. When there is competition, however, the same species is forced into a narrower niche. These patterns demonstrate that resource competition can influence the niches and populations of competing species.

Suggested Investigation

Inquiry Investigation 2-B, What Happens When Food Is Limited?, on page 80

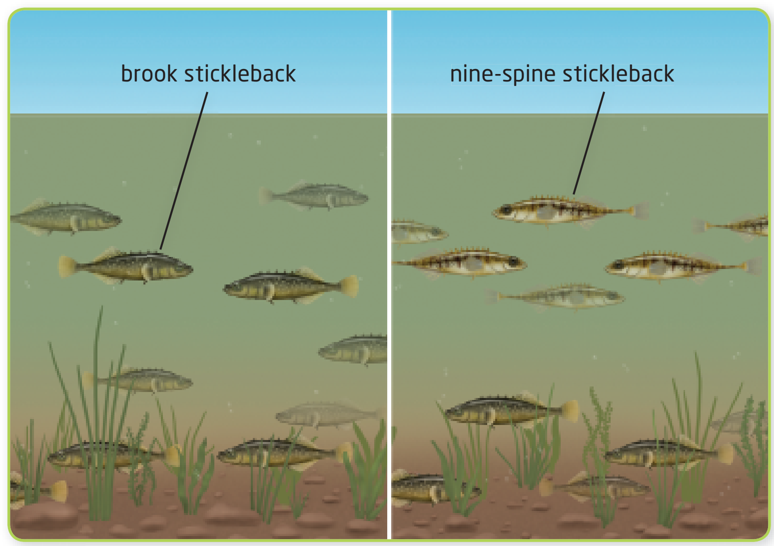


Figure 2.14 The niche of the brook stickleback depends on whether it shares a lake with the nine-spine stickleback.

Learning Check

1. What is an ecological niche?
2. What factors influence the populations of moose and wolves on Isle Royale?
3. What would be the advantage of studying an island ecosystem in which the only large herbivore was the moose and the only large predator was the wolf? What would be the disadvantage?
4. Imagine an island with maple trees and pine trees, and only one species of insect-eating bird. On another island with maple trees and pine trees, there are two species of insect-eating birds. In terms of where the birds look for food, what kinds of patterns might exist on the two islands?

Symbiosis

As you learned in Chapter 1, symbiosis is the interaction between members of two different species that live together in a close association. Two types of symbiosis are mutualism and parasitism.

Mutualism

Mutualism is the symbiotic relationship between two species in which both species benefit from the relationship. Canada's oceans are home to corals, but the world's best-known and most colourful coral reef systems are tropical. Special photosynthetic algae live inside the tissues of most tropical reef-building corals, as shown in **Figure 2.15A**. The algae provide the coral *host* with up to 90 percent of the coral's energy requirements. The coral provides the algae with protection, nutrients, and a constant supply of carbon dioxide for photosynthesis.

mutualism a symbiotic relationship between two species in which both species benefit from the relationship

In 1998, about 16 percent of the world's tropical coral reefs were destroyed when the corals within them turned white, as shown in **Figure 2.15B**. This is known as bleaching. Bleaching occurs because of a breakdown in the mutualistic relationship between the coral animal and its photosynthetic algal partner. The algae contribute most of the colour to the coral. When the algae leave, so does the coral's vibrant colouration. Although not fully understood, scientists hypothesize that higher than normal temperatures cause the coral to lose the algae, which leads to bleaching. Elevated sea temperatures that last as little as six weeks can lead to coral death.

Study Toolkit

Base Words What is the base word of the term *mutualism?* How does knowing the base word help you understand and remember the meaning of the term?

Coral reef bleaching demonstrates that the niches of organisms are defined by both abiotic and biotic factors. For corals, an essential biotic factor is their symbiotic algal partner. An essential abiotic factor is sea temperatures that do not become excessively warm. Scientists use satellite images, such as the one shown in **Figure 2.15C**, to monitor sea surface temperatures.

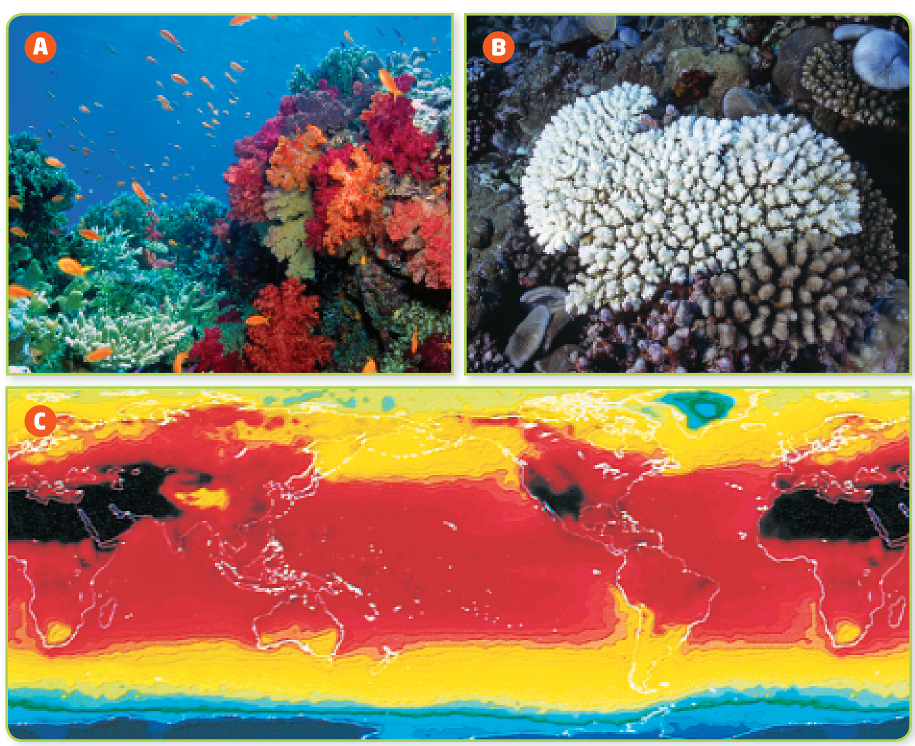


Figure 2.15 **A** The rich colours of healthy corals are partly due to the relationship between the coral animal and a photosynthetic species of algae. **B** Sea-temperature increases of as little as 2°C for six weeks can trigger coral bleaching. Death follows if the temperatures remain high. **C** Satellite images can be used to determine sea surface temperatures to monitor risk to the coral reefs. In this image, red represents the warmest temperatures.

Parasitism

A **parasite** is an organism whose niche is dependent on a close association with a larger host organism. The brainworm, for example, is a common parasite of white-tailed deer. **Figure 2.16** shows how eggs that are laid in the blood vessels of a deer's brain travel through the circulatory system to the deer's lungs, where they hatch. Eventually, the larval worms are excreted. The larval worms then live inside snails and slugs, which are consumed by other deer as they browse on vegetation.

Parasites usually harm their hosts to some extent, but white-tailed deer appear to be little affected by the brainworm. In fact, the minimal impact of the brainworm on its host allows the brainworm to complete its life cycle successfully. Other members of the deer family that are not the usual hosts, however, are very vulnerable. For example, when a brainworm infects a moose, the moose suffers from *moose disease*. This is a degenerative condition that is characterized by stumbling movements and apparent confusion, often leading to death. As for the brainworm, it is unlikely to complete its life cycle in the moose.

Brainworms and white-tailed deer probably have an ancient relationship. This may be why deer are relatively immune to the damage. As deer have moved north into the range of the moose, however, they have brought brainworms with them. Thus, the damaging moose-brainworm relationship is probably relatively recent. Even though wolves seem to have relatively little impact on moose populations, the deer-brainworm team can have a severe impact.

parasite an organism whose niche is dependent on a close association with a larger host organism

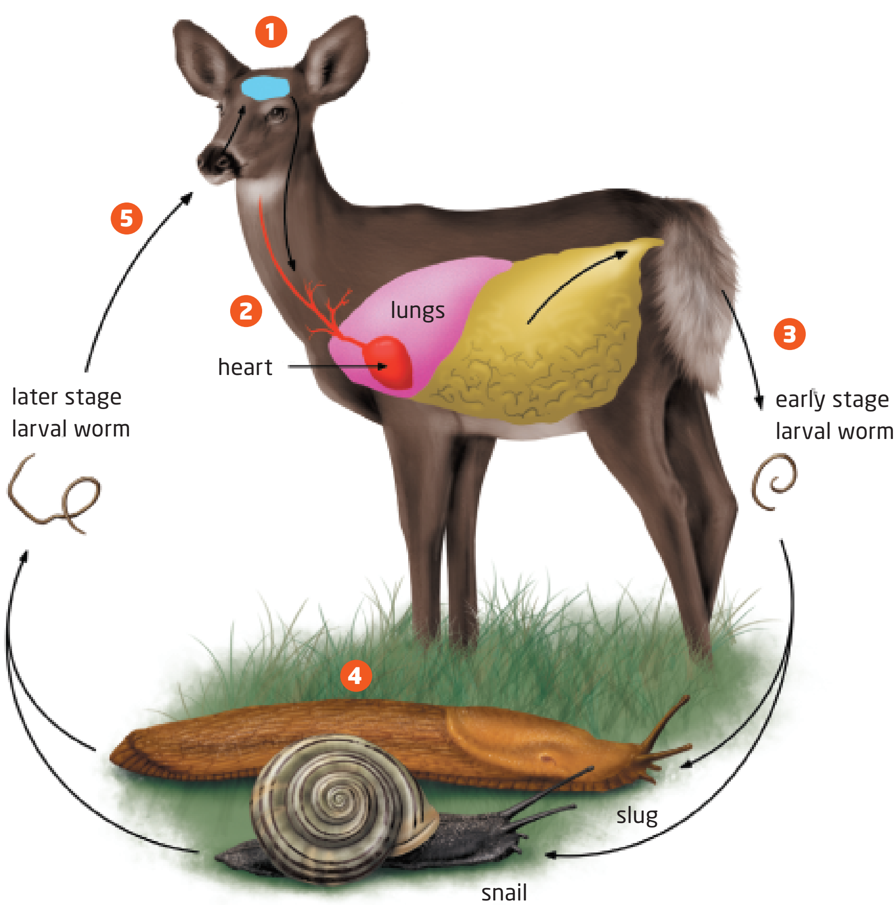


Figure 2.16 White-tailed deer can tolerate brainworm parasites, but other members of the deer family, such as moose, cannot.

1. The worm lays eggs in the blood vessels that cover a deer's brain.
2. The eggs travel through blood vessels to the lungs, where they hatch.
3. Eventually larval worms are excreted.
4. The worms are consumed by and then live inside snails and slugs.
5. The worm enters the deer's body when the deer consumes plants on which snails and slugs are attached.

Section 2.2 Review

Section Summary

- Each species occupies an ecological niche, which has biotic and abiotic components.
- Many species, such as bog plants, occupy narrow niches for which they are well adapted.
- Predation, competition, mutualism, and parasitism are four major kinds of relationships between species.
- These relationships help to define a species' niche and influence the distribution and abundance of the species.

Review Questions

K/U **1.** Use a Venn diagram to compare and contrast an ecological niche and a job.

T/I **2.** Analyze what would happen to a niche if the resources and energy in the ecosystem were not sustainable.

K/U **3.** What adaptation allows bog plants to live in a bog? Why do they need this adaptation to live in a bog?

A **4.** Name two different types of organisms that are responsible for inputting nutrients into nutrient-deprived ecosystems.

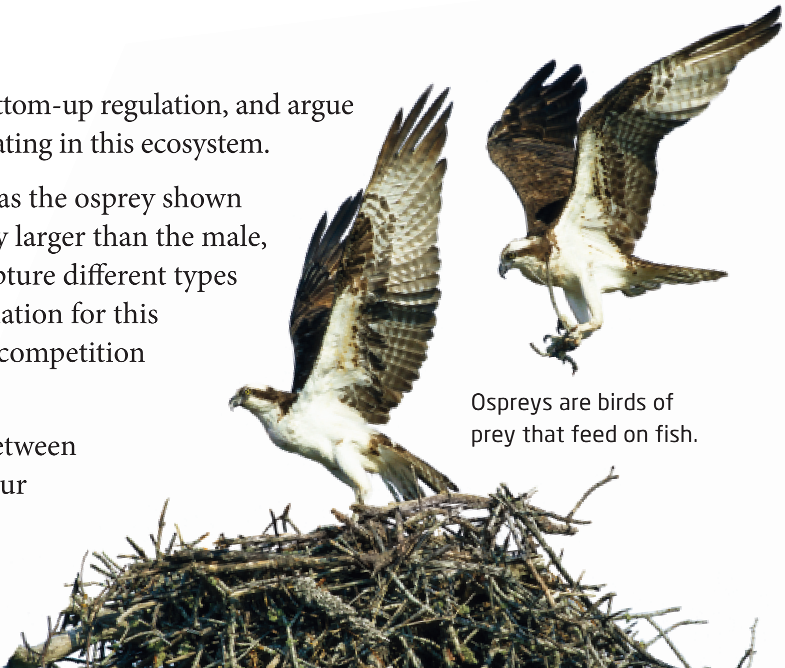
A **5.** Suppose that you are in charge of a plan to restock elk in Ontario. What factors would you consider if you wanted to have success?

C **6.** Consider an ecosystem with snowshoe hares and lynx, as well as shrubs that are food for the snowshoe hares. Over many years, you notice that the shrubs are never in short supply. You also notice that the populations go up and down over the years.
- First, the hares increase.
- Then lynx increase.
- The hares decrease once the lynx become common.
- Then the lynx decrease.
- Then the pattern starts over again.

Distinguish between top-down and bottom-up regulation, and argue why you think one or the other is operating in this ecosystem.

A **7.** In many species of birds of prey, such as the osprey shown on the right, the female is considerably larger than the male, so much so that males and females capture different types of food. What would be a good explanation for this pattern? Refer to carrying capacity or competition in your explanation.

K/U **8.** Describe the symbiotic relationship between corals and algae. What causes the colour loss associated with bleaching?



Ospreys are birds of prey that feed on fish.