minerals present in the watershed. For example, when an acid interacts with limestone, the following dissolution reaction occurs:

$$H^+ + CaCO_3 = Ca^{2+} + HCO_3^-$$

This reaction consumes hydrogen ions, thus raising the pH of the water. Conversely, runoff may acidify when all alkalinity in the water is consumed by acids, a process often attributed to the input of strong mineral acids, such as sulfuric acid, from acid mine drainage, and weak organic acids, such as humic and fulvic acids, which are naturally produced in large quantities in some types of soils, such as those associated with coniferous forests, bogs, and wetlands. In some streams, pH levels can be increased by restoring degraded wetlands that intercept acid inputs, such as acid mine drainage, and help neutralize acidity by converting sulfates from sulfuric acid to insoluble nonacidic metal sulfides that remain trapped in wetland sediments.

pH, Alkalinity, and Acidity Along the Stream Corridor

Within a stream, similar reactions occur between acids in the water, atmospheric CO_2, alkalinity in the water column, and streambed material. An additional characteristic of pH in some poorly buffered waters is high daily variability in pH levels attributable to biological processes that affect the carbonate buffering system. In waters with large standing crops of aquatic plants, uptake of carbon dioxide by plants during photosynthesis removes carbonic acid from the water, which can increase pH by several units. Conversely, pH levels may fall by several units during the night when photosynthesis does not occur and plants give off carbon dioxide. Restoration techniques that decrease instream plant growth through increased shading or reduction in nutrient loads or that increase reaeration also tend to stabilize highly variable pH levels attributable to high rates of photosynthesis.

The pH within streams can have important consequences for toxic materials. High acidity or high alkalinity and oxidizing conditions tend to convert insoluble metal sulfides soluble forms and can increase the concentration of toxic metals. Conversely, high pH can promote ammonia toxicity. Ammonia is present in water in two forms, unionized (NH_3) and ionized (NH_4^+). Of these two forms of ammonia, un-ionized ammonia is relatively highly toxic to aquatic life, while ionized ammonia is relatively negligibly toxic. The proportion of un-ionized ammonia is determined by the pH and temperature of the water (Bowie et al. 1985)—as pH or temperature increases, the proportion of un-ionized ammonia and the toxicity also increase. For example, with a pH of 7 and a temperature of 68°F, only about 0.4 percent of the total ammonia is in the un-ionized form, while at a pH of 8.5 and a temperature of 78°F, 15 percent of the total ammonia is in the un-ionized form, representing 35 times greater potential toxicity to aquatic life.

Dissolved Oxygen

Dissolved oxygen (DO) is a basic requirement for a healthy aquatic ecosystem. Most fish and aquatic insects “breathe” oxygen dissolved in the water column. Some fish and aquatic organisms, such as carp and sludge worms, are adapted to low oxygen conditions, but most sport fish species, such as trout and salmon, suffer if DO concentrations fall below a concentration of 3 to 4 mg/L. Larvae and juvenile fish are more sensitive and require even higher concentrations of DO (USEPA 1997).

Many fish and other aquatic organisms can recover from short periods of low