Air and Water: A Healthy Environment

The integrity of ecosystems depends on air quality and both the quality and quantity of water. Access to air and water is also a fundamental human right. Thus, making ethical decisions about our use of air and water requires understanding how nature purifies both and then relying on this knowledge to provide access for everyone.

We begin with the ecology of the atmosphere and consider how we should respond to air pollution and the increase in greenhouse gases (GHGs). Then we consider the water cycle and confront the problems of water pollution and the scarcity of clean water. Finally, we confirm that protecting a healthy environment makes more sense than depending on economic markets to allocate our use of these precious resources.

The Earth's Atmosphere

In the biosphere, air and water intermingle almost everywhere. The atmosphere contains water particles, and water in the oceans, lakes, and streams absorbs the gases of the atmosphere. Plants absorb carbon dioxide from the air, using solar energy in the process of photosynthesis, which produces needed materials for the plants and releases oxygen into the atmosphere as a waste product. Animals breathe in oxygen and exhale carbon dioxide. Both plants and animals require water, which is the medium for the metabolism of every organism.

Life on Earth also depends on nitrogen, sulfur, and phosphorus compounds as well as chemicals using carbon, oxygen, and hydrogen. A water molecule, which is the most common molecule on the planet, is made up of two atoms of hydrogen and one atom of oxygen. Carbon is the sixth most common atom on Earth, but carbon dioxide (an atom of carbon plus two atoms of oxygen) makes up only a small fraction of the atmosphere. Nitrogen, which is the second most common element in our bodies, is an essential ingredient for the proteins and nucleic acids needed for life. Nitrogen must be "fixed" (in compounds) to be utilized by plant and animal cells, and this occurs in the atmosphere due to lightning and in the soil because of bacteria.

Sulfur is found in rocks and ocean sediment and enters the atmosphere with volcanic eruptions and forest fires, and as bacteria decomposes organic matter. Plants and animals require sulfur for proteins and enzymes, but sulfur dioxide in the atmosphere may react with water to form sulfuric acid. Similarly, nitrous oxides in the atmosphere may react with water to form nitric acid. Because this is natural, plants have evolved resistance to rain that is slightly acidic.

Phosphorus is essential for life on Earth, because it forms part of the structural framework of DNA (deoxyribonucleic acid) and RNA (ribonucleic acid), is used in cell walls and bones, and is involved in energy transfers using ATP (adenosine triphosphate) within cells. Because it is highly reactive, phosphorus is never found as a free element in nature. Where phosphorus is scarce in the natural environment, life will also be scarce.

Ozone (a molecule with three atoms of oxygen) is in the air naturally, produced from oxygen by lightning. In the upper atmosphere, the ozone layer prevents ultraviolet light (which damages organic tissue) from reaching the earth's surface. In the lower atmosphere, ozone levels are naturally too low to harm plants and the respiratory organs of animals.

Air and water are only “polluted” by the presence of these substances when the concentration is too high. Too much sulfuric acid in the atmosphere causes “acid rain,” which kills plants, and too much ground-level ozone harms plants and animals. Humans are not the only cause of pollution; natural events such as forest fires and volcanic eruptions contaminate air and water. Nonetheless, as ethical beings, we are responsible for our impact on the biosphere.

Air: Pollution and Greenhouse Gases

The US Congress passed the Clean Air Act in 1963 and the Air Quality Act in 1967. In 1970 it amended these in the Clean Air Act Extension, which charged the newly formed Environmental Protection Agency (EPA) to develop and enforce regulations to protect the public from airborne contaminants known to be dangerous for human health. These laws reflect a growing awareness of our duty to restore and maintain nature’s capacity to purify the atmosphere.

In 1977 Congress again amended the Clean Air Act, this time to require the EPA “to make a special effort to clean the air in national parks, wildlife refuges and other places of ‘scenic’ and ‘historical’ value it hoped to leave in somewhat better shape for future generations.”[1] Yet no administration since then, of either party, has obeyed this mandate.[2] As a result, air pollution has damaged one in three national parks.

There have been efforts, however, to reduce lead poisoning, petrochemical smog in urban areas, acid rain where power plants are burning soft coal, the hole in the ozone layer caused by chlorofluorocarbon gases (CFCs) entering the stratosphere (above thirty thousand feet), and the new threat caused by the increase in GHGs in the atmosphere.

Lead

Lead is found naturally in water, but there was little lead in the air until, it was added to gasoline in the 1920s to improve the efficiency of the automobile engine. Within two decades the dangers for human health were clear. “Long-term exposure to lead, even in low concentrations, can cause improper brain functioning and development. Scientific studies have clearly established the link between lead intake and the intellectual impairment of children. Unlike some contaminants, lead does not flush out of the body with body fluids. Once ingested, it remains in the fat and body tissue for life.”[3]

Public health officials pushed for government regulations that would ban the use of lead in paint, require that lead pipes used to carry drinking water be replaced with copper or plastic pipes, and end the use of lead in gasoline (because particles of lead were introduced into the air with engine emissions). In 1976 the EPA banned the use of lead in gasoline, and since then concentrations of lead in the air have dropped more than 90 percent.[4]

Other sources of lead in the atmosphere are lead smelters, tobacco smoke, production of iron and steel, and burning of coal and oil. A recent study endorsed by the EPA’s Clean Air Science Advisory Committee concludes that there is no safe human level for exposure to lead. Because of the continuing danger from air pollution, the EPA monitors not only lead, but also five other air pollutants—ozone, soot, sulfur dioxide, carbon monoxide, and nitrogen oxides.[5]

Although lead pollution has been reduced in the United States,[6] it is on the rise in many developing countries. The battery industry uses about 80 percent of the lead produced each year. In response to a growing demand for batteries to store energy generated by solar collectors as well as for other applications, the manufacturing of lead batteries is increasing rapidly in countries, such as China and India, which have less stringent regulations governing air and water pollution.[7]

Smog

In the 1950s smog in urban areas began to endanger human health. This "photochemical smog" occurs when sunlight causes nitrogen oxides and volatile organic compounds to react, which produces airborne particles and ozone.[8] Scientists created a catalytic converter to reduce nitrogen oxides to nitrogen and oxygen, to oxidize carbon monoxide into carbon dioxide, and to oxidize unburned hydrocarbons into carbon dioxide and water.[9] In 1976 the EPA required all new cars to have catalytic converters, and now these devices neutralize about 90 percent of the harmful emissions produced by automobile engines.[10]

In 2008, during the George W. Bush administration, the EPA decreased the amount of ozone that should be allowed in the air to consider it healthy, but the Clean Air Scientific Advisory Committee, which was created by Congress to advise the EPA, has protested that the new air quality standard for smog does not protect public health as required by law and should be strengthened.[11] Research in 2008 also indicates that high levels of ozone in the lower atmosphere can decrease forest growth by as much as 30 percent and interfere with "the ability of bees and other insects to follow the scent of flowers to their source, undermining the essential process of pollination."[12]

Reducing ozone in the lower atmosphere to levels that are harmless will require substantial investment in mass transit; engines for vehicles that produce fewer emissions; lower-cost housing in cities enabling people to live closer to where they work; and higher gasoline prices, which motivate people to walk, bicycle, ride mass transit, and use car pools.

Air pollution in the United States had been cut dramatically by 2010 through enforcement of the Clean Air Act and its amendments. That year, the EPA reported, reductions in fine particle and ozone pollution prevented more than 160,000 premature deaths.[13]

Elsewhere, however, the World Health Organization (WHO) reported that outdoor air pollution causes 1.3 million deaths each year, and indoor air pollution, 2 million premature deaths. Most of these deaths are in developing countries. In China two-thirds of the cities fail to meet stricter air quality standards that the government is phasing in over four years.[14] Exposure to air pollutants is largely beyond the control of individuals, so action to improve air quality and lower the death rate from pollution must be taken by public officials at all levels of government.[15]

Acid Rain

Acid rain is caused largely by excess amounts of sulfur dioxide in the atmosphere. It is not only a problem in North America and Europe, but also in Asia and Latin America. In

Europe, the Convention on Long-Range Transboundary Air Pollution (CLRTAP) regulates emissions of both sulfur dioxide and nitrogen oxides.[16]

In the United States, utility companies burning coal with a high sulfur content produce 70 percent of this airborne sulfur dioxide.[17] Acid rain reduces the yield of crops, kills pine trees, and renders lakes sterile by killing the small plants in the water. The heat of combustion and the height of the smokestacks cause the contaminated smoke to rise high into the atmosphere. Strong winds can carry the damaging gases for long distances before they settle on the ground.

The Clean Air Act of 1990 directed the EPA to regulate the emissions of power plants. The act required regulators to study the records of each utility company to calculate the amount of sulfur dioxide generated by each factory in the preceding years. Because sulfur dioxide gas is the most common pollutant, this figure is used to determine the amount of pollutants that each factory is allowed to emit.

This allowance defines the “cap” (limit) of the sulfur dioxide emissions from a power plant. The cap is reduced over time, requiring power plants to decrease their sulfur dioxide emissions to avoid paying a penalty. Power companies that lower their emissions below their cap may sell the “extra allowances” to other companies. Under this program, “Emissions of sulfur dioxide have dropped by 35 percent even though the gross domestic product has more than doubled.”[18]

This “cap-and-trade system” lowers the level of contaminants, but does not end pollution. In 2003, when an overload of the electrical circuits in northeastern North America shut down several power plants, scientists measured the air pollutants a day later. In comparison with measurements made a year earlier, there was “a 90 percent drop in the sulfur oxides that cause acid rain, a 50 percent drop in the nitrogen oxides that generate smog, and an increase of aerial visibility of 40 miles (64 km).”[19]

In 2011 the EPA issued a new cross-state emissions rule that requires twenty-seven states to further cut power plant emissions of sulfur dioxide and nitrogen oxide pollutants. The EPA argues that the health benefits of the rule will significantly outweigh the costs of complying with it, which could reach $800 million a year by 2014. Critics, who claim the EPA has exaggerated the health benefits and has not given the power industry enough time to comply, have said they will go to court to try to block enforcement of the rule.[20]

At the end of 2011 the EPA also issued new rules on curbing toxic emissions, including mercury, from industrial boilers. The initial standards promulgated by the EPA in 2000 were set aside by an appeals court ruling that found the rules were not sufficiently inclusive. The EPA revision in 2005 was again blocked by a court ruling. In 2010 the Obama administration proposed new rules, which after extensive hearings and opposition have been scaled back.[21]

Nonetheless, the final rules are expected to have significant health benefits. The EPA estimates the rules will prevent more than 45,000 premature deaths, about 500,000 asthma attacks among children, and over 20,000 emergency room visits and hospital admissions, saving $90 billion annually. These benefits, even if overstated, appear to outweigh the $10 billion it will cost power plants annually to comply with the rules. Also, many old, inefficient coal-burning power plants will be closed, but most of these were to be shut down anyway because of stricter state air-quality rules, the increasing price of coal, and the switch to natural gas because of its lower cost.[22]

Ozone in the Upper Atmosphere

In the stratosphere, ozone deflects ultraviolet light that, if it reached the earth, would "kill fish and shrimp larvae near the surface of the oceans, stunt the growth of plants, and contribute to vision problems and skin cancer in humans."[23]

The ozone layer in the stratosphere was stable until chlorofluorocarbons (CFCs) were invented in 1930 for use in air conditioners. These synthetic gases, which are odorless, nontoxic, nonflammable, and chemically inert, were soon used in aerosol dispensers. In 1973, however, researchers found that CFC molecules exposed to undiluted light in the stratosphere break up, releasing chlorine gas, which reacts with ozone and produces oxygen. Five years later the US Congress banned CFCs in aerosol dispensers, despite arguments by CFC manufacturers that scientific evidence of the danger to the ozone layer was inconclusive.

In 1986 a large hole in the ozone layer was confirmed, and a year later scientists verified the presence of chlorine molecules in this hole. At the end of 1987 the United Nations Environment Programme launched the Montreal Protocol on Substances That Deplete the Ozone Layer, which came into force as international law in 1989. The Montreal Protocol effectively ended production of CFCs, but these gases will continue to be emitted in smaller amounts into the atmosphere, because the protocol allows the reuse of gases in refrigerators and air conditioners made before 2000.

Hydrochlorofluorocarbons (HCFCs) were developed as transitional substitutes for CFCs, because they are less damaging to the ozone layer. The Montreal Protocol, however, requires that developed countries reduce the use of these gases by 90 percent below the baseline use by 2015 and completely phase out HCFCs by 2030.[24]

The Montreal Protocol is an example of successful international regulation. The battle for the Montreal Protocol was won because proponents (1) were able to define the issue as a serious threat to public health, (2) made the precautionary principle the standard for intervention, (3) gained credibility when the ozone hole over Antarctica was discovered, and (4) had a more effective lobbying network than the opposition.[25]

The recovery of the ozone layer is a slow process, because the ozone-depleting substances already in the atmosphere will continue to react with ozone for several decades. In 2011 the World Meteorological Organization reported that the presence of CFCs and other reactive gases, combined with an extremely cold winter, had further depleted the ozone layer above the Arctic.[26] Without the Montreal Protocol, however, the depletion would have been greater.

Greenhouse Gases

Water vapor and other natural gases in the atmosphere act like a glass ceiling, letting the light through and blocking much of the heat radiating from the earth. This is known as the greenhouse effect, because this process is how glass warms a greenhouse. Greenhouse gases include carbon dioxide, carbon monoxide, nitrous oxide, methane, fluorocarbons, and hydrofluocarbons.[27]

The greenhouse effect of the atmosphere is natural and sustains life.[28] Since the beginning of the industrial era, however, the carbon dioxide in the atmosphere has risen by 30 percent,[29] and the rate of growth is increasing each year. This increase, which is causing rapid global warming, is largely due to burning fossil fuels (coal, oil, and natural gas).[30] To slow global warming, we must lower carbon dioxide emissions, which requires reducing our consumption of fossil fuels. Chapter 15 addresses this critical issue.

Water: Quality and Scarcity

Nature purifies water through the *hydrologic cycle.* Evaporation from streams, lakes, and oceans leaves impurities behind. If the atmosphere is not polluted, then rain will bring clean water back to the earth. Impurities added to water in the atmosphere, or picked up in streams from rocks and sediments, are filtered out by plants growing along streams and wetlands that absorb organic material and minerals. Water in underground aquifers has been filtered by the soil and purified by bacteria in the ground that transform chemicals into nutrients.

What is our duty to maintain these ecosystem processes and to restore ecosystems when these functions are damaged? We look first at the stress now on surface water and groundwater ecosystems. Then we consider our choices in treating water and how we might protect access to water where there is scarcity.

Surface Water

In 1972 Congress passed the Federal Water Pollution Control Act Amendments, which were later modified and are now known as the Clean Water Act (CWA). The purpose of this act is "to restore and maintain the chemical, physical, and biological integrity of the nation's waters."[31] The CWA requires protecting streams and wetlands, because they provide essential ecosystem services such as filtering out sediment.

Streams and wetlands also filter and process organic material, such as manure, leaves, and dead insects, and chemicals, such as nitrogen and phosphorus compounds in fertilizers that run off fields and golf courses. "In headwater streams and wetlands, more water is in direct contact with the streambed, where most processing takes place. Bacteria, fungi, and other microorganisms living on the bottom of a stream consume inorganic nitrogen and phosphorus and convert them into less harmful, more biologically beneficial compounds."[32]

In one study of small streams, nitrogen and phosphorus were removed before the water traveled less than sixty-five feet (twenty meters). Where the forest surrounding a small stream is replaced by fields or lawns, however, grasses along the banks of the stream trap sediment and expand, shrinking the width of the moving water. This greatly reduces the cleansing capability of a stream, causing nitrogen and phosphorus to travel five to ten times farther.

In Appalachia from 1986 to 1998 more than nine hundred miles of streams were buried because of mining operations, and in Maryland more than half of the streams of the Rock Creek watershed were destroyed when the area was developed.[33] Land development in the twentieth century throughout the United States destroyed over ninety million acres of wetlands.[34]

Laws concerning water pollution distinguish between *point source* pollution (from factories, mining, landfills, and leaking sewage treatment facilities) and *nonpoint source* pollution.[35] Point source pollution is addressed by efforts to ensure that wastewater released into the environment has been properly treated, so it is safe for the designated uses of the area, such as fishing or agriculture. The direct discharge of wastes from point sources into streams and lakes is regulated by the National Pollutant Discharge Elimination System (NPDES), a permit system established by the Clean Water Act and administered by the EPA.[36]

Prevention is the best way to reduce point source pollution. Remember the three Rs? Reducing waste dumped in landfills, for example, means fewer pollutants washed into nearby streams. Reusing water in industry lowers the demand for clean water, reduces the wastewater requiring treatment, and minimizes the volume of treated wastewater discharged into the environment. Recycling paper reduces demand for trees, which means there are more trees maintaining soil and preventing runoff. Also, producing recycled paper takes less water than making paper from raw wood.[37]

Nonpoint source pollution in the United States is largely from *storm water runoff,* which carries pollutants from surface areas, such as roadways, parking lots, golf courses, farm fields, and construction sites, into storm gutters and streams.[38] The EPA says that nonpoint source pollution is the main cause of contaminants in our water, and that this is largely due to industrial agriculture. Because storm water runoff is dispersed, it is harder to prevent.

Agricultural runoff contains phosphorus used in fertilizer and animal feeds. Phosphorus is a limiting nutrient in plants, because the supply of phosphorus is usually lower than other nutrients. When storm water runoff brings phosphorus into a water system, algae thrive, but too much phosphorus causes eutrophication. "When thick blooms of algal growth block sunlight from reaching the plants below, the decay of dead algae uses up the available oxygen in the water, suffocating fish and sometimes causing whole populations of species to be lost."[39]

The intensive use of fertilizer and animal feed (containing phosphorus and nitrogen) has led to a global catastrophe. By 1994 "significant eutrophication problems were being reported in 54 percent of all lakes and reservoirs in Southeast Asia, 53 percent of those in Europe, 48 percent in North America, 41 percent in South America, and 28 percent in Africa."[40]

Nature cleans water in *watersheds* that maintain the natural processes of sedimentation, biodegradation, filtration, and sorption (referring to both absorption and adsorption, the adherence of one substance to the surface of another). When constructing highways or buildings disrupts watersheds, we should restore these natural processes.[41] Sedimentation works best in standing water, so storm water runoff ponds should be used to allow surface water to collect.

Biodegradation, filtering, and sorption occur where water is in contact with soil and plants, and is most effective when water is moving slowly across a large surface area. This means developed areas should have grass-lined, flat drainage ditches (called swales). Because surface water runoff not only spreads chemical pollutants but also erodes soil, it is important to reduce the velocity of runoff by using swales, ponds, and boulders where the velocity is great, by planting grass and other vegetation to hold the soil, and by capturing eroded sediments near their source.

Dams to produce power and levees to control flooding often interfere with the natural cleansing provided by rivers and streams.[42] Holding water behind a dam expands the surface area and exposes the water to more sunlight. As the water temperature rises, the amount of oxygen in the water decreases, causing a decline in the fish population and an increase in algae. Dams and levees also interfere with the migratory routes of fish.

Our ethical presumption is that sustainable development requires restoring and managing natural systems of water purification, because these ecosystem processes are the most effective (and least costly) way to maintain both the health of the environment and clean water for our use.[43]

Groundwater

Surface water, due to the hydrologic cycle, is a renewable resource. Groundwater, however, for all practical purposes is a *nonrenewable resource,* because on average it takes fourteen hundred years to replenish an underground aquifer.[44] About 97 percent of the liquid freshwater on Earth is underground, but these reserves are shrinking. "Today, aquifers supply water to more than half of India's irrigated land. The United States, with the third highest irrigated area in the world, uses groundwater for 43 percent of its irrigated farmland."[45] Groundwater is also the main source of drinking water for 1.5 billion people.

A study of fifty-four streams by the US Geological Survey found that groundwater is the source of about half the flow of surface water. Also, aquifers stabilize wetlands by providing water during the dry season and absorbing water when rains are heavy. Pumping water from aquifers tends to remove moisture from the earth's surface, which in agricultural areas increases the need for irrigation and dries up shallow wells. As aquifers are depleted, surface water may also decline.

Because surface water seeps into groundwater, pollutants in surface water eventually reach aquifers. DDT has been banned in the United States since 1972, but is present in groundwater. Nitrate contamination (which may cause cancer) is a problem in Iowa, Kansas, Nebraska, and South Dakota,[46] and the fissured aquifers of southern California, Florida, and Maine are polluted.[47] Chemicals also enter groundwater from landfills and leaking petroleum storage tanks.

In addition, the process of extracting groundwater may pollute it. In the 1970s the WHO began a well-drilling program in Bangladesh to reduce the use of contaminated surface water, and today 95 percent of the people there drink groundwater from aquifers. Recently, however, arsenic has been found in this water. It seems that oxygen entering the aquifers during pumping has oxidized iron pyrite sediment around the aquifer, causing the arsenic to dissolve and contaminate the groundwater.

Also, an aquifer near the ocean may be contaminated by salt. A full aquifer drains to the sea, but as the aquifer is emptied, seawater may flow back into the aquifer. Due to the high salt content of seawater, just 2 percent mixed with freshwater makes the water unsuitable for drinking or irrigation. The aquifers under the heavily populated cities of Manila, Jakarta, Madras, and areas of Florida are now threatened by seawater.[48]

Increasingly, therefore, groundwater will have to be treated before it can be used. Furthermore, because aquifers offer only a limited supply of water, it will not be long before they are unable to provide the quantity of water now used for agriculture, manufacturing, and drinking. This means we must use water more efficiently. Our goal should be "to improve social and individual well-being per unit of water used."[49]

It is estimated that more than 40 percent of the world's peoples live in river basins suffering from water stress, and that more than eighty countries with about 40 percent of the world's population are experiencing water scarcity.[50] Countries that have dry ecosystems and sufficient funds often import "virtual water" in the form of grain, because it takes about a thousand tons of water to grow a ton of grain.[51]

Population growth, however, and greater consumption of beef, are raising the demand for grain. This means more water will be allocated for cash crops and cattle grazing, and less water for other uses. "Water is available only if water sources are regenerated and used within limits of renewability. When development philosophy erodes community control and instead promotes technologies that violate the water cycle, scarcity is inevitable."[52]

Allowing the market to determine the use of water and its price will not ensure its conservation and best use. Markets are oblivious to ecological limits on water use set by the water cycle and also to economic constraints due to poverty. Overexploiting water and disrupting the water cycle creates absolute scarcity, and markets have no way to respond to this scarcity. In India, for example, even as water projects were being developed to support irrigation for growing export crops, many villages were running out of water to drink and grow their own food.[53]

Clearly, public and private investment in recycling wastewater makes sense. Israel recycles 75 percent of its water, and Orange County, California, plans to "pump 70 million gallons of treated sewage into the aquifer under the county, thereby replenishing the volume of underground water and ensuring available supplies for the county's growing population."[54]

Water Treatment

Governments must also invest in more effective water treatment systems. Chemical pollution is pervasive; virtually "every industrial facility in the United States that manufactured or used toxic chemicals has historically polluted air, land, and water resources."[55]

There are now about eighty-five thousand chemicals in use in the United States, and two thousand more are added each year. The EPA does not review every toxic chemical, but only the three thousand chemicals produced or imported into the United States at levels greater than one million pounds annually. A study by the General Accounting Office of 236 facilities manufacturing pulp and paper, pharmaceuticals, and pesticides found that 77 percent of the toxic pollutants identified were *not* being controlled through the EPA point source permit process.[56]

Pesticides are used everywhere, but are often not regulated. The EPA lists twenty-one pesticides (four of which are banned), and the WHO lists thirty-one pesticides (eleven on the US list and another twenty of concern). The European Union enforces the precautionary principle by requiring that drinking water be free of pesticides. Water regulation in the United States provides less protection.

The Environmental Working Group (EWG), an NGO based in Washington, D.C., reviewed water quality tests taken between 2004 and 2009 that identified 316 contaminants in water supplied in forty-five states to 250 million Americans in forty-eight thousand communities. Among the contaminants were over 200 chemicals that are not regulated under the EPA's primary drinking water standards. [57]

The CWA established programs to control water quality in watersheds by enforcing the maximum pollutant load allowable daily from each source. This requires identifying what pollutants are to be measured and what level of contamination is unacceptable. In effect, CWA regulation makes it acceptable "to pollute the environment up to specified water quality standards and not worry about unregulated chemicals."[58]

In the United States this *permissible pollution* approach also applies to regulating facilities that purify water for human consumption. The EPA sets maximum contaminant levels (MCLs) for the pollutants that must be treated, and there are now about ninety contaminants on this list. Since 1996 the EPA has also been required to publish a list of contaminants that are not subject to MCLs, but are "known or anticipated" to occur in public water systems. This contaminant candidate list (CCL) includes over fifty chemicals and seven microbiological contaminants.[59]

The process of studying and setting an MCL for a chemical that is known to be dangerous can be lengthy. Arsenic, for example, is known to cause cancer, but the EPA did not propose an MCL for arsenic until 2001 (perhaps because it is costly to measure). Then it took five years for the EPA to enforce this MCL in public water systems.

There are also problems with water treatment techniques. Two chemicals commonly used to combine small particles (to facilitate their removal from water) have been identified by the Public Health Service as "reasonably anticipated to be human carcinogens."[60] Also, the use of chlorine and bromine to destroy biological contaminants produces toxic halogenated compounds, most of which are not covered by the EPA's primary drinking water standards.[61]

Pharmaceutical pollutants not covered by the primary drinking water standards may well survive the treatment process that is generally used in publicly operated treatment systems. In 2001 a report published by the Centers for Disease Control (CDC) found that almost all humans have measurable levels of industrial chemicals in their bodies.

Who has the duty to ensure that chemicals are safe? If we affirm the precautionary principle, industries have this responsibility. Some companies have voluntarily accepted this duty,[62] and the FDA requires companies manufacturing pharmaceutical drugs to ensure that these chemicals are safe before they are sold. Many of the industrial chemicals in the environment are as dangerous as pharmaceutical drugs. Therefore, it seems reasonable that these substances should meet the same burden of proof before being released into the environment.

Implementing such a system, however, would require government monitoring and would not remove the tens of thousands of chemicals already in our water. So governments have a duty to provide effective water treatment. Is it sufficient to meet the EPA's MCL standards? Affirming the precautionary principles, as in Europe, would mean local governments in the United States have a duty to use the best available technology (BAT) to make our water as safe as possible. This would mean using ozone and ultraviolet light now and more effective forms of treatment as these are developed.

Because water treatment impacts our human right to safe water, those who argue the BAT standard is too costly bear the burden of showing that this is a compelling reason for setting aside our ethical presumption. In California, water utility managers estimate that using "advanced treatment technologies should add only 15 to 25 percent to a water utility's budget."[63] In areas where there is a shortage of water, treatment programs may find it cost effective to use new techniques for recycling wastewater to supply the drinking water that communities require.

Economic Predictions: Shortsighted

Clear air and clean water are essential for a healthy environment and for human health, which is why the purpose of the CWA is "to restore and maintain the chemical, physical, and biological integrity of the nation's waters."[64] In this statement the word *integrity* is used in a scientific sense, but we may draw an ethical inference as well. We should restore and maintain the integrity of the nation's waters, because we have a duty to care for the ecosystems that sustain life on Earth, protect the human right to clean air and water, and preserve these ecosystem functions for future generations.

Will doing our duty be cost effective? There is ample evidence that restoring and maintaining natural systems that cleanse water saves money in both capital and operating costs.[65]

Nonmarket Goods

Life on Earth depends on the atmosphere and the hydrologic cycle. The air is not a commodity to be priced by the market, and no one has a right to waste or pollute water systems. On the contrary, under international law every person has a human right to clean air and water. Under a ruling by the Committee on Economic, Social and Cultural Rights, which administers the International Covenant on Economic, Social and Cultural Rights (ICESCR), governments have a "core obligation" to ensure the minimum conditions for health, which include clean air, and an adequate supply of safe, potable water.[66]

In 1985 the Supreme Court of India restrained the mining of limestone quarries in the Doon Valley, arguing that the law must protect "the right of the people to live in a healthy environment with minimum disturbance of ecological balance and without avoidable hazards to them and to their cattle, homes and agricultural land and undue affection of air, water and environment."[67] This decision rests on ethical reasoning that community rights, which secure the necessary social conditions for human dignity, outweigh individual property rights.

Also, to protect human rights, we must resist the *privatization of water.* The World Bank failed to do this in Maharashtra, India, where it subsidized the construction of tube wells and mechanized pumping systems for irrigation, although 80 percent of the water supplied was used to grow sugar cane as a cash crop. This may make economic sense for those with the financial capital to invest in sugar cane production, but as a consequence shallow wells for public use, and also those owned by small farmers, have run dry.[68]

Our ethical presumption, therefore, is that the cost of using air and water has to increase when the use of the resource is polluting, or wasteful, or violates a human right. Also, the public costs of monitoring air and water and treating water to make it safe must be paid, and these costs should be assessed in a way that is proportional to "bad" uses of air and water. Good uses should be cheap, bad uses expensive.

Although the cap-and-trade approach has reduced sulfur dioxide emissions, setting a cap and providing tax credits for companies that reduce emissions below their cap might be more effective in providing incentives for companies to invest in conservation.[69] Also, offering tax credits would not encourage trade in a "bad" (pollution), as the cap-and-trade approach does, but instead would reward companies for the "good" of reducing pollution.

Certainly, without legal mandates many corporations will not take into account the long-term environmental and social costs of the air and water pollution they create. That is, they will not include (internalize) these nonproduction costs (externalities) in their balance sheets. Therefore, we should support government regulations that impose these long-term costs fairly on manufacturing companies and agribusiness.

Bottled Water

As a final example, consider the present market in bottled water, which is growing rapidly all over the world. In India, between 1992 and 2000 sales of bottled water increased tenfold. In 1998 alone the number of plastic water bottles sold in India was estimated at six billion.[70]

Yet research in the United States has shown that 25 to 40 percent of bottled water is tap water. Moreover, a 2008 study of ten brands revealed a wide range of pollutants, including not only disinfection by-products, but also common urban wastewater pollutants like caffeine and pharmaceuticals, arsenic and radioactive isotopes, fertilizer residue, and industrial chemicals used as solvents, viscosity decreasing agents, and propellants.[71]

Bottled water is a fraud or an expensive convenience, and this privatization of water undermines support for public access.[72] Selling bottled water raises India's GNP and thus counts as economic development, but the main beneficiaries are those able to invest in the water-bottling industry.

Using plastic to bottle water adds nothing to water quality and adds energy costs to making water available. Marketing bottled water has also increased the global debris of plastic now covering about 40 percent of the surface of the oceans, which threatens these ecosystems.[73]

"[T]he plastic polymers commonly used in consumer products, even as single molecules of plastic, are indigestible by any known organism. Even those single molecules must be further degraded by sunlight or slow oxidative breakdown before their constituents can be recycled in the building blocks of life. There is no data on how long such recycling takes in the oceans—some ecologists have made estimates of five hundred years or more. Even more ominously, no one knows the ultimate consequences of the worldwide dispersion of plastic fragments that can concentrate the toxic chemicals already present in the world's oceans."[74]

In 2011 the Gateway Authority, a coalition of sixteen cities and several public water agencies in southeastern Los Angeles County, began to install thousands of trash screens at nearly every storm drain where the Los Angeles River runs into the Pacific Ocean. It is estimated that this system will prevent about 840,000 pounds of debris each year from entering the sea.[75]

Even more important than clearing the debris from rivers, however, is keeping it from being discarded in the environment. The short-term costs of producing bottled water are unnecessary,[76] and the long-term costs of removing the plastic debris from the environment are enormous. To prevent this pollution, corporations producing bottled water (or other plastic containers) should be required by law to implement recycling programs that meet a high standard of compliance and to invest in the development of plastic that will degrade and be recycled by nature within a reasonable period of time.

Restoring Ecosystems

I have argued that the likely long-term consequences of restoring and maintaining the earth's air and water ecosystems do not give us reason to set aside these ethical duties, but instead confirm them. At least, I suggest, the following three ethical presumptions meet this test:

Prevention is best. Preventing air and water pollution requires emphasizing point source intervention. Strategies that tax actions that are "bad" for the environment and provide incentives for actions that are "good" will likely have the best results.

Polluters should pay. Applying this presumption to every industry ensures competition among companies to reduce their "pollution tax" by reducing their pollution and allows businesses to pass on to consumers (in the price of each product) the costs of minimizing pollution and cleaning up the environment.

Better safe than sorry. This version of the precautionary principle rejects the permissible pollution approach, which puts the burden of proof on governments to show that chemicals are unsafe. Just as we expect pharmaceutical drugs and our food to be safe, we should also expect that manufactured products will not harm the integrity of the earth's ecosystem or our health. Therefore, we should support laws that make producers liable for the safety of their products. Also, we should support the taxes that are necessary to ensure our water treatment systems use the best available technology to purify drinking water.

NOTES

1. Editorial, "Parks in Peril," *New York Times,* March 24, 2008, http://www.nytimes.com/2008/03/24/opinion/24mon1.html.

2. Ibid. In 2008, under the Bush administration, "the antiregulatory brigade in the Office of Management and Budget killed ozone standards that would have offered stronger protections for plants, trees, crops and wildlife."

3. Kenneth M. Vigil, *Clean Water: An Introduction to Water Quality and Water Pollution Control,* 128.

4. See Michael Milstein, “Unleaded Gas Helps Create an Unleaded Columbia Gorge,” *The Oregonian,* October 15, 2007. “In the 1990s, scientists found unusually high levels of lead in rock-dwelling lichens, which are used as barometers of air quality in the gorge because they soak up whatever pollution drifts by. But the United States removed lead from gasoline starting about two decades ago. That has paid off for the gorge: In new analyses, scientists have found that lead has nearly disappeared from gorge lichens.”

5. John Heilprin, “EPA May Drop Lead Air Pollution Limits,” *News Center,* December 7, 2006, http://www.commondreams.org/headlines06/1207–01.htm.

6. Anna Gorman, “Unsafe Levels of Lead Still Found in California Youths,” *Los Angeles Times*, February 19, 2012, http://www.latimes.com/news/local/la-me-lead-poisoning-20120219,0,738166.story.

7. Anthony Watts, “Solar’s Lead Balloon of Pollution in Developing Countries” (August 31, 2011), http://wattsupwiththat.com/2011/08/31/solars-lead-balloon-of-pollution-in-developing-countries/.

8. “Smog,” http://en.wikipedia.org/wiki/Smog.

9. “Catalytic Converter,” http://en.wikipedia.org/wiki/Catalytic_converter.

10. J. S. Kidd and Renee A. Kidd, *Air Pollution: Problems and Solutions,* 71.

11. H. Josef Hebert, “EPA Advisors Slam New Smog Rule,” *USA Today,* April 10, 2008, http://www.usatoday.com/news/washington/2008–04–10–2804644109_x.htm. See Bob Egelko, “Judge Orders EPA to Hurry on Carbon Monoxide,” *San Francisco Chronicle,* May 7, 2008, A-2, http://articles.sfgate.com/2008–05–08/news/17152142_1_carbon-monoxide-environmental-protection-agency-federal-agency.

12. “[S]cent-bearing hydrocarbon molecules released by flowers can be destroyed when they come into contact with ozone and other pollutants.” Juliet Eilperin, “Air Pollution Impedes Bees’ Ability to Find Flowers,” *Washington Post,* May 5, 2008, A03, http://www.washingtonpost.com/wp-dyn/content/article/2008/05/04/AR2008050401737.html. See also Juliet Eilperin, “Ozone Rules Weakened at Bush’s Request,” *Washington Post,* March 14, 2008, A01, http://www.washingtonpost.com/wp-dyn/content/article/2008/03/13/AR2008031304175.html.

13. “US EPA: Clean Air Act Saved 160,000 lives in 2010,” *Environment News Service* (March 2011), http://www.ens-newswire.com/ens/mar2011/2011–03–02–01.html.

14. “China Air Quality Standards: Two-Thirds Of Cities Failing,” *Huffington Post*, March 3, 2012, http://www.huffingtonpost.com/2012/03/02/china-air-quality-standards_n_1315874.html.

15. “Air Quality and Health,” World Health Organization, http://www.who.int/mediacentre/factsheets/fs313/en/index.html.

16. United Nations Economic Commission for Europe, http://www.unece.org/env/lrtap.

17. See Bernie Woodall, “Texas Leads List of Dirtiest US Power Plants,” *Reuters,* July 26, 2007, http://www.reuters.com/article/scienceNews/idUSN2645126520070726.

18. “Clean Air Act,” Foundation for Clean Air Progress, http://www.sourcewatch.org/index.php?title=Clean_Air_Act.

19. J. S. Kidd and Renee A. Kidd, *Air Pollution,* 83.

20. Jon Hurdle, “Eastern Democrats Defend Cross-State Power Plant Emissions Rule,” *AOL Energy,* November 11, 2011, *http://energy.aol.com/2011/11/08/eastern-democrats-defend-cross-state-power-plant-emissions-rule/*. See Bill Lambrecht, “Debate Opens in US Senate on Curbing Power Plant Pollution,” *stltoday.com,* November 10, 2011, http://www.stltoday.com/news/local/govt-and-politics/political-fix/debate-opens-in-u-s-senate-on-curbing-power-plant/article_77edba10–0bb9–11e1-ab9a-0019bb30f31a.html.

21. Bill Chameides, “Toxic Emissions: New Boiler Rule Coming to a Boil,” *The Green Grok,* December 9, 2011, *http://www.nicholas.duke.edu/thegreengrok/MACT-122011*. The bill passed by the House of Representatives at the end of December 2011, which refused to endorse the Senate bill on extending the payroll tax for another two months, blocks enforcement of the EPA rule on industrial boiler pollution. See

“Comparison of House, Senate Payroll Tax Cut Bills,” *Washington Post,* December 19, 2011, http://www.washingtonpost.com/national/comparison-of-house-senate-payroll-tax-cut-bills/2011/12/19/gIQA9QSw3O_story.html.

22. Kevin Drum, “President Obama’s Christmas Present to America,” *Mother Jones,* December 23, 2011, http://motherjones.com/kevin-drum/2011/12/president-obamas-christmas-present-america. The EPA standards will apply to about six hundred power plants.

23. Kidd and Kidd, *Air Pollution*, 92.

24. “Phase Out of HCFCs (Class II Ozone-Depleting Substances),” Environmental Protection Agency, http://www.epa.gov/ozone/title6/phaseout/classtwo.html.

25. Reiner Grundmann, “The Strange Success of the Montreal Protocol,” *International Environmental Affairs* 10, no. 3 (1998): 197, in James Gustave Speth, *Red Sky at Morning,* 182.

26. “Press Release No. 912,” World Meteorological Organization (April 5, 2011), http://www.wmo.int/pages/mediacentre/press_releases/pr_912_en.html.

27. The substitutes for the chlorofluorocarbons (CFCs) prohibited by the Montreal Protocol, which are called HCFCs (hydrochlorofluorocarbons), are now known to be “stronger greenhouse gases than carbon dioxide,” so there is an urgent need to develop replacements for HCFCs that “are not toxic, do not deplete the stratospheric ozone layer, and do not contribute to global warming.” Kidd and Kidd, *Air Pollution,* 117.

28. “Earth has just the right amount [of GHGs] to help life flourish. Too many of these gases, as is the case on Venus, would create a runaway greenhouse and a sizzling hot surface. On the other hand, without any greenhouse gases, much of the sun’s heat would be lost, and the Earth would become a frozen wasteland.” “Greenhouse—Green Planet,” *NOVA* (1997), http://www.pbs.org/wgbh/nova/ice/greenhouse.html.

29. Thomas R. Karl and Kevin E. Trenberth, “Modern Global Climate Change,” in Donald Kennedy, ed., *Science Magazine’s the State of the Planet: 2006–2007*, 89.

30. Speth, *Red Sky at Morning,* 16.

31. Federal Water Pollution Control Act, as amended November 27, 2002, Section 101(a), in Joseph Orlins and Anner Wehrly, “The Quest for Clean Water,” in Calhoun, ed., *Water Pollution*, 4.

32. Ibid., 35.

33. Restoration of waterways is difficult. See Cornelia Dean, “Follow the Silt,” *New York Times,* June 24, 2008, http://www.nytimes.com/2008/06/24/science/24stream.

34. Kenneth M. Vigil, *Clean Water,* 16.

35. “In 1977, as a result of pressure from industry, the focus in the United States shifted from control-point discharge regulation to water quality standards. Tacitly, this shift marked a move away from pollution as a violation to pollution as permissible.” Vandana Shiva, *Water Wars,* 32.

36. Under the Bush administration these EPA rules were poorly enforced. Zachery Coile, “Pollution Pouring into Nation’s Waters Far beyond Legal Limits,” *San Francisco Chronicle,* October 12, 2007, A-1, http://sfgate.com/cgi-bin/article.cgi?f=/c/a/2007/10/12/MNIPSOF76.DTL.

37. Vigil, *Clean Water,* 61–62. Effective recycling requires products designed for recycling. William McDonough and Michael Braungart, *Cradle to Cradle,* 56–58.

38. Heavy rain and runoff may increase point source pollution. See Peter Fimrite, “Rain Brings Sewage into San Francisco Bay,” *San Francisco Chronicle,* February 26, 2008, http://sfgate.com/cgi-bin/article.cgi?f=/c/a/2008/02/26/BA6UV906K.DTL.

39. Elena Bennett and Steve Carpenter, “P Soup: The Global Phosphorus Cycle,” in Calhoun, *Water Pollution,* 47.

40. Ibid., 48.

41. Natural storm water management is cost effective. James J. Kay, "On Complexity Theory, Exergy, and Industrial Ecology," in Charles J. Kibert, Jan Sendzimir, and G. Bradley Guy, eds. *Construction Ecology,* 95.

42. "Fifty-year-old levees blew up in a dramatic display of dirt and smoke Tuesday, freeing lake water as part of an unprecedented wetlands restoration effort to save protected fish and cool the water wars that have divided the Klamath Basin for decades." Gail Kinsey Hill, "Levee Blast Signals a Truce in Water Wars," *The Oregonian,* October 31, 2007, http://www.klamathforestalliance.org/Newsarticles/newsarticle20071031.html.

43. This will require legislation with incentives and disincentives for producers to design products that are not harmful to the environment. McDonough and Braungart, *Cradle to Cradle,* 146–147.

44. Payla Sampat, "Groundwater Shock," in Calhoun, *Water Pollution,* 66.

45. Ibid., 68.

46. Kenneth M. Vigil, *Clean Water,* 125.

47. Payla Sampat, "Groundwater Shock," in Calhoun, *Water Pollution,* 73.

48. Ibid.

49. Kennedy, *Science Magazine's State of the Planet,* 64.

50. Speth, *Red Sky at Morning,* 16. In general, "When water use falls below 1,700 cubic meters per person per year, a country encounters water stress through lack of adequate supply. When water use falls below 1,000 cubic meters, there is water scarcity, meaning a significant and often severe restriction on material welfare at the individual level and on development prospects at the national level." Norman Myers and Jennifer Kent, *Perverse Subsidies,* 122.

51. This is why the Middle East as a whole imports 30 percent of its grain. Myers and Kent, *Perverse Subsidies,* 122. "As food prices escalate and water scarcity extends worldwide, the best solution to both issues would be a global reduction in wasted food." Ben Block, "Conserve Water through Food Efficiency, Report Says," Worldwatch Institute, http://www.worldwatch.org/node/5751.

52. Shiva, *Water Wars,* 12.

53. Ibid., 12.

54. James Flanigan, "Keeping the Water Pure Is Suddenly in Demand," *New York Times,* June 19, 2008, http://www.nytimes.com/2008/06/19/business/smallbusiness/19edge.html.

55. Patrick J. Sullivan, Franklin J. Agardy, and James J. J. Clark, *The Environmental Science of Drinking Water*, 74.

56. Ibid., 66, 166. See also Gigi Stone, "Drug Traces Found in Tap Water," *ABC News,* October 15, 2008, http://abcnews.go.com/Health/story?id=6040196&page=1#.Ts6Fw_IgBqA.

57. Douglas McIntyre, "10 U.S. Cities with the Worst Drinking Water," *Daily Finance,* February 3, 2011, http://www.msnbc.msn.com/id/41354370/ns/business-going_green/t/us-cities-worst-drinking-water/#.Ts6GVPIgBqA.

58. Sullivan, Agardy, and Clark, *The Environmental Science of Drinking Water*, 81.

59. "Drinking Water Contaminants," EPA, http://water.epa.gov/drink/contaminants/index.cfm#List.

60. Sullivan, Agardy, and Clark, *The Environmental Science of Drinking Water,* 96. Carcinogens are substances known to cause cancer.

61. Ibid. Generally chlorine is added to water being distributed to combat microbes in the pipes of the system.

62. Procter & Gamble, for instance. See http://www.pg.com/company/our_commitment/environment.jhtml.

63. Sullivan, Agardy, and Clark, *The Environmental Science of Drinking Water,* 218.

64. Federal Water Pollution Control Act, as amended November 27, 2002, Section 101(a).

65. James J. Kay, “On Complexity Theory, Exergy, and Industrial Ecology,” in Kibert, Sendzimir, and Guy, eds., *Construction Ecology*, 95.

66. Committee on Economic, Social and Cultural Rights, “The Right to the Highest Attainable Standard of Health,” General Comment No. 14, E/C.12/2000/4 (August 11, 2000), 43.c, http://www.unhchr.ch/tbs/doc.nsf/(symbol)/E.C.12.2000.4.En?OpenDocument. See also Rebecca Brown, “South African Win Landmark Victory for the Human Right to Water,” Unitarian Universalist Service Committee, http://www.uusc.org/category/blog_subject/south_africa .

67. Shiva, *Water Wars,* 7.

68. Ibid., 10.

69. By putting “a national cap on greenhouse gas emissions and running a national auction for emissions permits under the cap, the federal government could [probably] accrue tens of billions [of dollars] annually,” which might be better than simply a cap-and-trade program. “When Europe first tried regulating greenhouse gases under a cap-and-trade program, in 2005, it gave away, or ‘grandfathered,’ emissions permits to its power generators, which made modest changes in their operations and then sold the permits to others at a premium. The result: windfall profits for the power companies. Europe is now switching to emissions auctions and plans to finance programs promoting climate protection, economic growth and energy security with the proceeds.” Ian Bowlers, “Want to Buy Some Pollution?” *New York Times,* March 15, 2008, http://www.nytimes.com/2008/03/15/opinion/15bowles.html.

70. Shiva, *Water Wars,* 100–101. See “Bottled Water Industry in India,” http://www.gits4u.com/water/water16.htm.

71. “Bottled Water Contains Disinfection Byproducts, Fertilizer Residue, and Pain Medication,” Environmental Working Group, http://www.ewg.org/reports/BottledWater/Bottled-Water-Quality-Investigation.

72. “According to the Washington, D.C.–based Earth Policy Institute, consumers spend about $100 billion on bottled water each year. By comparison, experts estimate that just $15 billion per year, above and beyond what is already spent, could bring reliable and lasting access to safe drinking water to half a billion people worldwide—fully half of those who lack it.” Aaron Glanz, “Coke Faces New Charges in India, Including ‘Greenwashing’,” *Common Dreams,* June 7, 2007, http://www.commondreams.org/archive/2007/06/07/1727.

73. In the Pacific, this stew of floating garbage is about 1,000 miles from San Francisco. Justin Berton, “Feds Want to Survey, Possibly Clean Up Vast Garbage Pit in Pacific,” *San Francisco Chronicle,* October 21, 2007, A-1, http://www.sfgate.com/cgi-bin/article.cgi?file=/c/a/2007/10/30/MNT5T1NER.DTL.

74. Charles Moor, “Trashed: Across the Pacific Oceans, Plastics, Plastics Everywhere,” *Water Pollution,* in Yael Calhoun, ed., *Water Pollution*? 151.

75. “Tons of L.A. River Trash to Be Captured Before Hitting the Sea,” *Greenspace,* November 1, 2011, http://latimesblogs.latimes.com/greenspace/2011/11/la-river-trash-project-completed-tons-to-be-captured-before-hitting-the-sea.html.

76. It takes 1.5 million barrels of oil per year to create enough PET plastic to make the bottles. “The Real Cost of Bottled Water,” *WWF News,* May 3, 2001. “In 2006, more than 900,000 tons of plastic was used to package 8 billion gallons of bottled water. Production of this plastic leads to the release of a variety of chemicals. Most smaller bottles are made from polyethylene terephthalate (PET), which generates more than 100 times more toxic emissions than an equivalent amount of glass (Berkeley Ecology Center).” “Bottled Water,” The Sierra Club, http://www.sierraclub.org/committees/cac/water/bottled_water/bottled_water.pdf.