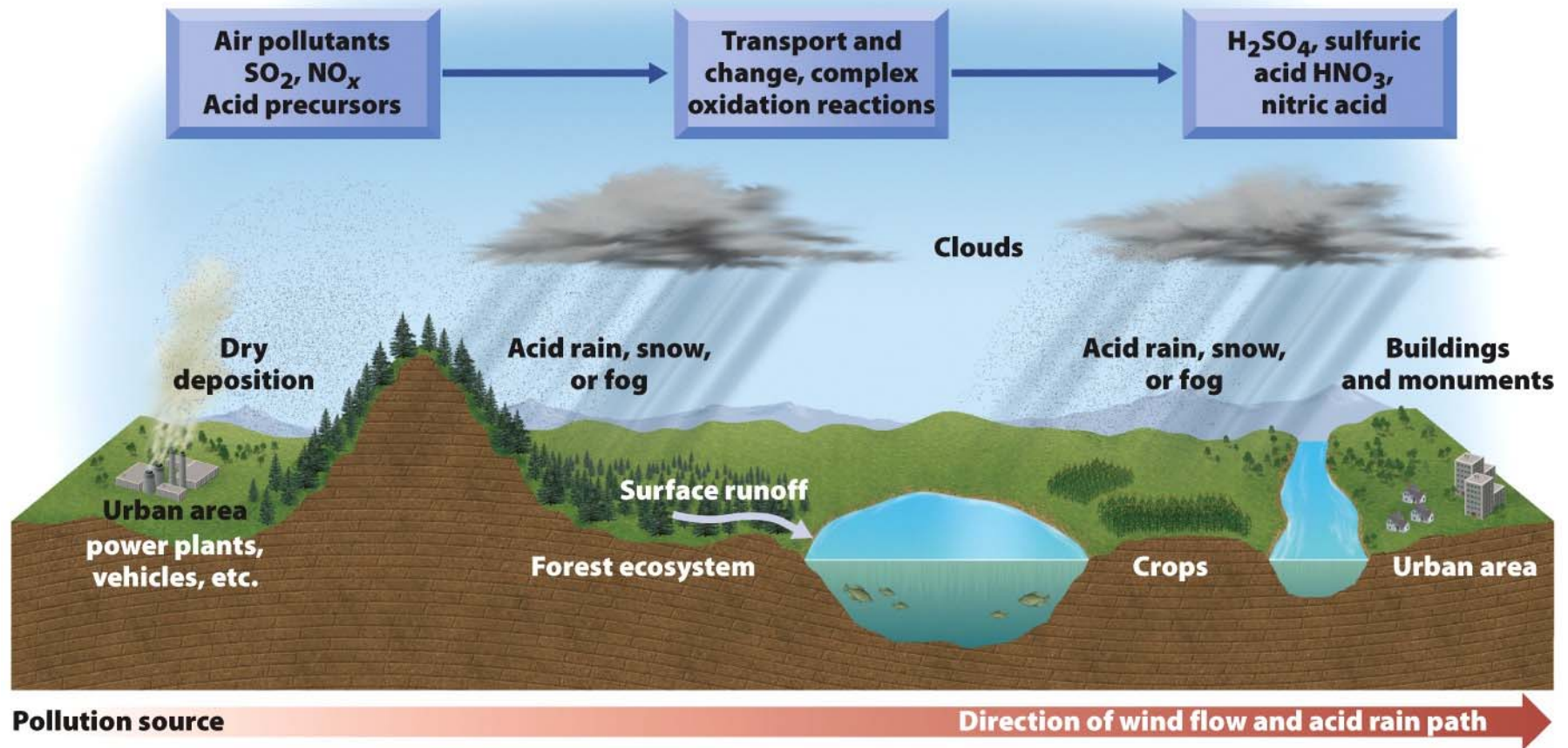


Chapter 21:

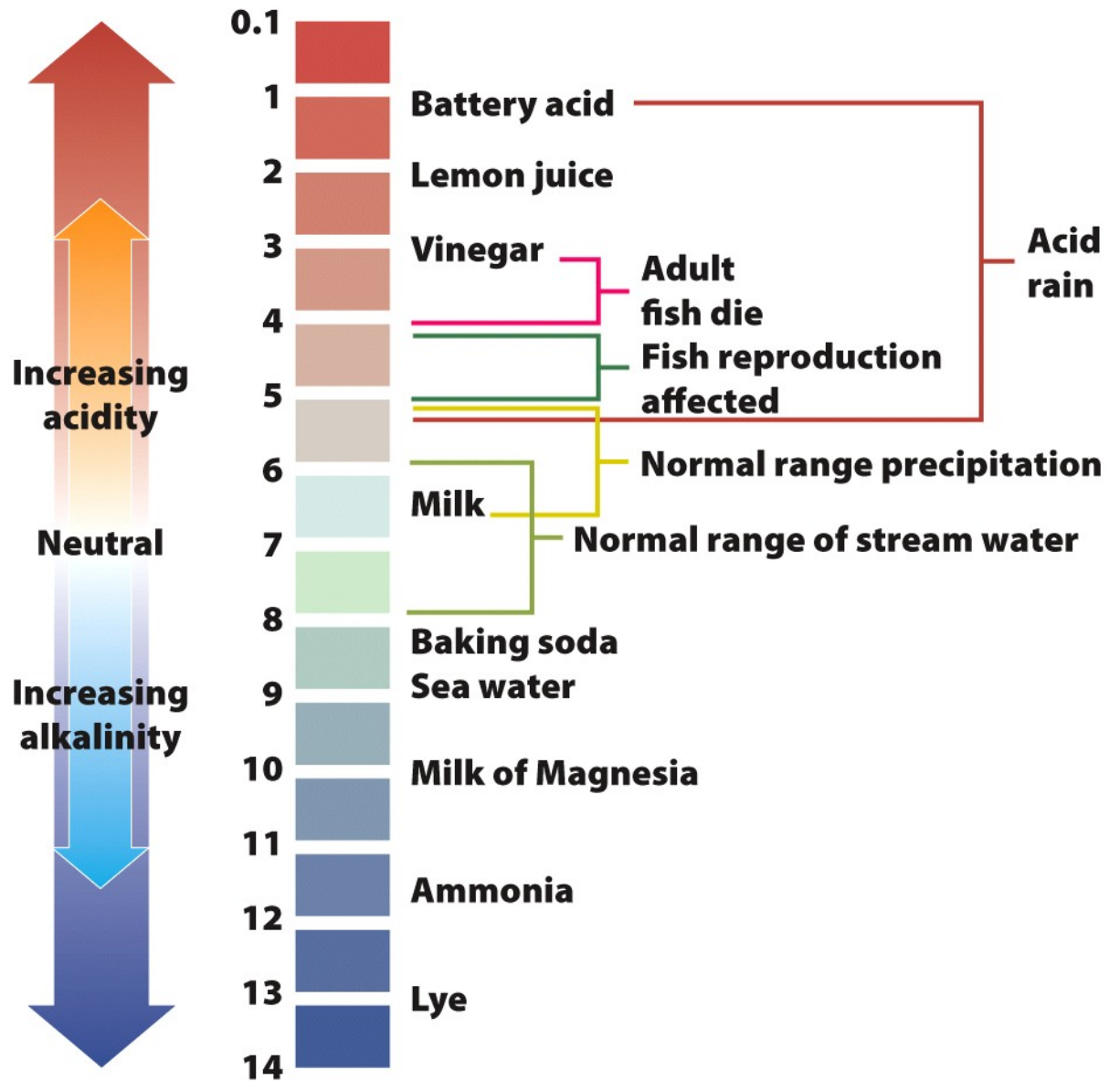
Closer Look Acid Rain



pH spectrum

The pH, a measure of acidity and alkalinity, is the negative logarithm of the concentration of the hydrogen ion

(Source: <http://ga.water.usgs.gov/edu/phdiagram.html>. Accessed March 25, 2013.)



Acid Rain Closer Look 21.1

- **Acid rain** is precipitation in which the pH is below 5.6.

Acid rain includes both wet (rain, snow, fog) and dry (particulate) **acidic depositions**.

The depositions occur near and downwind of areas where the burning of fossil fuels produces major emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x).

These oxides are the primary contributors to acid rain.

In the atmosphere, reactions with oxygen and water vapor transform SO_2 s NO_x into sulfuric and nitric acids, which may travel long distances with prevailing **winds and be deposited as acid precipitation**—rainfall, snow, or fog.

Sulfate and nitrate particles may also be deposited directly on the surface of the land as dry deposition and later be activated by moisture to become **sulfuric and nitric acids**.

Again, sulfur dioxide is emitted primarily by **stationary sources**, such as **power plants that burn fossil fuels**, whereas **nitrogen oxides are emitted by both stationary and mobile sources, such as automobiles**.

Sensitivity to Acid Rain

Geology, climate, vegetation, and soil help determine the effects of acid rain because these differ widely in their buffers”—chemicals that can neutralize acids. Sensitive areas

are those in which the type of bedrock (such as granite) or soils (such as those consisting largely of sand) cannot buffer acid input.

Soils may lose their fertility when exposed to acid rain, either because nutrients are leached out by acid water or because the acid in the soil releases elements that are toxic to plants.

Limestone bedrock provides the best buffering because it is made up mainly of calcium carbonate (CaCO_3), the mineral known as calcite. *Calcium carbonate reacts with the hydrogen in the water and neutralizes the acid.*

Acid Rain's Effects on Forest Ecosystems

Studies in Germany led scientists to cite acid rain and other air pollution as the cause of death for thousands of acres of evergreen trees in Bavaria. Appalachian Mountains of Vermont (where many soils are naturally acidic) suggest that in some locations half the red spruce trees have died in past years.

The acid rain does not directly kill trees; rather, it weakens them as essential nutrients are leached from soils or stripped from leaves by acid fog. Acidic rainfall also may release toxic chemicals, such as aluminum, that damage trees.

- Lakes on limestone or other rocks rich in calcium or magnesium carbonates can readily buffer river and lake water against acids.
- HCO_3^- (ion) forms
- Lakes with high concentrations of such elements are called hard water lakes.

Acid Rain's Effects on Lake Ecosystems

Records from Scandinavian lakes show an increase in acidity accompanied by a decrease in fish. The increased acidity has been traced to acid rain caused by industrial processes in other countries, particularly Germany and Great Britain

First, it damages aquatic species (fish, amphibians, and crayfish) directly by disrupting their life processes in ways that limit growth or cause death.

For example, crayfish produce fewer eggs in acidic water, and the eggs produced often grow into malformed larvae.

Second, acid rain dissolves chemical elements necessary for life in the lake.

Once in solution, the necessary elements leave the lake with water outflow. Thus, elements that once cycled in the lake are lost.

Third, acid rain leaches metals, such as aluminum, lead, mercury, and calcium, from the soils and rocks in a drainage basin and discharges them into rivers and lakes.

Elevated concentrations of aluminum are particularly damaging to fish because the metal can clog the gills and cause suffocation.

The heavy metals may pose health, because the metals may become concentrated in fish and then be passed on to people, mammals, and birds that eat the fish.

Drinking water from acidic lakes may also have high concentrations of toxic metals.

Acid Rain's Effects on Human Society

Acid rain damages building materials, including steel, galvanized steel, paint, plastics, cement, masonry, and several types of rock, especially limestone, sandstone, and marble.

Stone decays about twice as rapidly in cities as it does in less urban areas.

The damage comes mainly from acid rain and humidity in the atmosphere, as well as from corrosive groundwater