3.2

Equilibrium and Change

equilibrium describes the state of an ecosystem with relatively constant conditions over a period of time

On a large scale, most natural ecosystems are in a state of **equilibrium**. This means that their biotic and abiotic features remain relatively constant over time. The major biomes, for example, usually maintain a characteristic set of species over hundreds or thousands of years. Changes on a large scale occur slowly and are caused by changes in climatic conditions.

Equilibrium is established when abiotic conditions are stable. Energy flows through the ecosystem. Nutrients are cycled through food webs. In addition, photosynthesis and cellular respiration are balanced. When ecosystems are in equilibrium, populations are healthy and stable.

On the scale of biomes, ecosystems remain relatively unchanged over time. This is not true, however, on a small scale. Smaller ecosystems are in a constant state of change. A forest fire or disease outbreak can cause short-term changes on a local level.

Figure 1 The eruption of Krakatoa was the loudest sound in recorded history.

On August 27, 1883, the volcanic island of Krakatoa in Indonesia literally blew up. This explosion produced a sound wave that carried for 4600 km (Figure 1). The island was destroyed, along with every living thing that inhabited its lush tropical forests. The remaining part of the island was buried in more than 40 m of ash and volcanic rock.

Despite this dramatic disturbance, life had returned to the island within 9 months. Seeds were carried from nearby islands by the wind, the sea, and birds. Insects and spiders soon followed. In time, many other organisms returned to the island. Within a hundred years, a lush, rainforest community was re-established. This process of establishing and replacing a community following a disturbance is called ecological **succession** (Figure 2).

succession the gradual and usually predictable changes in the composition of a community and the abiotic conditions following a disturbance

Figure 2 After Mount St. Helens, in Washington State, erupted in 1980, lupines were the first plants to appear. Other plant species then arrived, taking advantage of the additional nutrients provided by the lupines. This is an example of ecological succession.

Ecological Succession

Ecological succession is initiated by a disturbance such as a geological event, a fire, or human activity. **Primary succession** occurs on soil or bare rock, where no life previously existed, such as following a volcanic eruption. **Secondary succession** follows a disturbance that disrupts but does not destroy the community. The regrowth of an area following a forest fire is an example of secondary succession. Severe pollution events or industrial

primary succession succession on newly exposed ground, such as following a volcanic eruption

secondary succession succession in a partially disturbed ecosystem, such as following a forest fire

activity, such as surface mining, are human-caused disturbances that initiate secondary succession.

Succession results in gradual changes as plants, animals, fungi, and micro-organisms become established in an area. The typical pattern sees small, hardy plants such as grasses colonizing the open landscape. These plants gradually alter the soil and local abiotic environment and make conditions suitable for shrubs and small trees to grow. These shrubs and trees, in turn, create conditions suitable for large trees that may come to dominate the landscape. Eventually, a relatively stable community may form (Figure 3). While plants are the most visible part of succession, animal species also change.

Aquatic ecosystems also undergo succession. In northern Ontario, bogs form when small lakes of non-flowing water are gradually covered over and filled by vegetation. Bog succession proceeds as sphagnum moss forms a floating mat along the shoreline. Year after year, the floating moss grows further outward from the shore. The dying and decaying moss sinks below the surface, slowly filling in the lake. This living carpet is colonized by other plants. Eventually, the once open body of water becomes completely covered in vegetation.

DID YOU KNOW?

Fires Are Important to Succession

Fires play an important role in some types of succession. Some natural grassland is maintained by occasional fires. Periodic fires kill off young trees and shrubs that have started to grow. Grasses are able to quickly re-establish themselves.

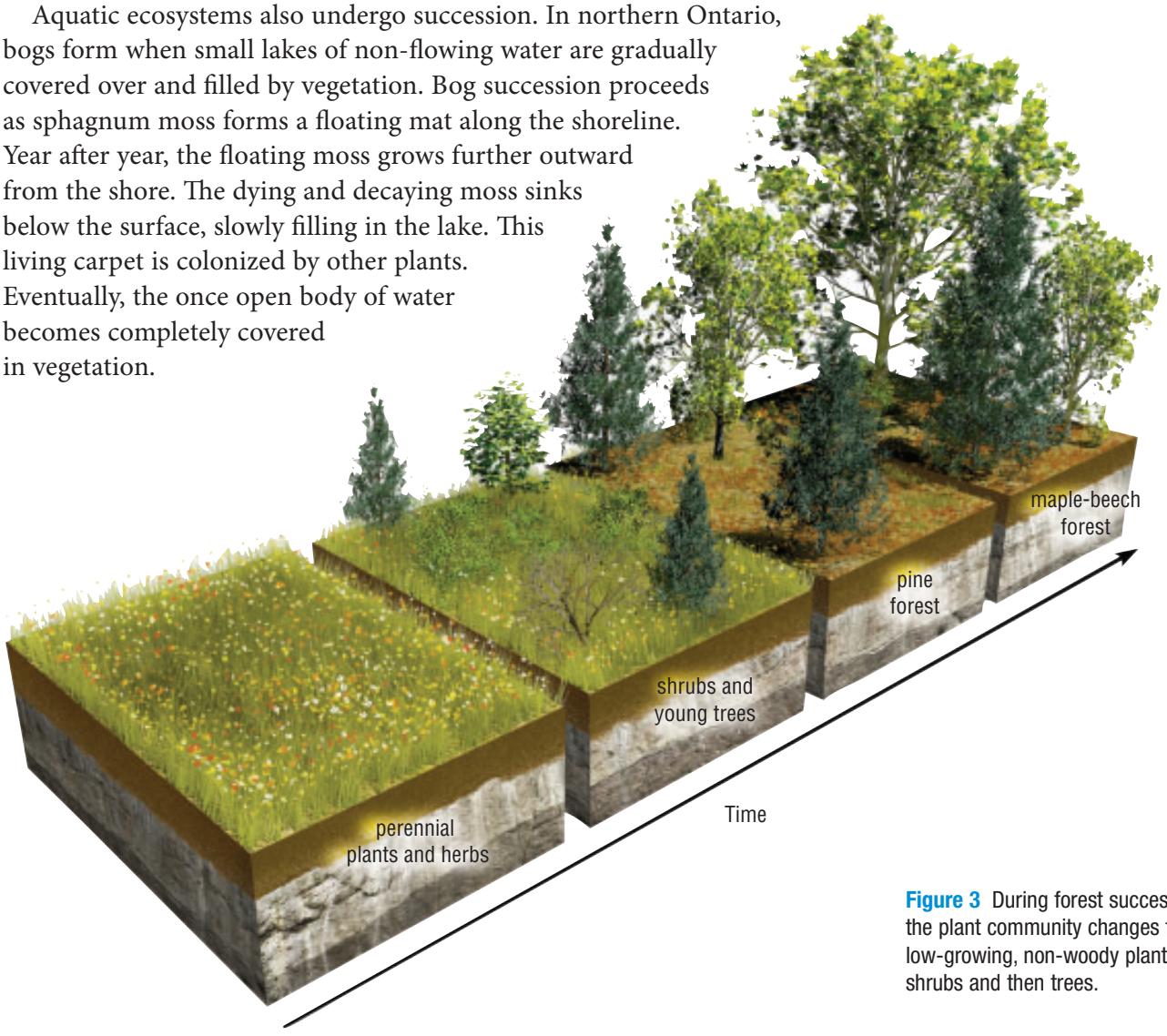

Figure 3 During forest succession, the plant community changes from low-growing, non-woody plants to shrubs and then trees.

Another example of succession occurs along sandy shores of oceans and large lakes, such as along the coast of Lake Huron. Dune succession begins when grasses establish in loose sand. Once the grasses establish, they reduce wind erosion and their roots hold the sand in place. Over time, plant numbers increase and soil characteristics change. Eventually a large sand dune can be transformed into a lush forested ecosystem. Unfortunately, sand dune communities are fragile and easily disturbed by human activity.

Benefits of Succession

Succession provides a mechanism by which ecosystems maintain their long-term sustainability. It also allows ecosystems to recover from natural or human-caused disturbances. Succession offers hope that even severe environmental damage may be reversed (Figure 4). The time needed, however, is very long, and the original cause of the disturbance must be eliminated. Not all human-caused disturbances can be repaired through natural succession. Often disturbances must be repaired through human actions that support the natural processes of succession.

Figure 4 The combination of human actions and succession have helped rehabilitate this old Ontario quarry.

The rest of this chapter looks at several types of human-caused disturbances to natural ecosystems. As you read, think about how communities are disturbed by these activities and how succession can help us to manage ecosystems subjected to disturbance.

IN SUMMARY

- The key biotic and abiotic features of large ecosystems remain relatively constant over time. They are in a state of equilibrium.
- Succession is the gradual changes in the biotic and abiotic features of an ecosystem following a disturbance.
- Succession allows an ecosystem to recover following a natural or human-caused disturbance.

CHECK YOUR LEARNING

1. Explain what it means when we describe an ecosystem as being in equilibrium. K/U
2. Distinguish between primary and secondary succession. K/U
3. Explain which type of succession occurs most often and why. K/U
4. Describe how biotic and abiotic conditions change during secondary succession. K/U
5. From your own experience, list two examples of secondary succession. A
6. Describe how succession can help restore the equilibrium of an ecosystem. K/U
7. Why is succession slower on sand or bare rock than on previously vegetated soil exposed by a fire? K/U
8. The Krakatoa eruption destroyed life and left behind volcanic ash. A large chemical spill can also destroy life. How would succession be very different following these two events? A
9. Why is it reasonable to describe a large ecosystem like a biome as being in equilibrium, but not a very small ecosystem like a rotting log? T/I