Because they appear on both sides of the overall ionic equation, Na^+ and Cl^- are spectator ions. The only participants in the reaction are the hydronium ion and the hydroxide ion, as shown in the following net ionic equation.

$$H_3O^+(aq) + OH^-(aq) \longrightarrow 2H_2O(l)$$

There are equal numbers of H_3O^+ and OH^- ions in this reaction, and they are fully converted to water. In aqueous solutions, **neutralization** *is the reaction of hydronium ions and hydroxide ions to form water molecules.*

Notice that water is not the only product of a neutralization. A salt is also produced. *A* **salt** *is an ionic compound composed of a cation from a base and an anion from an acid.*

Acid Rain

Many industrial processes produce gases such as NO, NO_2, CO_2, SO_2, and SO_3. These compounds can dissolve in atmospheric water to produce acidic solutions that fall to the ground in the form of rain or snow. For example, sulfur from the burning of oil and coal forms sulfur dioxide, SO_2. The SO_2 is then converted to SO_3, sulfur trioxide, which reacts with water in the atmosphere to produce sulfuric acid, as shown below.

$$SO_3(g) + H_2O(l) \longrightarrow H_2SO_4(aq)$$

Rainwater is normally slightly acidic, but sometimes rain is very acidic and is called *acid rain.* **Figure 15** shows a forest that was damaged by severe acid rain. Acid rain can erode statues and affect ecosystems, such as water environments and forests. In the 1970s, scientists found that acid rain was causing the fish populations in some lakes and streams to decline. When fish are completely eliminated from lakes and streams because of acid rain, the biodiversity of the ecosystem decreases. Because of amendments to the Clean Air Act in 1990, a limit was set on the amount of SO_2 that power plants are permitted to emit. This limit has decreased but not eliminated acid rain in the United States.

FIGURE 15 Acid precipitation causes extensive environmental damage.

SECTION REVIEW

1. Complete and balance the equations for the following acid-base reactions:
   - **a.** $H_2CO_3 + Sr(OH)_2 \longrightarrow$
   - **b.** $HClO_4 + NaOH \longrightarrow$
   - **c.** $HBr + Ba(OH)_2 \longrightarrow$
   - **d.** $NaHCO_3 + H_2SO_4 \longrightarrow$
2. Consider the equation for acetic acid plus water.

   $$CH_3COOH + H_2O \longrightarrow CH_3COO^- + H_3O^+$$

   - **a.** Refer to **Table 6** to compare the strengths of the two acids in the equation. Do the same for the two bases.
   - **b.** Determine which direction—forward or reverse—is favored in the reaction.

Critical Thinking

3. **INFERRING RELATIONSHIPS** Explain how the presence of several oxygen atoms in a compound containing an –OH group can make the compound acidic.