Ten Stresses on the Planet

Center for Earth Leadership
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The Center for Earth Leadership is a non-profit organization that trains and motivates Northwest citizens to assume a leadership role in forging a sustainable culture. This work is funded by contributions from interested individuals. See www.earthleaders.org for more information.

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This booklet may be purchased in quantities of ten or more.

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Introduction

This booklet was prepared by the Center for Earth Leadership as a resource for citizens who wish to be informed on ecological degradation—a primary context of our time. In our work at the Center, an understanding of the current state of our ecosystems allows us to make better choices in our program development and outreach work.

Needless to say, knowledge about what is happening to the earth can be distressing. Therefore the Center has written a companion piece, "Personal Practices to Save Ecosystems," which presents individual actions that can ameliorate the stresses. The Center has used its knowledge to prioritize the practices, recognizing that most of us seek to take incremental steps on the journey to a sustainable future.

According to the 2005 Millennium Ecosystem Assessment, human activity has damaged two-thirds of nature’s systems that support life. It concluded, “Human activity is putting such a strain on the natural functions of Earth that the ability of the planet’s ecosystems to sustain future generations can no longer be taken for granted.”¹ In fact, humans began consuming beyond the natural regenerative capacity of the earth around 1980 and are now exceeding that capacity by about 20 percent.²

Jane Lubchenco, a pre-eminent scientist at Oregon State University, puts it this way:

*The point here is not “oh, we’re terrible” but simply that we need to wake up, be aware of the inadvertent consequences of our activities, and modify our individual and collective actions if we don’t like the current trajectory. Humanity is now changing the planet at faster rates, over broader scales, and in fundamentally new ways than ever before. Now is a very different time than any other time in the history of humans on earth.*³

In our everyday lives we constantly make decisions that affect the planet—personal lifestyle choices, decisions about spending money, the content of our conversations, and political actions. Information about the consequences of our actions on the planet allows us to make better decisions.

For this reason the Center for Earth Leadership has prepared a series of fact sheets, which together portray the major stresses on the planet. Jeanne Roy, Education Director of the Center, conducted the research in 2006. Some of the fact sheets were revised again in 2008.

The Center for Earth Leadership was founded in 2006 by Jeanne and Dick Roy. The goal of the Center is to encourage concerned citizens to be leaders to a sustainable future. It offers classes and workshops, creates projects managed by teams of volunteers, and organizes events.

¹ *Guardian Weekly*, April 2005
² Hayes, Denis presentation (study by Mathis Wackernagel in *Proceedings of National Academy of Sciences*, 2002)
1. Degradation of the Oceans

Destructive fishing practices in combination with over fishing, toxic runoff from the land, and warming of the ocean are rapidly degrading marine ecosystems. Twenty-nine percent of all marine species caught for human consumption have collapsed. Marine animals are killed by the millions each year as unintended by-products of industrial fishing. Excess nitrogen is causing dead zones, and coral reefs are disappearing. This degradation is often overlooked due to the vast expanse of oceanic waters.

DESTRUCTIVE FISHING METHODS

Industrial fishing has impacts on the ocean analogous to clear cutting of forests on the land. We just don’t see them. The common practice of bottom trawling, where huge weighted nets are dragged across the ocean floor, is an indiscriminate fishing method that catches everything in its path and destroys structurally complex habitats. Another widely used method is surface long-lining. A boat sets a monofilament line up to 60 miles long to support vertical lines dangling at different depths. The lines hold up to 10,000 baited hooks intended to catch primarily tuna and swordfish. In fact, an estimated 40,000 sea turtles and millions of sharks are killed annually as well. Even the massive albatross, some species of which are critically endangered, is hooked on these lines as it dives for baited hooks or hooked fish. A third technique is drift netting where almost invisible nylon nets are set, sometimes as much as 1,600 feet below the surface, and left unattended. In stormy seas they may get lost but continue to ensnare marine life. For every four pounds of fish caught, one pound of by-catch (unwanted species) is dumped overboard.

OVERFISHING

In 2000 the total wild fish catch, which grew 500 percent between 1940 and 1997, peaked despite better technology and intensified efforts by fishermen. In some areas the catch is less than one percent of what it was before industrial fishing. Large fish, such as tuna, halibut, and cod, have been hit particularly hard. In the last 50 years, industrial fleets have fished out 90 percent of the ocean’s large fish. The few blue marlin still in the ocean reach only one-fifth the weight they once reached. According to the Millennium Ecosystem Assessment, fisheries cannot sustain current demand, which is projected to increase.

As many of the world’s important commercial fish populations have collapsed, fish farms have stepped in to fill the void. Farming of plant-eating fish, such as tilapia, in fresh water can be done without harm to the environment, but both salmon and shrimp farming have created problems. Off both coasts of North America, salmon are farmed in pens. Because salmon are carnivorous, millions of tons of small fish like herring, sardines, and anchovies are ground up and made into fish meal for them, hastening the collapse of fish stocks in the lower half of the food chain. It can take three pounds of fish meal to yield one pound of salmon. Other environmental effects of coastal fish farming are the transmission of diseases to wild fish and the feces and uneaten food wastes which are dispersed into the water. A single farm of 200,000 fish can produce as much waste as a city of 62,000 people.

Rapidly expanding shrimp farming in Southeast Asia, India, and parts of South and Central America poses one of the gravest threats to mangroves, which are often clear cut to make way for farms. Mangroves are salt-tolerant trees and shrubs with stilt-like roots that form dense
thickets along tidal shores of tropical and subtropical coastlines. These ecosystems filter water, control sediments, prevent flooding, and provide food and fiber to indigenous people. They also serve as a buffer for strong winds and waves produced by cyclones. When they are removed, the coastline is subject to rapid erosion. More than 50 percent of the world’s mangroves have already been lost.¹²

**Pollution**

Some 80 percent of pollution in the ocean is runoff from agricultural, industrial, and urban activities. One of the most serious problems in coastal waters is excess nitrogen. As humans have converted fossil fuels to our own uses like burning them for fuel and making billions of pounds of synthetic fertilizers, we have more than doubled the amount of fixed nitrogen in the biosphere.¹³ When farmers apply synthetic fertilizer, not all of the nitrogen is used by the intended plants, and the excess flows into rivers. The emissions from power plants eventually fall to the land and waters. Other sources of nitrogen include outflows from sewage treatment plants and manure from industrial feedlots.

Excess nitrogen is one cause of dead zones in coastal waters. The Gulf of Mexico, once one of the world’s most biologically prolific bodies of water, is now one of the most polluted. In addition to nitrogen, massive quantities of phosphorus and other nutrients flow down the Mississippi creating a dead zone the size of New Jersey in the Gulf. Algae, feeding on the nutrients, bloom, and when they die, the decomposing bacteria use up all the oxygen.¹⁴ Some of the blooms, called “red tides” or “brown tides,” also produce biological toxins. The lack of oxygen and toxins result in mass fish kills every summer.¹⁵ Scientists have found 200 dead zones in the world's oceans; the largest permanent one—more than three times the size of the one in the Gulf—is in the Baltic Sea.

Pesticides, heavy metals, and industrial chemicals are also found in runoff. Ten tons of mercury flow down the Mississippi annually. The Food and Drug Administration has found pesticide residues in 73 percent of seafood samples from U.S. fishing waters. High rates of tumors in fish have been found in Quincy Bay, Massachusetts, Chesapeake Bay, and Puget Sound.¹⁶ Oysters, especially vulnerable to contamination from heavy metals, are almost gone on the Atlantic coast of the US.¹⁷

Shipping is another source of pollution. Every year the Army Corps of Engineers dredges some 500 to 700 million cubic yards of material from harbors and channels and deposits them in the ocean. Some are highly contaminated with pesticides, heavy metals, PCBs, and oil. The infamous Exxon Valdez oil spill in Alaska spewed 11 million gallons (40,700 tons) of crude oil into the marine environment and killed at least 100,000 sea birds and 1000 sea otters.¹⁸ Mussel beds may take 30 years to recover from the spill.¹⁹ Since that time, even larger spills have occurred. The Braer ran aground on Shetland Island, UK, in 1993, losing 77,000 tons of heavy bunker oil. Millions of salmon had to be destroyed, and mussel and lobster fishing are still excluded. In 1996 the Sea Empress grounded off Wales and released almost 66,000 tons of heavy fuel oil. In 2002 the Prestige suffered damage in heavy seas off Spain and lost 57,400 tons of fuel oil.²⁰
Cutting plastic six-pack holders so they don’t ensnare wildlife is common practice in many American households, but plastic takes many forms (raw pellets used in manufacturing, fish nets and Styrofoam are a few examples) and causes a wide range of threats to wildlife. An estimated 100,000 mammals and thousands of birds die annually from ingesting or becoming entangled in plastic. Dead birds have been found with plastic toys, bottle caps, and toothbrushes in their stomachs. Sea turtles often mistake plastic bags for jellyfish. When ingested, the bags block their stomach openings. Over time plastic breaks down into “dust.” A Seattle oceanographer says that one pound of plastic turns into 100,000 small pieces resembling zooplankton. In an area of the western Pacific Ocean, he found six times more plastic than zooplankton. It is eaten by jellyfish, which are eaten by fish, which in turn are eaten by larger consumers. The plastic “dust” cannot be digested, thereby affecting the health of the whole food chain.

WARMING AND EXCESS CARBON DIOXIDE

In recent years a great deal of attention has been focused on coral reefs for two reasons; (1) they shelter or nourish up to 9 million species—a third of all marine life forms, and (2) they are particularly sensitive to changes in their environment (light, temperature, salinity, and nutrients). A coral is an animal that secretes limestone for its exoskeleton and lives in colonies, forming large reefs that that help protect coastlines. It lives in symbiotic relationship with a type of algae that provides it with the bulk of its food and gives a reef its golden, red, and yellow hues.

According to the Millennium Ecosystem Assessment, 20 percent of coral reefs have been destroyed and another 20 percent degraded. One of the causes of this die-off is sediment and pollution runoff from cleared land. However the 2005 Status of the Coral Reefs of the World warns that global warming is the single greatest threat to corals. When the temperature of the water heats up, the corals become stressed and spit out the algae in a phenomenon called “bleaching.” The corals become weak and quit reproducing. Sometimes they bounce back, but if the stress is repeated or is too great, as in the El Niño of 1997, they die.

Oceans absorb about a third of the carbon emitted by humans, raising the acid level of the sea. The current rate of carbon input is 50 times higher than normal, and in less than 100 years the pH of the oceans could drop from 8.2 to 7.7, marking a huge change in ocean chemistry. The acid causes the shells and skeletons of marine organisms, such as corals, clams, and plankton, to dissolve. When smaller creatures disappear, the salmon, cod, and baleen whales that feed on them also will be threatened.

Many of the plants, animals, and microbes around and inside the reefs may vanish before they are even identified, similar to the extinction of species in rain forests. Ken Caldeira of the Carnegie Institution’s global ecology department says that coral reefs could disappear within two decades along with hundreds of other species. Some scientists say the consequences could be even greater than for extinctions on land because of the enormous biological wealth and diversity in the oceans. The oceans contain many more major groups of animals that have undergone separate evolution for hundreds of millions of years.

WHAT IS BEING DONE?

Two promising methods of restoring fisheries and protecting threatened species are gaining favor: individual transferable quotas and marine protected areas. For example, in Alaska,
sablefish and halibut are regulated by individual fishing quotas. Each fishing boat gets a permit for a share of the total allowable catch. When this system was introduced in the Gulf of Mexico, unintentional by-catch dropped by 80 percent, and red snapper began coming back because fishermen were no longer in a race to catch as many fish as possible.\textsuperscript{33}

Marine sanctuaries restrict certain activities within a specified area so that wildlife populations have a chance to recover. Most of the 13 sanctuaries in the US, administered by the National Oceanic and Atmospheric Administration, are small, but in 2006 President Bush designated a 140,000-square-mile area around the northern Hawaiian Islands as a national monument. Fishing in that area will be phased out within five years.\textsuperscript{34} In 2007, local management commissions have designated preserves along the coasts of California and the South Atlantic between North Carolina and Florida.
2. Land Conversion

*Humans are destroying ecosystems as we convert complex forests and grasslands into monocultures, fill wetlands, extract metals, and pave the land for roads or buildings. Globally, appropriation of forest lands is one of the most serious conversions. Eight thousand years ago our planet had 15 billion acres of forest; today close to half of it is gone, and the rate of destruction is increasing.*

**Forest Land**

In his book *Collapse*, Jared Diamond cites deforestation as a factor in the collapse of many civilizations. The Mayan civilization, for example, was a complex and highly organized society with vast cities by 700 B.C. but had collapsed by 900 A.D., in large part because of forest destruction. As a recent example, Diamond describes population pressure leading to deforestation and soil fertility losses in Rwanda, as factors in the 1990s genocide there.

**Tropical Rain Forests**

Large expanses of broad-leaved evergreen woodlands near the equator where at least 100 inches of rain fall each year significantly impact planetary climate, the hydrological cycle, soil, and biodiversity. Scientists call these forests the "lungs of the planet" because of the vast amounts of carbon dioxide they absorb and oxygen they release. Tropical forests serve as reservoirs for two-thirds of available fresh water on Earth; more water is stored in forests than in lakes. Forest vegetation holds soil in place. One-fifth of Indonesia’s soil has eroded since the country logged its rain forests. Forest loss also means loss of the rich diversity of plant and animal life as well as diverse indigenous human tribes. (See "Loss of Biodiversity.")

Fifty years ago tropical forests covered 12 percent of Earth’s land area. Now they cover less than six percent. Between 2000 and 2005, the worst deforestation rate occurred in Nigeria, which could lose its primary forests within a few years.

Logging is responsible for at least 25 percent of rainforest destruction. The US is the third largest importer of tropical woods such as teak, mahogany, rosewood, ebony, lauan, and ramin. Rain forests are also cleared to grow crops for export, such as bananas, coca, citrus fruits, coffee, and soybeans, often to pay international debts. About 80 percent of tree-cover loss in Haiti, for example, was for coffee production. In four decades, 40 percent of all the rain forests in Central America have been cleared or burned, mostly for cattle pasture used to produce fast-food hamburgers, hot dogs, and pet food for export.

Because the fragile soils underlying tropical rain forests cannot support continuous cropping or grazing, farms are generally abandoned after a few years, and new land is opened. Even small clearings surrounded by undisturbed forest can take 100 years to regenerate. Tropical forests cleared by mechanized logging can take up to 1000 years to regenerate, if conditions allow it at all. When the bulk of large forest areas is removed, as is happening in Brazil’s Amazon Basin, resultant climate change (lack of rain) can essentially prevent regeneration. In this respect the forest cannot be considered a renewable resource.

**Temperate Forests**

Temperate old-growth forests, which lie above or below tropical forests in latitude, are complex mature forest ecosystems with trees of multiple ages, dead trees, and fallen logs. They are very
unlike tree plantations, where trees of the same age and type are typically cut in 40-80 year cycles. Whereas tropical rain forests retain about 95 percent of nutrients in vegetation, temperate forests retain 95 percent in the soil. This is where the bulk of life is found. Scientists estimated that 8000 species of underground arthropods inhabit one study site in Oregon. They believe that these sowbugs, centipedes, ants, beetles, and mites recycle tons of litter and debris that fall to the forest floor. Chris Maser, a researcher, says, “A tree that’s fallen and has been on the forest floor for 100-150 years is twice as alive as when it died.” Other creatures too, such as flying squirrels and birds, find their homes in dead snags.6

Plant and animal life are highly interdependent in Pacific Northwest conifer forests. Fungi wrap around the tips of tree roots, passing water and nutrients to them. In return, trees send carbohydrates (from photosynthesis) back down to the roots, nourishing the fungi. Foresters have found that conifer seedlings don’t thrive when planted in locations where fungi aren’t naturally found.7 Fungi also depend on red-backed voles, deer mice, and flying squirrels, which eat them, to disperse their spores to other parts of the forest. These small mammals, in turn, are food for the marten, cougar, and owl.8

Temperate old-growth forests are cut for lumber and for paper pulp used for newspapers, phone books, toilet paper, paper towels, and disposable diapers. Since over 90 percent of Oregon and Washington’s old-growth forests have already been cut, lumber companies have increased operations in British Columbia and Alaska.

**Crop and Grazing Land**

Farming and grazing benefit the land by keeping it vegetated, but they also destroy habitat for wildlife. The great grasslands, which covered 40 percent of the present US when Europeans arrived, have declined to one percent.9 Overgrazing of grasslands allows annual weeds and tough shrubs to replace native perennial grasses that once anchored the soil. Cattle trample down bare ground, allowing rainwater to carry off the topsoil. The earth’s dry rangeland is losing its ability to support plants and animals. According to water-resources consultant Jim Myron, livestock grazing has been responsible for the loss of more native plants and animals than any other human activity in the Western United States.10

Industrial agriculture also results in soil erosion, loss of fertility, appropriation of fresh water, nutrient runoff into streams, and pesticide contamination. These impacts are covered in other sections. (See "Loss of Topsoil," "Loss of Fresh Water," and "Toxic Chemicals.")

**Wetlands**

Wetlands, which include swamps, marshes, bogs, and pools, act as natural water-purification systems. Sediments and pollutants in water passing through their marsh grasses, cattails, and sedges are filtered out. Wetlands buffer shorelands from hurricanes and provide significant erosion control by retaining sediments. They allow surface water to seep into the ground and replenish ground water. By absorbing water during heavy rainfall, they protect against flooding. Wetlands are among the most biologically productive areas on the planet, harboring more species and biomass per acre than other ecosystems.11 For instance, the Prairie Pothole Region of the US is thought to provide breeding grounds for 50-75 percent of the ducks born on the continent.12 About one-half of the fishes, two-thirds of the birds, and three-fourths of the amphibians listed as threatened or endangered in the US are associated with wetlands.13
Where wetlands have been drained, such as along the Mississippi River, heavy rains rush into the river, widening the channels through erosion, and floods are more frequent and severe. \(^\text{14}\) Between the 1780s and the 1980s, the lower US sacrificed 53 percent of its wetlands to other uses. California lost the largest percentage at 91, and Florida lost the most acreage. \(^\text{15}\) The rate has slowed, but the US continues to convert our wetlands at a rate of 70,000-90,000 acres a year. \(^\text{16}\) (For coastal wetlands, see "Degradation of the Oceans."

**MINING LANDS**

Large metal and coal open pit mines permanently scar landscapes and leave behind acid mine drainage. Mining companies often go bankrupt and fail to restore sites to even minimum requirements. The Butte copper mine in Montana, for example, leveled mountains and created a 2,200 foot deep pit. The pit water, containing dissolved heavy metals, is so acidic that it kills birds that drink it. \(^\text{17}\) Some of the world’s largest copper mines in Papua, New Guinea create hundreds of thousands of tons of rock waste and tailings daily. The tailings spill down the river valleys and across valley floors destroying large areas of rainforest and killing fish. Some descend as far as the coastline wetlands and estuaries.

In heap-leach gold mining, operators extract huge quantities of ore and pour cyanide over it to leach out the gold. Thirty tons of low-grade ore are required to produce one ounce of gold. \(^\text{18}\) Cyanide is extremely poisonous: one teaspoon can kill a person. In Montana millions of tons of cyanide were released into the soil and water before citizens banned heap-leach mining by initiative. \(^\text{19}\)

In the 1970s, strip mining of coal spread across Appalachia, leaving some soils that are too acidic to be productive. \(^\text{20}\) Now operators are using mountain-top mining to retrieve underground seams of low-sulfur coal. In one of North America's most biological diverse ecosystems, entire mountain tops are dynamited away and pushed into nearby streams. Some of the valley fills are hundreds of feet deep and several miles long. \(^\text{21}\) More earth is moved in these operations than for any other human activity. \(^\text{22}\)

Mine production of sand, gravel, and stone for use in roads and concrete construction exceeds production of all other types of mining. \(^\text{23}\) Mining sand and gravel along rivers damages riparian habitat and consumes large areas of prime farm soils, permanently removing them from agricultural production. A better alternative source for construction rock is quarrying of stone from upland areas, where farmland is poor and streams are not nearby.

**WHAT IS BEING DONE?**

Around the globe, land is being preserved by setting it aside as parks, wilderness, or protected areas. For example, as a result of lobbying by nongovernmental organizations (NGOs) such as Greenpeace, Rainforest Action Network, Sierra Club, and ForestEthics, Canada announced in 2006 a protection plan for the five-million-acre Great Bear Rainforest. Logging will be banned in the protected area, and in another ten million acres, logging practices are to be sustainable. In developing countries large NGOs, such as the World Wildlife Fund and the Nature Conservancy, have had some success purchasing conservation concessions (leases granted by governments for specific purposes). In other cases, NGOs or land trusts acquire land or conservation easements from private parties.
In the US, environmental organizations have used protests, boycotts, and consumer education campaigns to protect forests. In the 1990s, thousand of demonstrators blocked logging roads on Vancouver Island, tree-sitters attempted to prevent cutting of ancient redwoods in California, and non-profits carried out a campaign to convince Home Depot to stop selling lumber from old-growth forests. As a result, major paper purchasers cancelled contracts, home improvement centers made new commitments, and the state of California purchased threatened forest land. In other countries like China, India, and Turkey, strong government policies involving cutting restrictions and tree planting are bringing about a shift to reforestation.

Landowners are also changing forestry, agricultural, and grazing practices voluntarily. Since the development of the Forest Stewardship Council certification, more sustainable harvesting practices are now used on 180 million acres of forests, helping to protect wildlife habitat. In the US, Allan Savory has introduced Holistic Management for cattle ranchers—working with ecological processes to rebuild biological biodiversity. Land is grazed intensively but then given a rest, and ranchers report increases in perennial grass species and wildlife. The US Department of Agriculture has a cost-sharing program for farmers called Conservation Reserve that encourages them to convert environmentally sensitive acreage to grasses, trees, or wildlife plantings.

2. Loeb, Vernon, ibid.
7. Molina, Randy, Forestry Sciences Laboratory, Oregon State University, phone conversation, 3/24/06
20. Branscome, James, “Destroy to Save,” *Spectrum*
3. Loss of Topsoil

The thin layer of topsoil covering the planet’s land surface is, as Lester Brown says, the foundation of civilization. As soil formed on Earth from the weathering of rock and accumulation of organic material, it provided a medium in which plants could grow. Plants, in turn, protect the soil from erosion.\(^1\) In a natural state, the rate of soil formation is relatively equivalent to the rate of soil erosion, the gradual movement of soil to the sea. However, human activities causing soil erosion, degradation, and contamination are threatening this balance. Hope lies in new farming techniques and grassroots efforts that help restore the balance.

**Topsoil Erosion**

The rate of soil erosion now vastly exceeds soil formation. Soil is washed away ten times faster than it is replenished in the US and 40 times faster in China and India.\(^2\) In some areas of the Great Plains, agricultural topsoil has decreased in thickness from 12 inches to less than four inches.\(^3\) As a result of erosion in the last 40 years, 30 percent of the world’s arable land has become unproductive.\(^4\) Just as it takes hundreds of years for a clear-cut forest to return to an old growth state, an inch of topsoil can take 500 years to form, and at least six inches are needed for crop production.\(^5\)

Where land is dry and bare, soil is easily eroded by winds. Americans are familiar with the 1930s’ Dust Bowl of the Great Plains, which took place after years of over plowing followed by successive droughts. The same phenomenon occurred in the Soviet Union in the 1960s and is now frequent in northern Africa and China. In 2001, the western US was blanketed with dust from a huge storm in China and Mongolia.

**Soil Degradation**

Approximately 65 percent of the earth’s soils are degraded to some extent.\(^6\) The primary causes are overgrazing, removal of vegetation, and agricultural practices.\(^7\) When land is overgrazed or deforested or when crops are harvested, there is often not enough plant litter remaining to protect and nourish the soil. Soil organisms die, resulting in a loss of fertility. Sparse cover allows raindrops to erode the surface, loosening the soil’s structure, freeing up fine clay particles, and transporting them downhill.\(^8\) Repeated mechanical tilling changes the structure of the soil so it erodes more easily, and compaction by heavy farm equipment reduces water infiltration and increases runoff. Nutrients are also lost when farmers fail to allow fallow periods or to replenish the soil.

Desertification, the gradual process of soil productivity loss and thinning of vegetative cover, is a problem on 30 percent of Earth’s land.\(^9\) It is most extensive in Africa, central Asia, and northeastern Brazil. But the phenomenon has also occurred in the semi-arid Western US, primarily from cattle grazing in the late 1800s.\(^10\) More than 22,000 square miles of arable land on Earth turn into desert each year.\(^11\)
Over time, irrigation of land can cause water logging or salinization—a buildup of salt in the soil. In poorly drained soil, the excess water sometimes pushes the water table up near plant roots. Air spaces become filled with water, and plant roots suffocate. Water used for irrigation contains small amounts of salt, which are left behind when water evaporates from the ground surface. In arid areas, salt can accumulate, inhibiting the ability of plants to absorb water. Salt problems are especially severe throughout Asia and in California, where human use of the Colorado River has approximately doubled its salinity. According to a UN Food and Agricultural Organization estimate, salt buildup has severely damaged about 13 percent of the world’s irrigated farmland. Drip irrigation could help prevent this phenomenon, but poor countries have not been able to afford it.

**SOIL CONTAMINATION AND THE IMPORTANCE OF SOIL ORGANISMS IN ECOSYSTEMS**

Excessive application of chemicals by farmers or spills and leaks of petroleum products and toxic substances by other users kill soil organisms. Soil is a complex living food web, where a variety of organisms interact to process organic matter, recycle nutrients, and nurture plants. According to soil scientist Elaine Ingham at Oregon State University, just one gram of healthy agricultural soil contains around 100 yards of threadlike fungal material, 100 million bacteria, tens of thousands of one-celled organisms called protozoa, and up to 2000 tiny worms called nematodes. Growth of plants depends upon the presence of these microorganisms, which interact to retain nutrients and make nitrogen available. Higher up the food chain are the springtails and mites that prey on fungi. Larger still are the earthworms, ants, termites, millipedes, and beetles that fragment the organic debris, aerate the soil, and form channels for infiltration of water.

Ingham explains, “Once you start killing off these organisms, you’ve reduced the capacity of that ecosystem to resist disease. So you apply more pesticides, and you kill off more of these organisms, which just makes it easier for the pathogen to come back each year.” The effect is that soil viability can be lost in as little as 40 to 50 years. Fertilizers move right through the soil because fewer organisms are left to retain them. The solution is to rebuild populations of the microorganisms.

Lack of knowledge about the intricacies of soil ecosystems was highlighted by the failure of Biosphere 2. This manmade “ecosystem,” built in Arizona, was to house eight human beings along with 4,000 species of plants and animals for two years. The technological wonder began to experience problems soon after the experiment began in 1991. By 1993, oxygen concentrations had fallen precipitously within the enclosed atmosphere. Morning glory vines, introduced to absorb excess carbon dioxide, overran other plants. Nineteen of 25 vertebrate species died off, as did all pollinators, dooming many plants to seedlessness. The majority of insects were lost, leaving ants, cockroaches, and katydids as the dominant species. Scientists still don’t understand the causes of ecosystem failure, but one guess is the imbalance of introduced soil. A high level of organic matter caused microbial populations to take off and consume the available atmospheric oxygen.

**WHAT IS BEING DONE?**

A number of farming practices are currently being implemented in the developed world to limit soil degradation, including using drip irrigation, planting cover crops at the end of the growing
season, applying manure or other organic material to the soil, rotating crops, practicing contour
cultivation, and using no-till methods. The practice of organic agriculture, which eschews
pesticides and synthetic fertilizers and optimizes long-term soil fertility, is becoming more
prevalent to meet consumer demand. In parts of the developing world, grassroots community
action is being taken. In one region of Burkina Faso, Africa, basins are dug during the dry
season and filled with compost or manure to reclaim degraded land and restore soil fertility.
Sorghum yields there have increased by 400 percent.\textsuperscript{17}
4. Loss of Biodiversity

Biodiversity, the harvest of four billion years of evolutionary wisdom distilled into 5-15 million species that share the planet, is unraveling. Biologists now say that a sixth mass extinction is under way, and it is caused by humans.¹ The UN Convention on Biodiversity in 2006 estimated that average species abundance declined about 40 percent between 1970 and 2000. According to the 2005 Millennium Ecosystem Assessment involving more than 1300 scientists from 95 countries, humans have increased species extinction rates by as much as 100 times over background rates. These scientists estimate that 12 percent of remaining bird species, 23 percent of mammals, 25 percent of conifers, and 32 percent of amphibians are threatened with extinction.² Dr. Peter Raven, a world leader in plant conservation, has predicted that one-third to two-thirds of all species will be lost during the second half of this century. Based on the recovery rate of previous mass extinctions, it may take 50-100 million years for biological diversity to recover.¹

Driving Forces in the Loss

The three primary drivers in the loss of biodiversity are habitat destruction and fragmentation, invasive species, and over fishing and hunting.⁴ (Invasive species and over fishing are covered in other fact sheets of Stresses on the Planet.) Habitat destruction results from farming, grazing, paving the land, cutting forests, and building dams. For example, the prairie dog population declined by 98 percent when the great grasslands, which once covered 40 percent of the US, were converted to farms.

The main cause of habitat destruction is the clear cutting of forests, particularly rain forests. One in eight plant species is at risk of extinction due to forest decline. Tropical rain forests are believed to support half the world’s species.⁵ In some of these forests, the diversity of species is mind-boggling. In a study of ten 2.5-acre plots at a site in Indonesia, Harvard scientist Peter Ashton found 700 tree species—an amount equivalent to the total number of tree species native to North America. This abundance explains why there is such great concern about the clearing and burning of rain forests in the Amazon Basin. Edward O. Wilson, one of America's foremost experts on biodiversity, says we could be losing 4000-5000 species a year.⁶ In Wilson’s view, with an increased knowledge of wild species and a modest effort, more income could often be extracted from the sustainable harvesting of natural forest products than from clear cutting forests for timber and crops. In addition, the “ecosystem services,” like carbon storage and water purification provided by healthy ecosystems, have tremendous economic value (see below).

Dams destroy river habitats, trap nutrients that once flowed...
downriver to enrich the soils of deltas, and block fish migrations. In the Pacific Northwest, more than 25 percent of all juvenile salmon die going through the turbines of a dam. Salmon that do make it to the other side may suffer from “gas bubble disease” because the overflowing water becomes supersaturated with nitrogen. Furthermore, dams slow the flow of water behind them, increasing water temperature and delaying the movement of salmon smolts back to the sea. Wild salmon runs in the Columbia River Basin have dropped by 98 percent.

Global warming is destined to become another major driver in the loss of biodiversity, especially in higher latitudes where temperature change is occurring most rapidly. As rising temperatures cause habitats to shift, many species will not be able to migrate fast enough to survive.

**The Benefits of a Bio-Diverse Planet**

As we go about our daily lives, it’s hard for us to have the same sense of urgency scientific researchers have about the loss of species, especially if they are insects or plants. Yet biodiversity makes ecosystems resilient, giving them the ability to rebound from shocks of fires, floods, diseases, and droughts. As systems are simplified by monoculture or fragmented by roads, the webs that link them become disconnected and more vulnerable to catastrophic, irreversible decline. For example, mixed-perennial native prairies have root systems at various levels, some of them quite deep. They can therefore capture enough water to withstand droughts whereas human-planted annual grasses cannot. Diverse ecosystems have built-in redundancy. If one species dies off due to a disease, another may be able to take over its functions in the system.

Biodiverse ecosystems also provide many services that humans are not able to provide, or that would be outrageously expensive, such as purification of air and water and regulation of Earth’s temperature. The most obvious service of a biodiverse ecosystem is pollination of plants. Scientists estimate that approximately 150,000 animal species including bees, beetles, butterflies, flies, birds, and bats provide this service. In dollars, honeybee pollination services are up to 100 times more valuable than the honey itself. Unfortunately, in the US more than 50 percent of the honeybee colonies have disappeared in the last 50 years. We also rely on birds, spiders, parasitic wasps, and ladybugs to keep pests in check and to disperse seeds. In fact, the white-bark pine tree cannot reproduce successfully without Clark’s Nutcracker, which buries its seed.

A team of international researchers in 1997 determined that nature’s services were worth around $33 trillion per year, exceeding the global GNP of $25 trillion. A single example of the cost of ecosystem services is illustrated by the Catskills Watershed that supplies water to New York City. In the 1990s, the drinking water was below standard. The watershed had been overburdened by new homes, dairies, and failing septic systems. The watershed development corporation determined that a filtration plant to bring the water up to standard would cost $7 billion over ten years. Restoration of the watershed, on the other hand, would cost $1-1.5 billion. The corporation is now buying up and restoring land, paying people to upgrade sewage, getting farmers and foresters to sign up for sustainability plans, and getting cattle owners to fence cattle from streams.
Tugging at Threads
Each species plays some role in the web of an ecosystem. For example, marine researchers found that when humans decimated otter populations for their fur, kelp forests disappeared. (Kelp is a giant, rubbery seaweed stretching from the sea floor to the surface.) A primary food source of the otter is the sea urchin, whose favorite food is kelp. With their predator gone, sea urchins overpopulated, consuming all the kelp and leaving barren areas where biodiverse forests once thrived.\[15\]

Wolves have long been hunted by humans trying to protect their cattle. After wolves were eradicated from Yellowstone National Park, scientists noticed that aspens, cottonwoods, and willows stopped growing. Research scientists theorize that the elk, no longer fearful of their predator, spent more time browsing in the open stream areas. Now that wolves have been returned to Yellowstone, willows and cottonwoods are returning. Because more trees are available, beavers are re-colonizing and creating wetlands, which in turn are creating habitat for native trout and songbirds.\[16\]

In an ecosystem, it is not clear which species, if any, is expendable. To quote Carl Sagan, former director of the Laboratory for Planetary Studies at Cornell University, “We are ignorant about the complex mutual dependencies of the beings on Earth, and what the sequential consequences will be if we wipe out some especially vulnerable microbes on which larger organisms depend. We are tugging at a planet-wide biological tapestry and do not know whether one thread only will come out in our hands, or whether the whole tapestry will unravel before us.”\[17\]

Human Dependence
Perhaps it is easiest for us to understand the importance of preserving species when we consider our reliance on their diversity for food, fiber, fuel, and medicines. Future medicines are likely to be found in the many thousands of plants we have not yet studied. About 25 percent of the pharmaceuticals we use today contain ingredients originally derived from wild plants.\[18\] And of the plants useful in cancer treatment, about 70 percent are found only in rainforests. Of 3000 antibiotics, 2000 come from soil bacteria.\[19\]

Because of hybridization and the Green Revolution of the 1960s, our sources of food come from fewer and fewer varieties, increasing their vulnerability to disease. In 1970, a leaf fungus swept through uniform fields of the US Corn Belt. The disease destroyed 15 percent of the entire corn crop, pushing corn prices up 10 percent and causing losses of more than $2 billion. The solution turned out to be blight-resistant genetic material from an ancient variety of corn from Mexico.\[20\]

Today humans rely on about 20 species of plants, like wheat, rice, and corn, for most of their calories, while thousands of other calorie sources are ignored.\[21\] These 20 crops are bred for high yields and ease of farming, weakening their ability to overcome diseases or changes in climate.\[22\] In Mexico, four-fifths of the varieties of corn that existed in the 1930s have disappeared. China, which once had 10,000 wheat varieties, now has one-tenth that number. Seventy-five percent of the genetic diversity of crops has been lost since the beginning of the 20th century.\[23\]

As scientists breed resistance into new varieties, diseases and insects adapt. More than 400 species of pests are now resistant to one or more pesticides, and the proportion of crops that are
lost to insects has doubled since 1940. No one knows when we might need the genetic material
from a plant that we have inadvertently driven to extinction.\textsuperscript{24}

Loss of species and genetic diversity within species may preclude human use of nature’s library
of products, some with millions of years of evolutionary wisdom. As Edward O. Wilson has
said, “No artificially selected genetic strain has ever out-competed wild variants of the same
species in the natural environment.”\textsuperscript{25}

\textbf{WHAT IS BEING DONE?}

Some species that were almost lost in the US have made comebacks as a result of the
Endangered Species Act of 1973. The bald eagle and peregrine falcon have made remarkable
recoveries; the grey wolf introduced in Yellowstone is expanding to other states; even the
California condor, which was down to 21 individuals, now numbers over 150 birds as a result of
a captive breeding program.\textsuperscript{26} Since the Endangered Species Act, improved science about what
it takes to keep ecosystems intact has enabled governments and nonprofit organizations to give
highest priority to saving the most sensitive habitats and the species that have strong influence
over other plants and animals such as bears and wolves. For example, the organization
Wildlands Project is working to link vast corridors that connect natural places so that wildlife
can travel freely from place to place.

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5. Invasive Species

In 1986, a commercial ship, making a routine transatlantic run from Europe up the St. Lawrence Seaway, discharged its fresh water ballast into the St. Clair River near Detroit. Out of the ship gushed millions of tiny larvae destined to grow into one of the worst exotic species pests of our time: zebra mussels. By 1989, the fingernail-sized mussels had spread to Lake Erie, where their population density reached 23,000 per square meter. Unchecked by natural predators in North America, the mussels have since run amok. They clog pipes and shut down water intake systems. They mass on hulls of boats and piers. Zebra mussels displace native mussels, and their ingestion of algae, phytoplankton, and zooplankton cuts into the food supply of other animals. By 2000, zebra mussels had advanced to the Hudson, Illinois, Mississippi, Ohio, Arkansas, and Tennessee rivers. Dealing with this pest had cost $750 million to $1 billion.

Upsetting the Balance

Invasive species are non-native organisms that devastate populations of native species and agricultural crops by preying on, parasitizing, infecting, or outcompeting them. These exotics, a primary driver in reducing biodiversity, are almost always introduced by humans. Sometimes, as with the zebra mussel, they are introduced unintentionally. In other cases they are deliberately introduced.

In 1953 the Soil Conservation Service planted 23 million kudzu vines throughout the South to control erosion. What was a harmless ornamental vine in other parts of the world became a scourge in southeast America. By 1981, the vine covered seven million acres and was strangling forest vegetation. Native plants simply had no prior evolutionary experience with kudzu. As a result they were unable to compete. Other examples of invasive plants that were intentionally introduced, all as ornamentals, are the water hyacinth that now chokes waterways, purple loosestrife that outcompetes native marsh vegetation, cheatgrass that has displaced millions of acres of native grasslands, and English ivy that covers the floors of some Pacific Northwest conifer forests.

The principal pathways of introduction of invasive species are global trade, trade in live plants and animals, and travel. In today’s world of economic globalization, the problem of invasive species is escalating. In San Francisco Bay invasions have increased to one new species every 12 weeks. The Baltic Sea is now home to 100 creatures from other parts of the world, one-third of which are native to the Great Lakes of America. Conversely, one-third of the 170 alien species in the Great Lakes are originally from the Baltic.

Feral pigs in Hawaii, lampreys that devastated commercial fisheries in the Great Lakes, agricultural weeds like spotted knapweed and tansy ragwort, and tree diseases like the blights
that wiped out American elms\textsuperscript{5} are just a few more examples of the invasive species that have upset natural balances and cost governments and businesses billions of dollars.

**WHAT IS BEING DONE?**

Eradicating an invasive species is no easy task. For example, the US spent $172 million over a 24-year period to stamp out fire ants, but instead the campaign spread the pests by killing natural enemies.\textsuperscript{6} The good news is that localized efforts to combat invasive species have been effective. The Nature Conservancy has a Global Invasive Species Initiative with specific programs for states and countries that focus on early detection, multi-agency efforts, outreach, and education.\textsuperscript{7} One successful endeavor was in the Humboldt Bay National Wildlife Refuge where European beachgrass was removed from ten acres of protected dunes in a rigorous, time-consuming effort. Within five years native plant cover, including some endangered species, had increased by 47 percent. This achievement has encouraged other groups to carry out similar projects.\textsuperscript{8}

Environmental and other groups are also working for policy changes with the realization that the solution to invasive species lies ultimately in prevention. The Invasive Species Act calls for prevention of invasive species in US waters, and an International Maritime Organization program helps developing nations prevent the transfer of aquatic organisms through ballast water.

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6. Global Warming

Australia has its worst drought in history. Denver receives 57 inches of snow in a week. Thirty thousand people die in Europe from heat. Glaciers retreat. The Tundra thaws. Spring arrives two weeks early in eastern Canada. News of extreme weather comes to us with increasing frequency. While such events may not be individually attributed to global warming, they are consistent with patterns that scientists warn are stressing the planet. Indeed, many scientists prefer the term global climate change because the effects of Earth's warming are so varied.

These climate disruptions can be traced to subtle but far-reaching changes in Earth’s atmosphere. Carbon dioxide, methane, and other trace gases in the atmosphere absorb the sun’s heat, causing the lower atmosphere and Earth’s surface to warm as if wrapped in a blanket. This natural greenhouse effect keeps the earth from becoming an ice ball. But humans are adding greenhouse gases to the atmosphere—in effect adding more blankets. Since records have been kept, thirteen of the world’s warmest years have all occurred in the past 15 years with the highest occurring in 2005 and 2010.

RISING LEVELS OF GREENHOUSE GASES

The primary cause of global warming is the increase of carbon dioxide (CO₂) in the atmosphere. About 410 million years ago, during the Carboniferous Period, the atmospheric level of CO₂ and the temperature of the planet were many times higher than today. Plants, drawing CO₂ out of the air, grew so abundantly that they covered the land and ocean with a dense mat of vegetation—in some places hundreds, or even thousands, of feet deep. As the mats of vegetation were compressed under layers of sediment, they eventually became what we now call fossil fuels (coal, oil, natural gas).

When humans began digging up coal to fuel the industrial revolution, the level of atmospheric CO₂ began to rise slowly at first, then more rapidly in the late 19th century with the discovery of oil. Since the industrial revolution, the CO₂ level has increased by 40 percent, reaching a concentration unseen on the planet in 650,000 years. The atmospheric levels have risen from 280 ppm to 390 ppm in 2011.

Scientists estimate that CO₂ produced by burning fossil fuels, largely for electric power generation and transportation, is responsible for 60 percent of the overall warming effect. About 18 percent is from CO₂ released by deforestation and other land conversion. Fourteen percent is from methane, and eight percent is from nitrous oxide.

Methane and nitrous oxide have much lower atmospheric levels than CO₂, but because they trap heat more effectively per molecule, their warming impacts have become significant. Atmospheric concentrations of methane have more than doubled since the onset of the industrial revolution, largely because of an increase in the production of beef, rice, and oil. (Methane emissions from cow digestion quadrupled in the last century; waterlogged rice paddies release methane as submerged vegetation decays; and methane often leaks from poorly managed oil wells.) Landfills are another significant source of methane. Nitrous oxide escapes into the atmosphere when nitrogen fertilizers are applied to farm fields.

The US, with less than five percent of the world’s population, produces more than 22 percent of the annual CO₂ emissions resulting from human activity. Residents in the industrial nations are
responsible for 9 (Euro area) to 20 (US) tons of carbon emissions per person each year, whereas the world’s poorest citizens are responsible for about 0.1 ton.\textsuperscript{11}

**EXTREME WEATHER EVENTS**

In 1988, when governments first became alarmed about global warming, the World Meteorological Organization and United Nations Environmental Programme established the Intergovernmental Panel on Climate Change (IPCC) to provide independent scientific advice to governments on the complex issue of climate change. This Panel produced reports in 1990, 1995, 2001, and 2007. The reports, the most recent of which included the work of 2,500 scientists from 130 countries, have documented a number of observable changes caused by global warming.

The most obvious result of global warming is an increased number and severity of storms, floods, and droughts worldwide. A rule of thumb is that for every degree the temperature increases, three percent more water vapor is added to the air. More water vapor in the atmosphere leads to a significant increase in the energy available to drive storms. Total winter precipitation in the US has increased ten percent since 1900, and “extreme precipitation events,” such as rainstorms that dump more than two inches of water in 24 hours, have increased by 20 percent.

Rising ocean temperatures in tropical oceans are also increasing the intensity of hurricanes: category 4 and 5 hurricanes have doubled since 1990.\textsuperscript{12} One NASA analyst said, “We seem to be getting these storms of the century every couple of years.”

NASA data also show increases in incidences of drought. With warmer atmospheric temperatures, there’s more evaporation of soil moisture. Those parts of a continent that are normally dry are even drier. In 2008 half of Australia was in drought, and forecasters were calling it the new normal.\textsuperscript{13} IPCC has issued a special report on extreme weather predicting that heat waves that are once-a-generation events will become hotter and happen every five years by midcentury.\textsuperscript{14}

In the American West, longer, warmer, and drier summers have resulted in more wild fires. Since the 1980s, major wildfires have increased fourfold, and the area of forest burned, sixfold.\textsuperscript{15} The average California fire season runs 78 days longer than it did in the 1970s and 1980s.\textsuperscript{16} Costs associated with extreme weather events in the US increased from an annual average of $4 billion in the 1980s to over $200 billion in 2005.\textsuperscript{17}

**MELTING SEA ICE AND GLACIERS**

In 1995, large ice shelves in the Antarctica Peninsula disintegrated, and in 2002 the Larsen B Ice Shelf—about the size of Rhode Island—collapsed.\textsuperscript{18} Polar climate change effects are more pronounced because the Arctic and Antarctic warm at a much faster rate than the Equator. Scientists working in Alaska, 170 miles north of the Arctic Circle, have observed average summer temperatures rise by about seven degrees in the past two decades.\textsuperscript{19} In 2008 northwest and northeast passages in the Arctic opened for the first time in human history.\textsuperscript{20} Polar bears are getting thinner and reproducing less successfully as they are
forced to swim more often, and for longer distances, in search of floating ice sheets. Global warming could cause the Arctic's summer sea-ice to completely disappear in 40 years.\textsuperscript{21}

Non-polar glaciers, stable for 800 years, have been melting steadily, decreasing by an average of ten percent since 1960.\textsuperscript{22} The ice cap on Mt. Kilimanjaro, for example, is predicted to disappear within the next decade. In 1850 Glacier National Park had 150 glaciers; only about 25 named glaciers are left, and they could be gone by 2020.\textsuperscript{23} In the western US, studies suggest a reduction of snow pack by 50 to 70 percent by 2050.\textsuperscript{24} The consequences of such reductions could be catastrophic for communities that rely on snow and ice melt for drinking water, irrigation, and hydroelectric power.

**BIOTIC RESPONSE**

Spring is starting about a week earlier in the northern hemisphere than it did 20 years ago, and the distribution of vegetation and wildlife has begun to shift significantly toward the poles and toward higher elevations. For example, mosquitoes are appearing in the Arctic for the first time.\textsuperscript{25} Outbreaks of dengue fever and malaria, previously limited to tropical areas, are occurring at higher latitudes. Many plants and animals are unable to migrate fast enough to survive, or bodies of water or urban regions block their migration. Some mountainous animals, such as particular species of butterflies and pikas, are threatened with extinction because they can't move any higher. In some cases climate change has upset the delicate balance of plant-animal co-evolution. For example, pied flycatchers in some areas of Europe are now starving because the caterpillars they depend on for food peak before the young birds hatch.\textsuperscript{26}

**FUTURE SCENARIOS**

The IPCC expects weather-related catastrophes to increase. Its models project a rise in global temperature of 3.1 to 7.2 degrees (above 1980-99 levels) by 2100. Warming is expected to be greatest at high northern latitudes. A 3-degree increase could place 30 percent of all plants and animals at risk of extinction; a 7-degree increase could risk 70 percent. The panel projects a sea-level rise of 7 to 23 inches by 2100, due to melting ice and expansion of water itself as temperatures rise. Sea-level rises could be greater. Predictions are difficult because of uncertainties about ice melt and ocean absorption. Rising seas could displace tens of millions of people in low-lying areas, particularly deltas in China, Bangladesh, and Egypt. Human losses, in addition to those directly resulting from flooding and extreme weather events, will center around water and food shortages caused by climate change.

To avoid catastrophic climate impacts, the IPCC recommends a stabilization of CO\textsubscript{2} atmospheric levels at 450 ppm, which should keep temperature increases about 4 degrees above pre-industrial levels.\textsuperscript{27} Yet most climate researchers consider 600 ppm difficult to avoid by midcentury if the use of fossil fuels continues at anything like its present rate.\textsuperscript{28} Even with a reduction in CO\textsubscript{2} and other greenhouse gas levels, the temperature will continue to rise for decades because CO\textsubscript{2} can stay in the atmosphere for 100 years or more.\textsuperscript{29}

The IPCC goal cannot be reached without massive reductions in the use of fossil fuels. In this century CO\textsubscript{2} emissions have grown at a much faster rate than during the 1990s, and if current trends continue, they will increase by 57 percent by 2030.\textsuperscript{30} This is due to worldwide economic growth, powered by coal-intensive China. Researchers on the Panel and from the European
Union and California have determined that an 80 percent reduction in emissions by 2050 will be required to meet the goal.\textsuperscript{31}

Looking beyond predictions from models, scientists have posited a disturbing scenario of runaway warming from the melting of ice caps. Ice reflects 90 percent of the sun’s heat back into space, whereas seawater absorbs 90 percent. A reduction in ice creates a feedback loop whereby ocean temperature increases, promoting greater ice melt.\textsuperscript{32} A 5.4 degree increase in temperature above pre-industrial levels could make disintegration of ice caps in Antarctica and Greenland unstoppable.\textsuperscript{33} Sea levels would rise many feet within a few years and as much as 20 feet within a century or two.\textsuperscript{34} Many of the world’s cities, industrial areas, and agricultural lands would be flooded.

Another unpredictable feedback loop centers around the enormous amount of carbon locked in Arctic permafrost, the thick layer of soil just beneath the surface that remains frozen all year. Permafrost contains more than twice as much carbon as the entire atmosphere. When it begins to thaw, carbon dioxide (from the land) and methane (from lakes and wetlands) will escape into the atmosphere, trapping more heat and melting more permafrost. The worrying possibility is that a significant portion will emerge as methane, which has a greater heat trapping effect than CO\textsubscript{2}. Methane is also trapped in icy deposits in the oceans near continental shelves in the form of hydrates. If these hydrates were to become destabilized because of warmer waters, they could release a massive amount of methane in a short time.\textsuperscript{35}

**WHAT IS BEING DONE?**

The nations of the world responded to global warming in 1997 with the formation of the Kyoto Protocol. Effective in 2005, the protocol commits the industrialized nations that ratified it to reduce collective emissions of greenhouse gases by an average of five percent below 1990 levels by 2012. Europe acted quickly: France, Netherlands, Denmark, Finland, and Sweden passed taxes on carbon emissions or fossil fuels.\textsuperscript{36} The US did not ratify the protocol, but in 2006 California passed the first Kyoto-type law in the US, intending to decrease greenhouse gases to 1990 levels by 2020 and to 80 percent below those levels by 2050. Earlier, seven Northeast states signed an agreement to adopt a cap for power plants. At least 80 corporations, more than half of them Fortune 500 companies, have committed to reductions and are measuring progress toward their goals through the EPA's Climate Leaders program.\textsuperscript{37}

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7. Ozone Hole

The effects of Earth’s thinning ozone layer are far reaching. Increased ultraviolet radiation is linked to declining amphibian populations, increasing rates of skin cancer and cataracts in humans, and possibly serious interference with photosynthesis and metabolism in plankton—the base of the marine food chain. Chlorofluorocarbons (CFCs), previously perceived as harmless compounds, have turned out to be the driving force behind the growing ozone hole.

**IMPACT ON WILDLIFE**

Fourteen species of amphibians have disappeared from Australia in recent years, and frogs are endangered in the western US. Possible causes are the use of pesticides and nitrogen-based fertilizers and habitat loss from filling wetlands. However, some of the losses are occurring in high mountain lakes where none of these factors are present. In 1994 Oregon State University zoology professor Andrew Blaustein took a team to examine toads at a lake in the Cascade Mountains. Instead of finding 500 paired toads, as Blaustein had in previous years, the team found only 147. They observed almost two million eggs being laid, but two days later the eggs began to turn white and disintegrate. A week after being laid, only half were viable. In further experiments, Blaustein found that ultraviolet radiation killed frog and toad eggs. He suspects that thinning of the ozone layer, with increasing ultraviolet (UV) radiation, is contributing to frog and other amphibian deaths.

**THE EFFECTS OF CFCs**

Chlorofluorocarbons (CFCs), the primary driver of ozone depletion, were considered miracle compounds when first discovered in 1928. They are chemically stable, inflammable, and nonpoisonous. Manufacturers used them as coolants for refrigeration and air conditioning, for propellants in spray cans, in plastic foam, and in cleaning solvents for circuit boards. By the 1960s, international CFC production approached a billion pounds a year. About four decades after they were introduced, University of California chemists Rowland and Molina began tracking CFCs. They hypothesized that CFCs would rise to the upper atmosphere (6-30 miles above Earth’s surface) where UV radiation would break them down, releasing chlorine. One chlorine molecule can destroy up to 100,000 ozone molecules. In other words, CFCs could deplete the ozone layer that protects the planet from the sun’s most damaging radiation—radiation that can cause skin cancer and cataracts and weaken the body’s ability to fight disease.

In 1981 NASA satellites found a thinning of the ozone layer, confirming Rowland and Molina’s hypothesis. In the 1980s, research indicated that UV radiation caused cell and tissue damage in many organisms, and concern was growing that it could have serious effects on the photosynthesis and metabolism of plankton at the base of the marine food chain. A Texas A&M researcher found that increased ultraviolet light induced a decrease in phytoplankton in Antarctic waters. Public health officials cautioned people to wear sunglasses to protect against cataracts. In the US, the
incidence of the most dangerous form of skin cancer, melanoma, doubled in the 1980s. Whereas a child born in the 1930s had a 1 in 1,500 risk of developing melanoma, a child born in 1988 had a 1 in 135 risk.\textsuperscript{8}

While CFC use has decreased dramatically, the level of these chemicals in the atmosphere remains high because the molecules from previous emissions are still there. CFCs remain in the atmosphere for about a century before giving up their chlorine.\textsuperscript{9} By 1992, the hole over Antarctica had grown to nearly three times the size of the US.\textsuperscript{10} In 2006, the ozone hole was the largest ever measured.\textsuperscript{11} It may be decades before scientists detect an improvement in the ozone layer and at least the middle of this century before it returns to its 1970s’ levels.\textsuperscript{12} Scientists cannot predict the ultimate effect of increased ultraviolet radiation on ecosystems.\textsuperscript{13}

\textbf{WHAT IS BEING DONE?}

As a result of public pressure, the US banned CFCs in aerosol cans in 1978. In the Montreal Protocols of 1987 and 1990, 150 nations of the world agreed to phase out ozone-depleting substances by 2000.\textsuperscript{14} Although the treaty is not ideal—HCFCs (used in home air conditioning units and heat pumps) and methyl bromide (used to fumigate soil before planting crops such as strawberry plants) are still in use—it basically represents a success story.\textsuperscript{15} Seldom has the international community reacted so quickly to an environmental threat.

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\end{flushright}
Throughout most of human history, nature could handle the few toxins our species contributed. But in the 20th century we began producing synthetic chemicals in types and amounts that nature couldn’t assimilate. Of more than 85,000 chemicals registered in the United States, nearly 300 are produced in volumes of more than one million pounds per year. From gulls nesting with infertile eggs to significant rises in cancer rates in humans, the effects of the accumulation of chemicals in our air, water, and soil are showing up.

Many toxic chemicals persist in the environment long after they are released, with their effects magnified as they move up the food chain. In Lake Ontario, plankton were found to have levels of PCBs 500 times the level in the water. As fish ate the plankton, and larger fish ate smaller fish, the PCB level was magnified. A gull at the top of the food chain was measured with 25 million times the level of PCBs found in the water. PCBs and DDT are still found in living organisms today, even though they were phased out in North America in the 1970s. Persistent toxins also travel long distances in air, water, and animals. Canadian Inuit women, far from industrial pollution, carry the highest amount of persistent toxins ever measured in human breast milk.

Organochlorines

Some of the most persistent, bio-accumulative toxic substances are the synthetic chemicals containing chlorine. One of the largest-volume chemicals produced in the US, chlorine is used to manufacture synthetic chemicals for pesticides, solvents, plastics, and countless other products. In addition to the pesticide DDT and the industrial chemical PCB, organochlorines include PVC and dioxin. PVC, commonly called vinyl, is found in building materials such as siding, piping, window frames, and flooring. It is also found in countless consumer products, such as food containers, rubbery toys, garden hoses, shower curtains, upholstery, and shoes. PVC enters the environment during production and incineration of these products and is the primary contributor of dioxin emissions from municipal and medical waste incinerators. Dioxin also enters the environment from chlorine bleaching of paper and as a by-product of manufacturing pesticides and wood preservatives.

Organochlorines accumulate in the fat of animals and tend to concentrate in animals (including humans) at the top of the food chain. Over the past few decades, Beluga whale numbers in the St. Lawrence Seaway have plummeted by 90 percent, and organochlorine contamination is the suspected cause. One...
whale was found to have a level of PCBs ten times the level necessary to qualify as hazardous waste under Canadian law.\textsuperscript{5} Human health impacts of organochlorines include cancer, birth defects (particularly in the reproductive system), learning disabilities, and immune system damage. A study at the NYC Mt. Sinai Medical Center found that women whose blood contained large concentrations of residues from DDT are four times as likely to get breast cancer as those with low concentrations.\textsuperscript{6}

**HEAVY METALS**

Lead, mercury, cadmium, chromium, and arsenic are also persistent, bio-accumulative toxins. Although they are not manmade, humans are extracting them from Earth’s crust at an alarming rate. Industry has introduced 300 times as much lead, 20 times as much cadmium, and four times as much arsenic into the atmosphere than is naturally present.\textsuperscript{7}

Even though the US banned lead in gasoline and household paint in the 1970s, it still exists in homes and the dust around homes that were built before 1978. Two decades after it was banned, government officials estimated that one of six children under five had blood levels of lead high enough to be a health risk. Even in small doses, lead can slow child development and cause IQ deficits of up to eight points. It is correlated with hyperactivity, short attention spans, and aggression. Lead is still used for batteries, fish weights, ammunition, solder, and ceramic glaze.\textsuperscript{8}

The primary source of mercury in the US is emissions from coal plants and waste incinerators. It can also enter the environment after being used in electronic equipment, cell phones, fluorescent light bulbs, thermometers, and amalgam tooth fillings. Because mercury moves up the food chain, animals and humans that eat contaminated fish are at risk, particularly children and women of child-bearing age. One in six babies is born with higher than safe levels of mercury.\textsuperscript{9}

**PESTICIDES**

Since the publishing of Rachel Carson’s book *Silent Spring* in 1962, pesticide use has increased tenfold. In California’s Central Valley, where much of our nation’s produce is grown, state regulators detected pesticides in 95 of 100 locations. More than half of the sites exceeded safe levels for aquatic life and drinking-water consumption.\textsuperscript{10}

Pesticides have been found to have significant health effects, even at very small levels, in birds, fish, and frogs. Every year agricultural pesticides kill an estimated 76 million birds\textsuperscript{11}. In one infamous episode, 20,000 Swainson hawks died after eating grasshoppers in an Argentine cornfield that had been sprayed with pesticides.\textsuperscript{12}

Agricultural workers are particularly vulnerable. A State of Washington study found that one in five workers who mix or spray chemicals has significant health problems. Surprisingly, homeowners, not farmers, use the most pesticides. Homeowners apply an average of ten pounds of pesticides per acre to their lawns as compared to the 2.7 pounds per acre used on farms.\textsuperscript{13} That a chemical is approved for use in the home doesn’t guarantee its safety. A study of 40 lawn-care chemicals found that more than half cause long-term health effects in laboratory animals or humans, and nearly one-third are suspected carcinogens.\textsuperscript{14}
ENDOCRINE DISRUPTORS
Toxicologists used to say, “The dose makes the poison.” They assumed that everything is safe in small amounts. That assumption was turned on its head with the discovery of endocrine disrupters. In 1991, researcher Theo Colburn, who had been studying reproductive maladies in wildlife in the Great Lakes region, convened other American and European scientists to compile information and seek an understanding of the effects they were observing. In one reported incident, researchers at Tufts Medical School noticed that certain cancer-cell specimens in styrene flasks multiplied like crazy. They later learned that the flasks apparently leached a chemical that acted like estrogen.

Scientists now know that very low doses of chemicals may block or mimic hormones in living organisms. Because endocrine disruptor molecules are similar in shape to hormones, they readily fill up hormone receptors, thereby having a significant effect even at low doses. Endocrine disruptors have their greatest impact in a growing fetus because hormones direct each stage of development. Effects in humans include abnormal penis and urethra development, decrease in sperm count and quality, prostate and breast cancer, early sexual maturation, attention deficit syndrome, hyperactivity, and miscarriage.

Organochlorines are endocrine disruptors. So are other chemicals that the public has not heard as much about, such as phthalates, which are produced at a rate of nearly 11 billion pounds a year. Phthalates are added to plastics to make them soft and bendable and are perhaps best known as the chemical that helps create the “new car smell.” They are also a component of paints, carpets, electric cables, nail polish, the coating of time-release pills, and personal care products, especially those with fragrances including perfume, deodorant, soap, shampoo, and hand lotion. We are exposed to them when they migrate out of these products—for example, out of water bottles after repeated use and into food during microwaving of plastics.

Bisphenol A, an endocrine disruptor produced at a rate of 6 billion pounds per year, is found in clear plastic water and baby bottles, fiberglass, the lining of food cans, children’s dental sealants, and CDs. In his research on animals, Frederick vom Saal found that amounts as small as 0.1 part per trillionth of a gram could have adverse health effects.

CHEMICALS IN OUR BODIES
In 2003, the Environmental Working Group did a body burden study to determine how many chemicals are in human blood and urine. Of 210 chemicals studied, they found 167 including PCBs, dioxins, heavy metals, pesticides, and phthalates.

Other body burden studies have heightened our awareness about common chemicals, such as flame retardants. Flame retardants are used in computers and other electronics, and in polyurethane foam found in couches, mattresses, and carpet pads. They are found in textiles such as draperies, and in the plastic coverings of auto interiors. Studies of US mothers in 2003 indicated that their breast milk contained flame retardants at 10-100 times the level in European mothers. Another example is the chemical used in Teflon and Gortex. According to researcher Jane Houlihan, the Teflon chemical showed up in all people tested by 3M. It is found in carpet and textile treatments and in the coating of food packaging such as french fry and pizza boxes, as well as in the coating of cooking pans.
**WHAT IS BEING DONE?**
The most common action by governments has been to ban chemicals once their danger has been proven. Many pesticides have been banned in the US, the most recent one being guthion, which is widely used in orchards. A European Union (EU) directive that took effect in 2006 calls for the elimination of lead, mercury, cadmium, chromium, and two types of flame retardants from electronic and electrical equipment. The EU also passed a rule banning probable carcinogens, mutagens, and reproductive toxins from cosmetics.

A hopeful development in the effort to minimize toxic chemicals is an emerging acceptance of the precautionary principle. The precautionary principle states that if the introduction of a chemical raises a threat to human health or the environment, preventive measures should be taken even if cause and effect relationships are not fully established scientifically. In 2000, the European Commission stated that the precautionary principle must be considered in all new legislation of the EU. In 2003, the principle was adopted by the City of San Francisco.

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9. Air Pollution

In 2000, an estimated 800,000 people around the world died from health problems worsened by air pollution. While some air pollutants, such as sulfur dioxide, nitrogen oxide, ozone, and carbon monoxide, are declining in the US and Europe, they are increasing in other countries. Some northern cities of China experience sulfur dioxide and particulate levels three to eight times those of World Health Organization (WHO) guidelines, and Mexico City's residents breathe ozone levels more than 50 percent above these guidelines. Seven out of ten children in Mexico City are born with higher levels of lead in their blood than WHO standards.

Sources of Air Pollution

Burning fossil fuels, such as coal, oil, and natural gas, contributes more to air pollution than any other activity. Emissions include particulates, heavy metals, and acid gases, some of which travel long distances in the upper atmosphere. For example, one of the largest sources of the heavy metal cadmium in our air is from fossil-fuel emissions. The gases sulfur dioxide and nitrogen oxides, released when fossil fuels are burned, fall back to Earth as acid rain. In southern Norway, 80 percent of lakes are either biologically dead or endangered, and in Sweden 4000 lakes no longer support fish due to acidic conditions. In western Germany, acid rain has damaged more than half the forests. Acid rain has caused considerable damage to conifer forests in the Appalachian Mountains and to sugar maple trees in eastern Canada. In the US about 1200 lakes have become so acidified that little can live in them. In many developed countries, the situation is expected to improve in the next decade, but elsewhere in the world, it is expected to worsen.

As a result of human impact on land, some natural sources of air pollution, such as forest fires and dust storms, are also becoming a threat to global air quality. With increasing drought conditions, clouds of dust are picked up by winds in Africa and China and carried across the Atlantic or Pacific oceans. The dust often carries with it toxic substances, such as bacteria or pesticides, and is the suspected cause of massive die-offs of soft coral in the Caribbean. A substantial source of mercury in Pacific Northwest rivers comes from dust storms that have picked up the pollutant from Chinese coal plants.

Effects on Human Health

Air pollution's harmful effect on humans was brought to public attention with the Donora and London smog episodes. In 1948, the steel-mill town of Donora, Pennsylvania was blanketed by noxious smog. Residents had to keep their lights on all day. Twenty people died, and 7000 were sickened. Four years later was London's Great Smog in which 4000 people died as a result of industrial and coal-burning pollutants. These incidents led to the first national clean air legislation that required some controls on industrial and coal-burning emissions.

According to the EPA, motor vehicles are the single largest contributor to cancer risks from exposure to air toxics. Diesel exhaust from vehicles, as well as construction and agricultural
equipment, is particularly dangerous. In addition to the nearly 40 toxic substances such as metals and gases that diesel exhaust contains are particulates so small that they carry additional toxins to the deepest part of the lungs where the most damage can occur. Children riding diesel school buses increase their cancer risk, according to a California study.\(^9\)

Since the 1970s when buildings became air tight, indoor air pollution has become more of a concern for human health. According to the EPA, some offices, schools, hospitals, and nursing homes have levels of formaldehyde, asbestos, pesticides, organochlorines, and endocrine disruptors as high as 100 times the outdoor levels. Some of the sources of these pollutants include carpets and their adhesives, caulk, paints, computer cables, flooring tiles, and particle board.\(^{10}\)

**WHAT IS BEING DONE?**

In the US, the Clean Air Act of 1970 and subsequent amendments have been effective. Although there is still concern about two of the six major pollutants covered—ozone and particulates—the other four—carbon monoxide, sulfur dioxide, nitrogen dioxide, and lead—are no longer released at unhealthy levels. To supplement the national standards, California’s Air Resources Board established vehicle emissions standards stricter than those required by the Clean Air Act, making their emission tests among the strictest in the world. Today, 35 states have adopted measures that are modeled after those of California.\(^{11}\)

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10. Loss of Fresh Water

Over 97 percent of all water on Earth is salt water, leaving only 2.5 percent as fresh water. Most of Earth’s fresh water is either bound in ice caps (70 percent), present in the soil, or in deep underground aquifers. Less than one percent of fresh water is accessible for direct human uses either in surface water or ground water shallow enough to be tapped at an affordable price.\(^1\)

Overconsumption and contamination are altering Earth’s freshwater ecosystems to a greater extent than terrestrial ecosystems.\(^2\) Major rivers, such as the Colorado, the Nile, the Ganges, and the Yellow River in China, are used so extensively that little of their water reaches the sea.\(^3\) Worldwide, the drinking water of two billion people is contaminated by animal waste and chemical pollution.

**Consumption**

Ogallala Aquifer, the largest aquifer in the US, stretching from Texas to South Dakota, is being drained eight times faster than it can be recharged.\(^4\) The amount of acreage supported by the Ogallala Aquifer reached its peak in 1978 and fell 20 percent in less than a decade. In India, almost all water withdrawals are proceeding at double the rate of recharge, causing a drop in aquifers of three to ten feet per year—more than in any other nation. In many areas of the world, groundwater is called “fossil water” because it is not renewable. Three-fourths of the water supply of Saudi Arabia is considered to be fossil water.\(^5\)

Between 1900 and 1995 global water consumption rose six-fold, or almost double the population growth.\(^6\) Agriculture currently accounts for about 75 percent of the world’s freshwater consumption.\(^7\) Under current irrigation practices, it takes 1000 tons of water to produce a ton of wheat, at least 15,000 tons to produce a ton of beef, and nearly that much to produce a ton of cotton.\(^8\) According to the Millennium Ecosystem Assessment of 2005, the world's freshwater supply cannot sustain current, much less future, demand.\(^9\) The freshwater supply in 36 nations in Africa, Asia, and the Middle East is not sufficient to meet grain production needs.\(^10\)

Such extensive water use has been made possible by two technologies: electric pumps (for groundwater) and dams. In 1950 there were 5,270 large dams worldwide; in 2000 there were more than 36,500.\(^11\) In the US only two percent of rivers run unimpeded by dams.\(^12\) In the long-term, dams are only temporary because they will fill up with silt. Where soil erodes easily, as in China, dams can fill with silt at 2.3 percent per year.

**Contamination**

According to the EPA, agriculture is responsible for 70 percent of river and stream pollution.\(^13\) In the US, where about half of the public water systems get water from underground, the EPA found more than 50 percent of wells sampled to be contaminated with nitrates from agricultural and lawn fertilizer, manure, sewage sludge, or septic tanks.

These sources of nitrogen also release phosphorus, which can cause eutrophication in lakes and slow moving rivers. Excess phosphorus stimulates excessive growth of algae, which, when it dies, uses up the available oxygen in the water. Lakes become green and foul smelling, devoid
of fish, and unfit as a source of drinking water. This phenomenon has long been a problem in the Great Lakes and Europe and is now occurring in South America and Southeast Asia. The mineral phosphorous naturally cycles through the soil, to plants, and then to animals many times before reaching the ocean sediments in a process that might take millions of years. But since humans began mining phosphorous, the cycle has speeded up so that the amount of the mineral in the biosphere has almost quadrupled.14

Another serious contaminant from agriculture is pesticides, which run off fields into streams and seep into ground water. More than one-third of Iowa’s population consumes water contaminated with pesticides, including cancer-causing xylene and toluene.15

Dangerous toxins are also emitted from industries and urban sewage treatment facilities. The chemical industry is the largest generator of industrial hazardous wastes. Metal fabrication and battery manufacturing emit heavy metals. Even the "clean" high tech industry has used organochlorine solvents that have seeped into groundwater, causing cancer, miscarriages, and birth defects.16 In recent years, scientists have detected chemicals in the water from personal care products and pharmaceuticals that the sewage treatment facility did not break down.

Contamination of fresh water affects both humans and wildlife. As many as 1.2 billion people lack access to clean drinking water. More than five million die of waterborne disease each year.17 (See Toxic Chemicals for types of contamination.) Pollutants, as well as low water levels and warm water from industries, are contributing to the extinction of fish. Scientists now believe that the extra limbs found on frogs and toads in the Midwest may be due to the use of fertilizers.

**Future Concerns**

According to Justus von Liebig’s law of the minimum, the amount of life in a given environment is limited by the material need that is shortest in supply. Many scientists believe that fresh water will be the limiting factor for humans.18 The UN's *Global Environment Outlook* projects that demand for fresh water will rise by 50 percent in the developing world and 18 percent in industrialized countries by 2025. At the same time, climate change is shrinking the glaciers that provide drinking water for nearly one-third of humanity. Of all the environmental security issues facing nations, an adequate supply of clean water may be the most important.19

Water is unequally distributed over the earth and unequally consumed. The average American uses 2500 cubic yards of water per year, four times as much as the average Swiss and 70 times as much as the average Ghanaian.20 By 2025, two-thirds of the world’s population is expected to be water stressed.21 The Middle East and Africa are already water-poor, and most Asian countries are likely to have severe water problems by 2025.22 The Arab-Israeli wars have been fought partly over water. Conflicts over water are likely to increase in the years ahead.

**What Is Being Done?**

The UN General Assembly has declared 2005-2015 the International Decade for Action: Water for Life with a goal of reducing the number of people without access to safe drinking water by half. This involves protecting water resources from contamination and ending the unsustainable exploitation of water resources.23 Also many nonprofit organizations are forming in response to water issues. The Blue Planet Project, a global initiative fighting for water justice, works to
secure water rights for all, develop sustainable solutions to the exploitation of water resources, and protect freshwater sources. One of its goals is a treaty that would secure water as a public resource worldwide.

Many experts see reclamation and reuse of wastewater for agricultural, industrial, and even potable uses as a way of increasing water supply. Irrigation systems can channel treated urban wastewater to agricultural areas. In Israel, 50,000 acres of land are irrigated in this fashion. Singapore now treats domestic wastewater with membrane technology and UV disinfection and then reuses it for drinking water. The city’s goal is to become water self-sufficient.

In the US, the Clean Water Act has been very effective in cleaning up rivers and lakes: 66 percent are now safe for swimming compared to 36 percent in 1970. Other promising efforts are being carried out by regional collaborations, such as a California program to halt degradation of the San Francisco Bay-Delta system, which is used for irrigation and drinking water and receives much of the state’s agricultural runoff. Eighteen state and federal agencies have cooperated to develop a 30-year plan for long-term sustainability of the estuary.

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Appendix:
Personal Practices to Save Ecosystems

1. Protecting the Ocean

**FOOD**

1. **Fish.** Use the Monterey Bay Aquarium Seafood Guide (www.seafoodwatch.org) when purchasing fish or ordering fish in a restaurant. It lists the best and worst choices based on sources that are overfished and/or caught or farmed in ways that harm marine life.

2. **Shrimp.** Avoid eating shrimp from the tropics (the large ones, sometimes called prawns) because of the threats to mangroves.

3. **Organic food.** To prevent toxic runoff into waterways, purchase organic food grown by farmers who do not use synthetic fertilizers or pesticides. If you are shopping at a farmers' market and the produce is not labeled "organic," ask the farmer what fertilizers and sprays are used.

**YARD**

4. **Soil amendments.** Use organic soil amendments, such as compost, on your yard rather than synthetic fertilizers.

5. **Pesticides.** Declare your yard a chemical-free zone; use natural methods of minimizing pests. See www.govlink.org/hazwaste/house/yard/problems.

**PURCHASING**

6. **Plastic.** Because plastic is accumulating in the ocean and harming wildlife, avoid purchasing plastic products and packaging, and pick up any plastic litter you see. Take Styrofoam peanuts to a mail order house for reuse.

**HOME ENERGY**

7. **Electricity.** Because coal-fired plants are the largest source of mercury in the ocean, reduce electricity consumption to cut mercury emissions.

8. **Other.** Because global warming threatens coral reefs and other marine life, take the actions listed on page 40, "Reducing Greenhouse and Ozone-Depleting Gases."
2. Conserving Land and Topsoil

HOME

1. **Wood.** Live in a small home to reduce the use of wood framing materials. (A 1700 square foot home requires the equivalent of clear cutting one acre of forest.) Give preference to FSC (Forest Stewardship Council) certified or salvaged wood, or select a renewable wood, such as bamboo. Avoid any exotic wood from tropical forests.

FOOD

2. **Meat.** Eat more legumes, grains, and tofu as a substitute for meat. More than six times as much land is required to support a meat-based diet compared to a vegetarian diet. Producing meat puts pressures on farmers and ranchers to overgraze, degrade soils, and fill wetlands. See www.vegsource.com.

3. **Food sources.** Grow a vegetable garden, shop at a farmers’ market, or join a CSA (Community Supported Agriculture) farm. Small, local growers put much less stress on the land than large industrial operations. Other strategies include cooking from scratch, taking your lunch to work, and inviting friends over rather than frequenting restaurants, which are more likely to purchase food from industrial farms.

4. **Organic food.** Eat organic food. Practices used by organic farmers, such as cover cropping, crop rotation, and application of compost, conserve soil better than conventional agricultural practices.

PAPER

5. **Paper reduction.** Conserve paper by (1) reducing the number of copies, (2) using both sides of paper, (3) reducing packaging by buying in bulk and taking your own reusable bags, (4) using durable towels, napkins, handkerchiefs, and diapers instead of disposables, (5) eliminating junk mail, (6) keeping magazines, and newspapers to a minimum by sharing subscriptions, and (7) using the library rather than buying books.

6. **Paper recycling.** Recycle paper and purchase recycled products, such as toilet paper and copy paper.

PURCHASING

7. **Metals.** Minimize the purchase of new products made of metals, particularly copper and gold. For jewelry, wear heirlooms, or shop at antique or pawn shops. Make sure all metals get recycled at the end of their life.

YARD

8. **Compost.** Compost both your yard debris and food scraps so that the nutrients will be returned to the soil.
3. Preserving Biodiversity and Controlling Invasive Species

HOME
1. House size. Live in a small home to preserve forest habitat. A 1700-square-foot, wood-framed home uses an amount of lumber equivalent to clear cutting one acre of forest.

FOOD
2. Meat. Reduce consumption of meat since large tracts of tropical forests are cut for pastureland or to grow livestock feed. When you do purchase meat, look for pasture-raised, local farm animals. See www.eatwild.com.

3. Seafood. To protect the diversity of species in the ocean, avoid purchasing shrimp from the tropics (the large ones, sometimes called prawns) and fish listed as "worst choices" on the Monterey Bay Seafood Guide, www.seafoodwatch.org.

4. Food variety. Eat a wide variety of plant species to encourage diverse varieties. Support small, local farms through CSAs (Community-Supported Agriculture) and farmers' markets, which are more likely to preserve a diversity of species rather than to create mono-crops.

5. Organic food. Prefer organic food. Organic farming better protects soil organisms, insects, birds, and wild plants than conventional farming does. It doesn't use genetically modified crops that threaten biodiversity. Corn, soybeans, and canola are commonly grown with genetically modified seeds.

CONSUMER GOODS
6. Paper. Reduce paper consumption to prevent cutting of more trees. More than 40 percent of logged trees are used for paper. Purchase paper with at least 30 percent post-consumer recycled content.

YARD

8. Invasive species. Learn about invasive species in your region. Google "Invasive Plant Council" or "Exotic Pest Plant Council" to find a list. Pull, cut down, or dig out exotic species that already have invaded your property. Volunteer to do the same on public property.
4. Reducing Greenhouse and Ozone-Depleting Gases

HOME

1. Home heating. Reduce the size of your living space if possible since larger spaces require more heat. In a typical home, 40 percent of energy consumption is from space heating. Arrange a home energy audit through your utility and follow the recommendations to keep heat from escaping. See energystar.gov for insulation and sealing instructions and "Anatomy of an Energy Efficient Window" on Google. Turn the thermostat down to 55° at night and when gone.

2. Hot water is the second largest energy consumer in homes. Reduce the time spent in the shower and the number of loads of laundry each week. Other strategies include installing a solar hot water system and/or tankless water heater, putting a timer on your water heater, and keeping the setting no higher than 120°.

3. Lighting is third in home energy use; one-third of this use is outdoor lighting. To reduce outdoor energy use, keep lighting to a minimum, use a motion detector so that lights go on only when someone approaches, and/or use a compact fluorescent bulb on a timer. Indoors, replace all light bulbs that are used for two hours or more each day with compact fluorescent bulbs. Turn off lights when you leave a room.

4. Appliances. Purchase the most energy-efficient appliances. New models of furnaces, refrigerators, and washing machines are significantly more efficient than those ten or twenty years old. Front-loading washing machines use about half as much energy and water as standard washers. New refrigerators also can save half the energy of old ones if you avoid models with freezers on the side, in-the-door icemakers, and water dispensers. State tax credits for the purchase of energy efficient appliances provide an added incentive. Even if you have a dryer, try to air dry clothes for six months of the year.

5. Solar power. If your home receives enough sunlight, install photovoltaic panels. Significant tax credits are available. If you are building or remodeling a home, develop a design to maximize passive solar heat. See www.eere.energy.gov/consumer/your_home/designing_remodeling.

TRANSPORTATION

6. Commuting. Since sixty-two percent of vehicle miles traveled in the US are from commuting, living close to work may be the single best strategy for reducing auto travel. Whether you live near or far, determine a way to commute by foot, bike, transit, or carpool. Even doing this three times a week will make a difference.

7. Auto trips. As an effective way to reduce trips, limit cars to one per household. When a car is not always available, single trips are reduced. Individuals put more effort into combining trips, carpooling, riding buses or lightrail, and other options such as using FlexCar.
8. **Fuel-efficiency.** If you are in the market for a new car, limit your options to those that get at least 33 miles per gallon.

9. **Airplane travel.** Keep airplane trips to a minimum. Aircraft emissions are the fastest growing transportation contributor to global warming. High altitude CO₂ emissions have a more harmful impact than emissions at ground level. Therefore the warming effect of a single individual's airplane trip across the US and back is equivalent to 15,077 passenger miles in a car (assuming 1.6 car passengers per trip and 22.23 mpg). For vacations, explore your local bioregion. Try Amtrak.

**PURCHASING**

10. **New products.** Since thirty-two percent of energy in Oregon is used by industry, keep purchases of new products to a minimum and recycle everything possible. In Oregon, recycling already saves enough energy to power 359,000 cars each year.

11. **Air conditioning.** If you have an older car with air conditioning, have it maintained at a facility with EPA-certified technicians. Air conditioning systems are inherently leaky and may be emitting ozone-depleting CFCs (chlorofluorocarbons). If all leaky systems were repaired, the release of millions of pounds of CFCs would be prevented. If you are purchasing a home air conditioner or heat pump, look for alternatives to HCFC-refrigerants, such as GENETRON A2-20, SVUA 410A, or Puron.

12. **Styrofoam.** Avoid rigid foam insulation, or purchase a type made without CFCs or HCFCs.
5. Reducing Toxic Chemicals and Air Pollutants

**PURCHASING PRACTICES**

1. **New products.** Purchase as few new products as possible since industry is the largest contributor of toxics in the environment: (a) for holidays and birthdays give services, tickets to events, or homemade gifts; (b) buy used goods at thrift stores; (c) share (or rent) tools and equipment with neighbors; (d) resist the temptation to purchase each new technology; and (e) since advertising creates demand, establish limits on children's TV time.

2. **Building materials.** To prevent persistent toxics, avoid any building materials made of vinyl, such as window frames, floors, siding, wallpaper, and piping. Watch for vinyl in consumer products as well: squeeze and inflatable toys, hoses, shower curtains, upholstery, shoes, and purses.

3. **Electronic equipment and batteries.** Minimize purchases of electronic equipment and battery-operated goods, which are likely to contain lead, mercury, cadmium, and other heavy metals. Assure that batteries and electronic equipment get recycled at the end of their lives.

4. **Household goods.** Avoid synthetic materials in carpets, furniture cushions, mattresses, other home furnishings, clothing, and coated cooking pans.

5. **Plastic packaging and disposables.** Avoid plastic products, such as Styrofoam cups, food packaging, water bottles, bags, and film: (1) keep a washable mug for coffee; (2) purchase food in bulk taking your own bags; (3) prefer stores where items are not prewrapped, such as those that have meat counters; (4) drink water from the tap and refill a reusable bottle; and (5) store food in reusable containers.

6. **Travel and yard equipment.** Purchase a gasoline- or alternative-fueled car other than diesel (even 20 percent biodiesel is much dirtier than gas). Use a push lawn mower. (The EPA estimates that using a power mower for an hour produces the same emissions as driving a car 50 miles.)

7. **Cleaning products.** For household cleaning, use basic baking soda, vinegar, and soap solutions rather than chemical formulations. See www.nwei.org/files/EcoCleaners.pdf.


**TRANSPORTATION AND HOME**

9. To reduce air emissions from fossil fuels, take the actions on p. 40, "Reducing Greenhouse and Ozone-Depleting Gases."

**INVESTMENT**

10. Invest in companies that are leaders in sustainable practices. See www.portfolio21.com or www.socialinvest.org.
6. Maintaining Clean, Plentiful Water

**HOME**

1. **Toilet.** Practice minimal flushing or purchase a low flush (1.6 gal) or dual flush toilet (1.6 and .8 gal for solid waste and liquid waste respectively). Toilet flushing accounts for over one-third of inside home water use.

2. **Cleaning.** Use basic, nontoxic cleaning products, such as castile soap, white vinegar, and baking soda rather than manufactured chemicals for cleaning. When you do purchase manufactured chemicals, read labels; they can indicate potential pollution problems.

3. **Laundry and dishes.** Use a plant-based detergent, such as Seventh Generation, Bio-Clean, or Ecover, rather than petroleum-based detergents, which often contain whiteners, fragrances, and bleaches that can harm aquatic life. For dishes use a non-phosphate detergent, such as Seventh Generation.

**FOOD**

4. **Meat.** Reduce meat consumption, especially beef. Agriculture accounts for about 75 percent of the world's water consumption. The water required to produce one pound of California beef—primarily for the irrigation needs of pasture—is equivalent to taking a five-minute shower every day for one year.

**CONSUMER GOODS**

5. **Clothing.** Purchase used clothing as much as possible. Production of synthetic fibers, pesticide use on cotton, and dying and bleaching of cloth contribute to water pollution.

6. **Household goods.** Select products made of natural materials (wool, linen, wood, ceramic, glass, and natural latex rubber) rather than synthetics to eliminate the release of persistent pollutants and endocrine disruptors into our water.

7. **Hazardous products.** Assure that products containing heavy metals, such as fluorescent light bulbs, electronics, batteries, and used motor oil are safely recycled.

**YARD**

8. **Maintenance.** Practice natural gardening in the yard rather than using pesticides and synthetic fertilizers, which run off into streams and pollute ground water. Pull weeds by hand, mulch heavily, and don't expect perfection.

9. **Lawn.** Replace grass with native or edible vegetation, such as herbs or berries. Switching from grass to shrubs or groundcovers can reduce outdoor water use by 80 percent. Or, if you live in a region that receives adequate rainfall part of the year, do not water your lawn during the dry months. Lawns require more water than other plantings. If allowed to go dormant, they become green again when the rains start.

10. **Gardens.** Use drip irrigation or soaker hoses, or water by hand only when plants need it.