

## Biotic and Abiotic Influences on Ecosystems

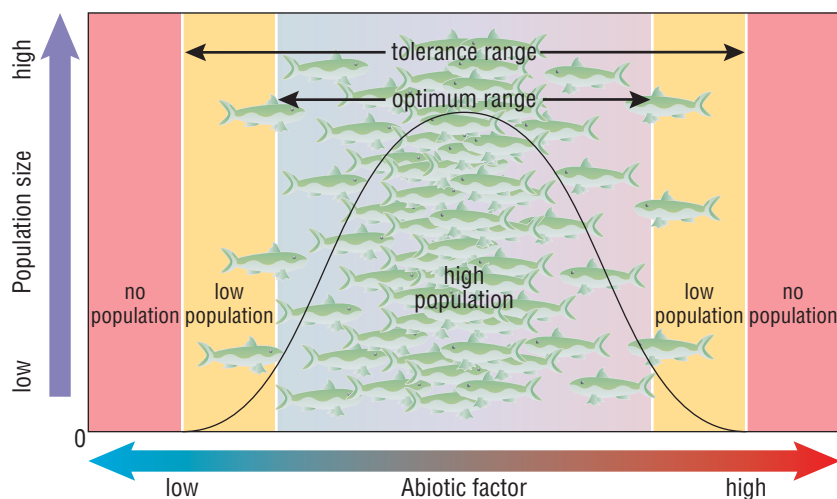
**limiting factor** any factor that restricts the size of a population

What determines the size of a population and where a particular species can and does live? The answer to this is important if we are to live sustainably in our environment. Ideal biotic and abiotic conditions allow a species to flourish. Other conditions may lead to a species' decline or even extinction. Both abiotic and biotic factors determine where a species can live. A **limiting factor** is any factor that places an upper limit on the size of a population. Limiting factors may be biotic, such as the availability of food, or abiotic, such as access to water. Human influences often act as limiting factors.

**tolerance range** the abiotic conditions within which a species can survive

### Influence of Abiotic Factors

Abiotic factors such as temperature, light, and soil can influence a species' ability to survive. Every species is able to survive within a range of each of these factors. This range is called the species' **tolerance range** (Figure 1). Near the upper and lower limits of the tolerance range, individuals experience stress. This will reduce their health and their rate of growth and reproduction. Within a species' tolerance range is an optimal range, within which the species is best adapted. The largest and healthiest populations of a species will occur when conditions are within the optimal range. Each species has a tolerance range for every abiotic factor.



**Figure 1** Species can be successful over a range of abiotic conditions. However, they will become stressed and will die out if conditions exceed their tolerance limits.

Some species have wide tolerance ranges, while others have much narrower ranges. Species with broad tolerance ranges will tend to be widely distributed and may easily invade other ecosystems. For example, buckthorn, a small tree native to Europe, has become widespread over much of southern and central Ontario due to its broad tolerance range. Conversely, the showy lady's-slipper orchid has a narrow tolerance range. It is found only in specific types of wetlands.

The distribution of most terrestrial plant species is largely limited by a combination of temperature, precipitation, and light (Figure 2). The distribution of black spruce in North America, for example, is limited to regions with long, cold winters and moderate precipitation (Figure 3). Other abiotic factors, such as soil type, often have less critical roles.



**Figure 2** (a) Cacti can withstand long periods of drought. If overwatered, they may die because their roots cannot survive consistently damp conditions. (b) Aquatic plants, such as water lilies, will perish quickly if the water level drops and the roots are exposed to air. (c) While both cacti and water lilies prefer exposure to full sun, bunchberries are adapted to shade.

The key abiotic factors in aquatic ecosystems are salt concentration and the availability of sunlight, oxygen, and nutrients. Light is abundant in shallow clear water but rapidly decreases with increasing depth. Oxygen concentration is greatest near the water's surface because this is where oxygen enters from the air and where most photosynthesis takes place. Remember that oxygen is released during photosynthesis.

Nutrient availability also varies in aquatic ecosystems. Plants growing in shallow water obtain nutrients directly from the bottom soil. In deeper water, however, the only available nutrients are those dissolved in the water. Table 1 summarizes some of the key abiotic factors and the human activities that can disrupt or alter them.



**Figure 3** The distribution of black spruce

**Table 1** Key Abiotic Factors of Terrestrial and Aquatic Ecosystems and the Effects Human Activities Can Have on Them

Ecosystem	Key abiotic factors	Human action and result
terrestrial ecosystems	light availability	Clear-cutting and fire remove shade and expose the remaining organisms to much more light.
	water availability	Damming rivers and draining swamps and marshes change water availability. Irrigation increases water availability.
	nutrient availability	Farming practices may increase or decrease nutrient levels in the soil.
	temperature	Global warming is decreasing suitable habitat for many cool-adapted species.
aquatic ecosystems	light availability	Activities that increase erosion or stir up the bottom cloud the water and reduce light penetration.
	nutrient availability	Nutrient runoff from agriculture and urban environments increases the nutrient content of surface water and groundwater, causing algal blooms.
	acidity	Acidic air pollution results in acid precipitation. Carbon dioxide emissions produced by the burning of fossil fuels are increasing the acidity of the oceans.
	temperature	Industries and power plants release heated waste water into lakes and rivers, killing fish and other organisms.
	salinity	Salting highways and long-term irrigation practices can cause salt to accumulate.

## Influence of Biotic Factors

While abiotic factors determine where a particular species is able to live, biotic factors often determine the species' success. For example, while deer are able to survive the abiotic conditions in dense forests, they are more abundant in open woodlands. This is where they obtain preferred food species and can watch for predators.

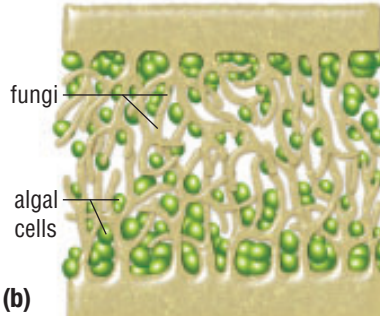
Many key biotic factors involve interactions between individuals. Individuals are often in competition with members of their own species and with other species. They compete for limited resources, such as food, light, space, and mates. For example, a maple tree and a birch tree may compete for sunlight and soil nutrients. Red squirrels compete with each other for pine cones and mates.

Interactions between individuals are not limited to competition. Predation occurs when an individual (the predator) kills and eats another individual (the prey), such as when wolves kill and eat a caribou. Mutualism occurs when two organisms interact, with both benefiting. Lichen, for example, is a mutualistic relationship between algae and fungi (Figures 4(a) and (b)). Parasitism occurs when one organism (the parasite) lives on or in a host and feeds on it. Commensalism occurs when one organism benefits and the other neither benefits nor is harmed (Figure 4(c)). Table 2 lists and describes some common interspecies interactions.

### DID YOU KNOW?

#### Whose Egg Am I?

Cowbirds are brood parasites. They lay their eggs in the nests of other birds. These host birds, such as the eastern phoebe, incubate the eggs and raise the cowbird young.



**Figure 4** Lichen such as this (a) reindeer lichen is a mutualistic relationship between (b) fungi and algae. Fungi form the structure and absorb nutrients. The algae photosynthesize, providing sugars to the fungi. (c) Barnacles, which are the brown patches on this humpback whale, benefit themselves but neither benefit nor hurt the whale in this commensal relationship.

**Table 2** Key Types and Examples of Species Interactions

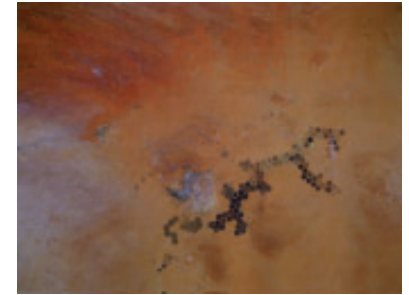
Relationships	Definitions	Examples
competition	two individuals vie for the same resource	<ul style="list-style-type: none"> <li>• Foxes and coyotes both feed on common prey such as mice and rabbits.</li> <li>• Humans and insects compete for the same crop plants.</li> </ul>
predation	one individual feeds on another	<ul style="list-style-type: none"> <li>• Lynx prey on snowshoe hares.</li> <li>• Leeches and black flies are “micro-predators” that feed on humans.</li> </ul>
mutualism	two individuals benefiting each other	<ul style="list-style-type: none"> <li>• Nitrogen-fixing bacteria live in the roots of certain plants. The plants provide sugars to the bacteria. The bacteria provide nitrogen to the plant.</li> </ul>
parasitism	one individual lives on or in and feeds on a host organism	<ul style="list-style-type: none"> <li>• Tapeworms are parasites of cats and dogs.</li> <li>• Microbes that cause malaria live within human blood cells.</li> </ul>
commensalism	one individual benefits and the other neither benefits nor is harmed	<ul style="list-style-type: none"> <li>• Many birds nest in particular kinds of trees or in abandoned burrows.</li> <li>• Spanish moss lives on certain tree species.</li> </ul>

## Carrying Capacity

As a population's size increases, the demand for resources, such as food, water, shelter, and space also increases. Eventually, there will not be enough resources for each individual. Furthermore, as individuals become more crowded, they become more susceptible to predators and diseases. Eventually, these and other factors will result in the population reaching the upper sustainable limit that the ecosystem can support, called the **carrying capacity**.

The carrying capacity can be altered through natural or human activity when resources are removed from or added to the ecosystem. Irrigation can change a desert into a lush oasis because it increases the carrying capacity of the desert (Figure 5). The loss or introduction of a species can change the carrying capacity of the ecosystem for other species in that ecosystem. For example, the removal of wolves by human hunters will increase the carrying capacity of the ecosystem for moose. When new species are introduced, they interact with the original species in many ways. As you will learn, such introductions are among the most serious threats to natural ecosystems.

**carrying capacity** the maximum population size of a particular species that a given ecosystem can sustain



**Figure 5** These green circles, visible from the International Space Station, are formed by an irrigation project in Libya. Irrigation increases the carrying capacity of the desert ecosystem.

### UNIT TASK Bookmark

You can apply what you learned in this section about how biotic and abiotic factors limit population size to the Unit Task described on page 156.

## IN SUMMARY

- Many factors place limits on the sizes of populations in an ecosystem.
- Tolerance ranges describe the physical conditions under which a species can survive.
- The type of ecosystem that occurs in a particular location is strongly influenced by abiotic factors such as light, water, and temperature.
- Species interactions include competition, predation, mutualism, parasitism, and commensalism.
- Carrying capacity is the maximum population size that an ecosystem can sustain.

## CHECK YOUR LEARNING

1. Distinguish between tolerance range and optimal range. **K/U**
2. List three abiotic factors important to both terrestrial and aquatic ecosystems. Explain your choices. **K/U**
3. How do human actions increase the carrying capacity of some ecosystems? **K/U**
4. Give some examples of each of the following: predation, competition, mutualism, parasitism, commensalism. **K/U**
5. Before reading this section, which types of species–species interactions were you already familiar with? **C**
6. What species–species relationship or example did you find the most interesting or unusual? **C**
7. Is it possible to describe abiotic factors as more or less important to an ecosystem than biotic factors? Explain your reasoning. **K/U**
8. Cedar waxwings are one species of bird that is adapted to withstand our cold winters. Bird watchers in Barrie provide cedar waxwings with seeds at birdfeeders during winter months. **K/U T/I**
  - (a) Would the seeds alter the carrying capacity of the ecosystem? Explain.
  - (b) Provide a hypothesis that explains why bird watchers have noted an increase in the falcon population in recent years.