Section 14.2 Questions

Understanding Concepts

1. How does an increase in genetic diversity enhance the overall health of an ecosystem?
2. What factors cause exotic species to be invasive?

Making Connections

3. You decide to plant a decorative flower bed filled with hundreds of begonias using a variety of colours to create a design. When you describe your plans to a landscape architect at the nursery, she suggests that you should create the same colourful display using at least six different flowering plants.
   (a) Offer the scientific reasoning behind her advice.
   (b) Explain the environmental advantage of taking her advice.

14.3 Fertilizers

In Chapter 13, you learned about the 17 essential nutrients that plants must acquire. In most natural situations, plants are able to obtain adequate supplies of the essential elements from the surrounding soil. Nutrients taken up by plants are replaced through natural cycles. Human agricultural practices, however, can result in a steady depletion of soil nutrients as plants are harvested year after year. For example, the growing and harvesting of crops that are high in protein content, such as corn, will result in a rapid decline in available soil nitrogen, since protein-rich plants take up large amounts of nitrogen. Intensive agricultural practices result in reductions of one or more of three nutrients: nitrogen, phosphorus, and potassium (NPK). If soils are deficient in one or more nutrients, the answer is to add **fertilizers** that contain whatever nutrients are required in suitable amounts to make the soil fertile.

fertilizers: any minerals added to soil, usually to replace those removed by crops

The nutritional demands of plants change as they grow and develop. Phosphorus is important in root formation and thus is needed most in early stages of development. Nitrogen is used in large quantities during the most active growing phase of the plant when vegetative growth is important. Too much nitrogen, however, can promote excessive leafy growth and delay or reduce flowering and fruit production. Potassium is also important for active growth as it is needed for strong stems. As plants enter the reproductive phase—when they produce flowers, seeds, and fruits—phosphorus and potassium are again needed in larger quantities while the nitrogen requirement decreases. For these reasons, fertilizers higher in nitrogen are often applied from early to mid season, while fertilizers with a reduced nitrogen content are used to encourage flower and fruit production later in the growing season, when vegetative growth is not encouraged. Fertilizers can be natural or synthetic. **Natural fertilizers** can be physically processed, but the chemical changes occur naturally. **Synthetic fertilizers** have been created through chemical processes directed by humans.

natural fertilizers: fertilizers produced without human-directed chemical processes

synthetic fertilizers: fertilizers produced through human-directed chemical processes

Natural Fertilizers

Manure and **compost** (Figures 1 and 2, page 558) are natural soil conditioners because they add a lot of humus to the soil. Humus is dark, spongy, decayed plant material that increases the soil's ability to hold water. It also contains minerals to increase the general soil fertility. Some municipal recycling programs accept

manure: animal waste

compost: a mixture that consists largely of decayed organic matter and is used as a soil conditioner and source of minerals

Figure 1
Manure direct from livestock barns can be used on fields. Gardeners can purchase bagged manure for use on their gardens.

Figure 2
Home composting prevents valuable nutrients from being thrown away.

Figure 3
Municipal composting reduces the need for landfill space and produces valuable soil conditioner. Some programs use indoor digesters. The program shown here is outdoors and uses a large machine to regularly mix the yard waste with air.

kitchen scraps and/or organic yard waste. These programs offer the potential for significant contributions to waste reduction and nutrient recycling (Figure 3). Properly processed **sewage sludge** from large urban centres also has the potential to be a significant soil conditioner. This sludge must be processed to kill any potentially pathogenic bacteria and must be carefully tested to ensure that safety levels for heavy metals and other contaminants are not exceeded. All of these natural sources of nutrients are not very concentrated, have varying amounts of different minerals, and release their nutrients slowly over time.

sewage sludge: semisolid matter produced during sewage treatment

Crop rotation is a natural way to maintain and improve soil fertility without the addition of any type of soil conditioner or fertilizer. With crop rotation, legumes are typically planted every second or third year. The nitrogen-fixing bacteria living in legume root nodules not only supply the legume with nitrogen but also add a lot of nitrogen to the soil for subsequent crops. The legumes may be harvested, leaving the roots in the ground to decompose, or the entire plant may be plowed under as "green manure" to maximize the addition of nitrogen to the soil. In the following one or two years, a crop with high nitrogen demand, such as corn, can be grown on the field with little or no additional input of nitrogen. During the cultivation of rice crops, a tiny fern is sometimes used to add nitrogen (Figure 4) instead of adding other fertilizers.

crop rotation: the agricultural practice of planting a field in successive years with various crops, each of which has a different nutrient requirement

Figure 4
In order to provide a nitrogen supply to rice crops, the small floating water fern *Azolla* (seen here covering the surface of the water) is often grown in the flooded rice paddies. Symbiotic nitrogen-fixing bacteria in the fern accumulate nitrogen. As the rice plants grow, they prevent sunlight from reaching the ferns. The small ferns die and decompose, releasing their nitrogen supplies.

Synthetic Fertilizers

In 1913, a process for the synthesis of ammonia was discovered. Using ammonia, millions of tonnes of synthetic nitrogen fertilizers are produced annually. The production and widespread use of synthetic fertilizers began in the 1930s and revolutionized agriculture. All synthetic fertilizers (Figure 5) are more concentrated and release their nutrients into the soil much more rapidly than do most natural fertilizers. Global food production increased dramatically. The application of specific amounts of quick-release concentrated fertilizers has enabled farmers to increase crop yields by rapidly replacing those nutrients removed by harvesting and/or lost due to erosion and leaching.

Unfortunately, we have paid a high price for these convenient synthetic fertilizers. It was once thought that manufacturing fertilizers was very efficient. We now understand that making synthetic fertilizers requires large inputs of energy. Synthetic fertilizers are prone to leaching and runoff and may alter the natural chemical balance in groundwater and surface water, and may affect associated

Figure 5
Synthetic fertilizers have an NPK code indicating the percent content of available nitrogen, phosphorus, and potassium, always in that order. For example, a label reading 5-10-10 indicates 5% nitrogen, 10% phosphorus, and 10% potassium. The remaining material is usually filler.

Figure 6
Great blue herons build huge nests in large trees, but the nutrient concentration in their droppings kills the nesting trees. Naturalists have a dilemma because they want to protect both the herons and the trees. Homeowners notice a similar effect on their lawns if excess fertilizer is used; areas that are too rich in nutrients show brown spots of dead grass.

organisms. In addition, the use of synthetic fertilizers can lead to imbalances in natural soil composition and biological activity, resulting in a loss of organic matter and increased erosion.

Another danger of using any fertilizer is that if too much is added, it can actually kill plants (Figure 6).

Hydroponics

Growing plants without soil is now common practice in home and commercial greenhouses. In **hydroponics**, the soil is replaced by a sterile solution of aerated water and essential plant nutrients or sterile sand and the nutrient solution (Figure 7). Growing plants hydroponically can reduce or eliminate pathogens and pests that normally reside in soils. It permits the precise regulation of nutrient concentrations which can be tailored to the changing needs of the growing plants. Although such technology increases the costs of production, the result is rapid growth and high yields.

hydroponics: a system of growing plants without soil but instead with a sterile medium and a solution containing all required nutrients

Figure 7
Hydroponically grown lettuce has a much larger root system than lettuce grown in soil.

SUMMARY Fertilizers

1. Synthetic fertilizers can be added to soil to replace nitrogen, phosphorus, and potassium lost as a result of current agricultural practices.
2. Nutritional requirements change over the plant's life cycle, for example, nitrogen promotes vegetative growth but can inhibit reproductive growth.
3. Natural fertilizers tend to release nutrients more slowly than synthetic fertilizers but condition the soil by increasing its ability to hold water.
4. Crop rotation increases soil fertility; legumes are planted every few years to replenish nitrogen.
5. Synthetic fertilizer labels show the percent content of nitrogen, phosphorus, and potassium.