Forest water contamination

Forests play a key role in cleaning water. Precipitation is “'filtered” through the tree canopy and filtered again throuph the organic matter on the forest floor. The water then seeps into the subsurface to replenish the ground water. Approximately 80% of the freshwarer in the United States originates in the 650 million acres (265 million hectares) of forest thar cover approximately one-third of the nation. These forested watersheds are the primary source of drinking water for nearly two our of three people in the United States. The United States' national forests and grasslands, which cover nearly

192 million acres (78 million hectares), are the largest single source of freshwater in the country, and the headwaters of many large river basins originate in the national forests. Forests are thus an important source of freshwater; however, mining, forestry practices, and altered fire regimes have increasingly caused the contamination of these valuable water resources.

Sources of water contamination. Numerous low-flow-volume point and non-point sources cause significant contamination of water originating in forests. Abandoned mines are an major source of forest water contamination. Acid drainage from abandoned mines, for example, has been shown to cause serious water quality problems. There are approximately 557,000 abandoned hard-rock mine sites in the United States, more than 1 in 70 of which are located in or new national forest lands. Runoff from railing piles containing the rejected materials from the mine also results in water contamination. Today, railings are buried in highly engineered clay-lined or synthetic linen, bur in the past when tailings were buried, it was not done with as much atrention to containment. In addition, ground water can flow into an abandoned mine and come into contact with sulfide minerals (chalcopyrite, galena, pyrite, pyrrhotite, and sphalerite). The most common metals associated with sulfide minerals include lead, zinc, copper, cadmium, iron, and arsenic. In the presence of air, FeS from the minerals reacts with water and oxygen to form ferrous iron (Fe^{2+}), sulfate (SO_4^{2-}), and acid (H^+). These compounds can lower the pH of the water to 2.5–3, which causes many metal ions to be leached from die rock. When the pH is greater than 3.5, ferrous iron will oxidize to ferric iron (Fe^{3+}), which causes the water to take on a run-stained appearance and can cause clogging of pipes and other plumbing problem. Althoqgh it affects the water's taste and smell, ferric iron is not directly hazardous to a person's health (as the body needs some iron in the diet as pan of the oxygen-carrying system in the blood). The oxidation of sulfide minerals is also catalyzed by *Thiobacillus ferrooxidanns* bacteria, which can increase the rate of sulfide oxidation by 10 to 100,000 times. Drainage from these mines can be a source of heavy-metal ions in watersheds that originate in forests.

Abandoned coal mine sires are also a serious problem. Pyrite, marcasite (FES_2), and greigite (FeS_4) are the primary sulfide minerals found in coal. Oxidation of the minerals also lowers local water pH and causes mobilization and transport of metal ions to ground and surface water.

Another forest water contamination issue results from the use of cyanide in base-metal flotation and gold mining. More than 100 million pounds (45 million kilograms) of sodium cyanide were used In the United States in 1990 (the most recent year for wich statistics are available). Cyanide is more toxic to aquatic organisms than to humans, although ai high enough levels it can cause both short-term and long-term health effects. Cyanide dissolved in water readily complexes with metals. At a pH below 9, cyanide compounds can dissociate and hydrogen cyanide (HCN) is formed as a byproduct. Hydrogen cyanide is a gas which is very toxic to humans.

There are many other sources and types of contaminants entering the water that comes from our forests including oil and grease from vehicles, and herbicides, insecticides, and fungicides used in the treatment of lawns and other managed areas within the forest. There are also naturally occurring contaminants such as arsenic. Arsenic generally enters drinking water supplies through a process of natural leaching. Arsenic-rich rock is widely dispersed throughout the Earth's crust. The Environmental Protection Agency recently proposed lowering the maximum allowed level of arsenic from 50 parts per billion (ppb) to 5 ppb due to concerns about bladder, lung, and skin cancer. A policy compromise of 10 ppb has been scheduled to go into effect in 2006.

Forest fires and water contamination. Fires can drastically affect the role of forests in the water supply Erosion after a fire can result in significant losses of topsoil, increases in the amount of sediments in the water (turbidity), and the release of large quantities of soluble chemicals. A major concern after a forest fire is the increase in concentraion of nitrate nitrogen (NO_3–N), mostly originating from dissolved herbicides. High levels of NO_3–N, along with phosphorus, can cause eutrophication of lakes and streams (excessive nutrient richness leading to excessive plant growth).

Soil type and vegetation coverage play a critical role in the ability of the land to adsorb water. In a healthy forest, where at least 60-75% of the ground is covered with vegetation, only 2% or less of the rainfall becomes surface runoff and erosion is low (loss of less than 0.05 ton soil/acre). When the vegetation cover drops to 35–50%, the surface runoff increases to 14% and soil loss increases tenfold. Finally, when the vegetation cover is less than 10%. the surface runoff increases to 73%, and soil loss is 100 times greater than seen in the mostly highly vegetated forests. After a fire, erosion is most serious in steep terrain where the slope exacerbates problems with runoff.

Another effect seen after a forest fire is that burned land usually adsorbs water more slowly than unburned land. A severe fire in a forest can therefore create ground conditions where surface runoff is more likely to lead to flash floods, and can also increase soil loss and contaminated water. Increases in water flow after a fire can further result in more solids and dissolved materials in the water. Inorganic compounds leached into the water increase the concentration of soluble ions, which may increase both turbidity and toxicity. Finally, both water-soluble and -insoluble nutrients can cause an increase in aquatic plant growth that may lead to decreased water flow.

Filtration. There are many types of filter systems in use, but innovations in filtration technology are needed to more effectively remove contaminants from water. The need to continually improve the efficiency of filtration has spawned an enormous industry, and its fastest-growing nonindusuial application is the generation of clean water. Global spending on all types of fitration (including dust collecton, air filtration, liquid cartridges, membranes, and liquid macrofiltration) is expected to increase from $ 17 billion in 1998 to $ 75 billion by 2020.

Currently, several types of filters are used in forests to prevent contaminants from entering the water supply. One type of filtration starts with the construction of holding ponds to contain water that has been identfied as contaminated. Evaporation and sand/soil filtration are then used to clean the water, and the contaminated sediment is periodically removed. In addition, holding ponds may be treated with bacteria to degrade organic contaminants to CO_2 and water. Another type of holding pond–based fitration is used to remediate low-pH water, which can be contained in holding ponds that slowly release the water through limestone-lined pipes or stream beds to increase the pH and precipitate the meds. Biofiters are also used in many places: these filters trap organic contaminatants until bacteria or fungi can degrade the compounds. Some other types of systems use bark and other waste forest biomass to filter out sediments, soluble metal ions, and toxic organics.

Forests are critical in protecting our surface water supply and sustaining it for the future. Minimizing pollution from mining and forestry processing is key, and it is also important to lower the fuel load in our forests to reduce the frequency of devastating forest fires. Otherwise, it will be increasingly necessary to rely on technological remedies to the problems of forest water contamination instead of taking advantage of the forests natural systems.

For background information see FOREST ECOSYSTEM; FOREST FIRE; GROUND-WATER HYDROLOGY; SEWAGE TREATMENT; SOIL CONSERVATION; SOIL DEGRADATION; WATER CONSERVATION; WATER POLLUTION; WATER SUPPLY ENGINEERING; WATER TREATMENT in the McGraw-Hill Encyclopedia of Science & Technology. Roger M. Rowell

Bibliography. G. Dissmeyer (ed.). *Drinking Water from Forests and Grasslands: A Synthesis of the Scientific Literature.* USDA, Forest Service, Southern Research Station, Gen. Tech. Rep. GTR-SRS–39; Asheville, NC, 2000; Forest Service, Wildland Raters, USDA. 1400 Independence Ave SW Washington, DC 20250–00036; U.S. Geological Survey, *The Quality of Our Nation's Waters: Nutrients and Pesticides,* USGS Circ. 1225, U.S. Department of the Interior, Box 25286, Denver. CO 80225.

McGRAW-HILL YEARBOOK OF
Science & Technology

2006

Comprehensive coverage of recent events and research as compiled by the staff of the McGraw-Hill Encyclopedia of Science & Technolog

McGraw-Hill
New York Chicago San Francisco Lisbon London Madrid Mexico City Milan
New Delhi San Juan Seoul Singapore Sydney Toronto