Appendix B

Case Studies

Reviewing case studies is an important part of your preparation for the AP Environmental Science exam and an important part of your knowledge about global environmental issues. Case studies can help you learn about environmental concerns by providing you with perspectives on real-world concepts such as laws and treaties. On the multiple-choice section of the exam, you may be given a set of events and then asked to match the event with a provided case study. On the free-response section of the exam, you will be asked to write about a particular case and then asked to provide additional, related examples.

This section of the book describes several case studies that are common in the AP Environmental Science course.

Species

Loss of Amphibians

Although the loss of any species or group of species impacts its ecosystem, the loss of amphibians is an especially important warning sign of the decline of ecosystem health as a whole. Because of their sensitivity to environmental change and pollution, amphibians (frogs, toads, and salamanders) are considered to be indicator species, which means declining population indicates likely environmental damage. The numbers of amphibians are declining globally, and up to 200 species have gone extinct within the past 20 years. In addition to indicating ecosystem health, amphibians carry out important roles, including controlling insect populations, acting as a food source for many other species, and providing products for pharmaceuticals such as antibiotics and painkillers.

Spending portions of their lives in both aquatic and terrestrial ecosystems, amphibians are exposed to a multitude of environmental risks. Major threats come from the loss of habitat due to fragmentation of land, filling in of wetlands, development of land, and deforestation. Pollution also has a harmful impact on amphibians, as does disease, overhunting, and the introduction of predators and competitors. Global climate change alters the temperatures of regions, which can lead to drought and the drying up of standing water pools. Since amphibians depend on this water to lay eggs and for early stages of life, the loss of these watering pools affects the survival of a population and, ultimately, a species. Amphibians also require wet skin. Any weakening of the organisms from events such as long-term drought or increased pollution can devastate a population, making the organisms more susceptible to fungi, bacteria, parasites, and viruses.

There is no definitive answer to the cause of the global decline in amphibian species, but it is likely due to some combination of the listed factors working in unison. For example, climate change is warming some environments, which increases the growth of some fungi, especially the chytrid. This fungus can be lethal for amphibians and tends to proliferate in warm temperatures. With the increase in temperatures in many regions and the expanding reach of the warmer climate, the chytrid fungus has grown exponentially in many areas, killing many amphibians, and has potentially contributed to the demise of the golden toad in Costa Rica.

No matter the specific reason for decline, the increasing loss of amphibians on a global scale is a warning to humans that ecosystems are being altered and the environment is changing quickly.

Zebra Mussels: Invasive Species

With the increase in trade between nations, there has been an increase in the number of nonnative species introduced throughout the world. The impact from the introduced species can cause major economic issues, physical damage, and ecosystem alteration. For example, the zebra mussel is an invasive species that has caused major damage in the United States. Zebra mussels first arrived in North America attached to the hulls and in the ballast water of ships from Europe, populating Lake Clair in Canada in 1988, and then spreading to the Great Lakes and their connected rivers, tributaries, and lakes. The ability of their larvae to drift far in flowing water, and for

adults to attach to many structures and then be transported, allowed their quick spread. And since zebra mussels were nonnative to both the United States and Canada, they had no natural predators, competitors, or diseases in the region, allowing them to proliferate without check.

Impacts from the spread of the mussels were far-reaching. Due to their small size, the zebra mussels not only damage boats, fishing gear, and docks, but also can damage and/or clog engines and pipes. Ecosystems can be altered because mussels consume large amounts of phytoplankton and zooplankton, reducing energy available to other species, and native mollusks can be suffocated when the mussels attach to their shells. Because of the large amount of food consumed by the zebra mussels, they deposit high quantities of nutrients on the bottom, which feeds the benthic population. Too much of this, though, can lead to eutrophication of the water. Because of invasive zebra mussels, large expanses of the Great Lakes that once teemed with life are nearly barren. Zebra mussels have caused extensive physical damage, and there are high costs associated with repair of this damage and with the eradication of this invasive species.

Extinction of the Passenger Pigeon

At one time, passenger pigeons were the most abundant birds in North America, nesting in huge colonies and flying in enormous flocks, sometimes numbering over a billion individuals. Unbelievably though, the passenger pigeon is now extinct, mainly due to deforestation, leading to loss of habitat and food sources, and from overhunting. Pigeons were edible, and people also used them for other purposes, including using feathers for pillows and bones for fertilizer.

Because of the vast number of large flocks, commercial hunters could kill many birds easily, sometimes over a thousand in one hunting session. Pigeons were seen as disposable—killed freely, easily, and indiscriminately. During a 70-year period, pigeon populations declined from their historic billions to only a few thousand. Because of the breeding habits of the birds, the regeneration of the species was slow. A female laid one egg per nest per year.

The last passenger pigeon died in 1914 in the Cincinnati Zoo. This is a prime example of how humans can singlehandedly bring a species to extinction within a brief period of time.

DDT

Diphenyl-trichloroethane (DDT) is a pesticide that was widely used from 1939 until 1973, when it was found to be toxic to humans, wildlife, and ecosystems. In 1973, it was banned in the United States and eventually became illegal in many other nations as well. The author Rachel Carson raised awareness of the dangers of DDT and other poisonous pesticides with her book *Silent Spring,* published in 1962. DDT effectively kills insects including malaria-carrying mosquitoes, but the risks of its use outweigh the benefits in most situations.

Nations at extreme risk of malaria still use DDT. Despite a treaty to reduce and phase out DDT, its use will likely continue until a safer, effective, inexpensive alternative is developed. Much of the DDT used internationally is, in fact, manufactured in the United States. Unfortunately, there is a chance that when we *import* goods from these countries that use DDT, the products we import may contain trace amounts of the chemical.

The results of historic DDT use in the United States include the decline and near extinction of birds of prey such as hawks, ospreys, brown pelicans, peregrine falcons, and bald eagles. The existence of DDT in water sources led to its proliferation throughout food webs where it began to bioaccumulate in organisms and biomagnify throughout food webs. In birds of prey, the pesticide weakens egg shells; ultimately, eggs break before hatching. This led to the decline in the birds' populations, and in the case of many, helped to endanger the species.

Although DDT was banned in 1973, it has persisted in the environment and is still found in some groundwater and aquifers in the United States.

Kudzu Invasion

Kudzu is an invasive plant that was intentionally introduced in the United States from Asia in 1876 for decorative purposes and also was used as soil cover to help control erosion in much of the Southeastern United States.

Although it has helped reduce erosion problems, kudzu is a fast-growing, hard-to-kill vine and can quickly smother other plants and trees by depriving them of carbon dioxide, water, and sunlight. Kudzu photosynthesizes quickly, has the ability to fix atmospheric nitrogen, absorbs large amounts of water through its roots, and can take root in almost any soil, allowing it to frequently out-compete native species. Biodiversity can decrease and entire ecosystems can be altered due to the kudzu invasion.

Grazing has been successful in reducing and controlling kudzu populations when done regularly during growing seasons. This weakens their tissues over time, and ultimately reduces their growth. Other methods of removal include the use of herbicides and removal of the plant and its roots. Of course, all of this requires time and money. The control and removal of kudzu costs companies, the U.S. government, and individuals millions of dollars every year. The repair of damage from kudzu also contributes to the cost of the invasive species. Because of its ability to grow almost anywhere quickly, it can grow on buildings, railroad tracks, and other vegetation. The weight and the roots can damage and deteriorate these structures. Many efforts are in place to eliminate kudzu, but it is a continual and never-ending battle. In the United States, kudzu is now listed as a federal noxious weed.

Reintroduction of Gray Wolves to Yellowstone National Park

The gray wolf is native to North America and once roamed the United States in large numbers. The colonization of the country, though, brought a dramatic decline in the population of gray wolves throughout the United States. To protect livestock and large game animals, humans killed over 1 million wolves, leaving a meager population throughout the northern United States (excluding Alaska). In 1974, the gray wolf was designated an endangered species.

We now have a better understanding of the species and its importance. The gray wolf acts as a keystone species, helping to keep the ecosystem in balance by controlling the populations of prey species and by providing food for other animals such as scavengers. With the dramatic decrease in their population, herbivores such as elk and deer became more prevalent and consumed more vegetation, drastically decreasing vegetation in areas including Yellowstone National Park. Vegetation loss led to soil erosion, loss of ecosystem niches, and less food for herbivores.

Noticing this ecosystem decline, officials decided to reintroduce gray wolves to Yellowstone National Park. In 1995, gray wolves were relocated to the park from Canada and the reintroduction began. Populations increased over time, and the ecosystem of the park started to rebalance back to its previous state. Having fewer large herbivores increased vegetation along streams, leading to an increase in beaver populations. More kills by the wolves meant more food for scavengers. And more wolves also meant more coyotes killed by the larger wolf, leading to an increase in smaller animal populations such as foxes and rodents.

Because of the success of the reintroduction, gray wolves were downgraded to threatened status in 2003.

California Condor

California condor numbers declined dramatically in the 20th century as result of habitat destruction, lead poisoning from consuming lead shot while scavenging hunting remains, poaching, and the inability of the birds to adapt to the changing environment caused by humans. In 1987, there were 22 remaining wild condors—7 in the wild and 15 in captive breeding programs. The last remaining condors in the wild were captured to expand the breeding programs at the San Diego and Los Angeles zoos. The San Diego Zoo's population was moved to the San Diego Wild Animal Park. The birds' DNA was tested so that the most unrelated birds could be mated to avoid over-similarity in the gene pool.

As the population in the two zoos grew, additional breeding programs were established, including in the Oregon Zoo and at the World Center for Birds of Prey in Boise, Idaho. Beginning in 1991, condors were released in California; in 1996, they were released in Arizona. Currently, wild condors can be seen in three sites in California; at Zion National Park in Utah; in the Grand Canyon area in Arizona; and in Baja California, Mexico. As of August 2010, there are 384 birds, including 188 in the wild. However, the birds continue to struggle to reproduce in the wild.

The California Condor recovery project is the most expensive species conservation project in U.S. history, costing over $35 million including $20 million in federal and state funding. Several milestones have been reached in the wild. In early 2007, a condor laid an egg in Mexico for the first time since the 1930s, with a second egg being laid in 2009.

Special note: Several sources suggest that DDT has played a role in the decline of the California condor. On the 2003 APES, the use of DDT as an explanation for the decline of the California condor *was not allowed.*

Water

Lake Erie Waste Dumping

By 1969, Lake Erie was generally regarded as dead due to a low amount of dissolved oxygen, high pollution concentrations, and large amounts of algae. The lake is surrounded by a large number of major cities, each contributing sewage and industrial wastes. Detroit was the capital of the automotive industry, Cleveland had petrochemical and steel industries, Toledo had steel works, Erie had paper mills, and chemical manufacturing took place in Buffalo. By the 1960s, the area was home to 9 million people on the U.S. side of Lake Erie. Partially treated waste was commonly discharged into the lake, and another 2 million people had septic-tank waste systems with waste that also frequently reached the Lake. By the 1960s, fish die-outs in the lake were common.

Changes were made in local and federal laws that reduced the waste dumped into Lake Erie. High-phosphate detergents were banned in several surrounding states, industrial waste dumping was put under strict controls, and municipal sewage was extensively treated before being discharged into the lake. As a result, it is making a comeback. The dissolved oxygen levels are improving, the algae are decreasing, and some game fish have been reintroduced. Beaches that had been closed for decades have reopened. The improvement is great but not complete.

St. James Bay Hydroelectric Dams

The St. James Project is a series of hydroelectric dams built in Quebec, Canada, since 1974. The eleven hydroelectric power stations are built on four rivers.

The four rivers affected directly by dams, and several rivers' waters were diverted into the major rivers to increase their flow. For example, the La Grande River's flow was substantially increased while the downstream flow of diverted rivers was decreased by as much as 90 percent, drastically affecting ecosystems. Major portions of the local boreal forest have been submerged behind the dams along the rivers. The waters in the affected areas fluctuate, filling shorelines with dead trees; shoreline plants are destroyed as well. The area is subject to earth tremors caused by the weight of the artificial rivers and reservoirs behind the dams, resulting in a shifting of rocks. There is the potential for great harm to the local population and the surrounding environment as fault lines are now present in the valley.

Other changes to the ecosystem include the decline of salmon spawning in the area as dams built in some areas block fish migrations, and other rivers' flow rates have been reduced, doing away with spawning sites altogether. Beaver habitats have been dislodged as the rivers and streams that fill the rivers have been altered. Migrating herds of caribou and flocks of Canadian geese and other migrating birds have been affected as the shores of the James and Hudson bays have been altered.

Gulf of Mexico's Dead Zone

Both the Mississippi and Atchafalaya rivers empty into the Gulf of Mexico, carrying with them the pollutants and nutrients they pick up along their courses. These pollutants include fertilizer, untreated sewage, deposition from fossil-fuel combustion, runoff from streets, and discharge from industries.

Every spring, the wealth of nutrients introduced into the Gulf of Mexico creates a great bloom in algae and plankton populations. However, with the increase in life is also an increase in death and decomposition, during which bacteria use oxygen. Over time, this depletes an aquatic ecosystem of dissolved oxygen and the area becomes hypoxic. Lack of oxygen affects all other organisms in the area. So, the organisms die or leave the area. Ultimately, this creates a dead zone, where there is no life.

Although one of the largest in the world, the Gulf of Mexico dead zone is not the only one. In fact, there are now over 400 dead zones found throughout the world. This number has doubled since 2000. Since such an area becomes

devoid of life, the ecosystem ceases to function and must start over again when the oxygen levels return to normal levels. Economically, dead zones cost fishermen income and also can affect tourism dollars.

Aral Sea

In the middle of central Asia in both Uzbekistan and Kazakhstan (once part of the former Soviet Union), the Aral Sea was once the fourth largest inland body of water in the world. Although it has always been a saline lake, it has progressively become more saline and has also been dramatically depleted due to diversion of water from the two rivers that empty into the lake, for use in irrigation in this hot, dry, drought-ridden region. The lake's volume has decreased by 75 percent, and its salinity has increased dramatically. Instead of being one large lake, the Aral Sea has been separated into three smaller lakes due to the extremely low water levels.

The ecosystem now cannot support the same amount of life and biodiversity it once could. Much of the wetlands have been lost, which in turn decreased the habitats for birds and small mammals, as well as native fish in the lake. In fact, all fish species once found in the Aral Sea have gone extinct or have been extirpated due to the extreme salinity levels, and plants and animals living on the surrounding land have vanished from the area or become extinct as well. The economic impact also has been extreme. The fishing industry that once depended on the sea is now nonexistent.

The extensive size of the Aral Sea once regulated the region's climate, helping to keep summer heat and winter cold to moderate temperatures. With the loss of such a high portion of the water from the lake, though, the regional climate is not moderated, leading to hotter and drier summers and colder winters. This has shortened the growing season and reduced crop yields.

One surprising consequence of the dropping water level in the Aral Sea is increased pace of snow melt in the Himalayas, in part because of the salty dust that blows from the dried-up Aral Sea and gets deposited on the mountains. The salty dust affects crops, vegetation, and wildlife. There is also an increased use of chemicals such as fertilizers and pesticides to help the growth of crops on the deteriorating soils. These chemicals, as well as contamination from the increasing population in the area, percolate down to the groundwater, the sum of which impacts human health.

Efforts are being made to improve the health of the ecosystems and of people through increasing flow back into the Aral Sea, implementing more efficient ways to irrigate the lands, purifying groundwater for consumption, using crops that are less water-dependent, and creating wetlands to reinvigorate life at the water's edge. Promises of a renewed Aral Sea are starting to be seen, including a return of fish to the lake. Although some parts of the past Aral Sea are forever damaged, there is hope that most of it will eventually return to a productive and thriving ecosystem.

Three Gorges Dam

The building of the Three Gorges Dam, the world's largest, was controversial and problematic. Completed in 2009 on the Yangtze River in China, the dam is being used to provide hydroelectric power throughout the country. Unfortunately, its construction displaced at least 1.2 million people, as their towns and cities were flooded when the reservoir was filled, and it flooded priceless archeological sites. The potential for water pollution in the reservoir also exists, since many industrial and agricultural areas, mines, and waste sites were also flooded. These pollutants can affect not only water, but also bottom sediment and surrounding lands. Because of the dam, there is less downstream flow of water, which reduces the natural recycling and cleaning processes that remove chemicals and contaminants. Also, from the slowed water flow of a reservoir, more sediment is deposited on the bottom, which can build up over time and slow shipping and block flood control gates.

Ecologically, the Three Gorges Dam presents another set of issues and threats. Upstream, in the flooded areas, cropland and forests have been lost. Downstream of the dam, there is less nutrient-rich sediment being deposited in the benthic environment, altering the nutrient availability for organisms. The dam also has disrupted the spawning and migration patterns of some fish below the dam. At the mouth of the Yangtze River, where it runs into the East China Sea, there has been increased saltwater intrusion into the drinking water due to the decreased water flow of the river pushing outward. With less freshwater being held in the groundwater, the saltwater from the ocean seeps in, taking its place. When the reservoir started filling, there were numerous landslides on its banks, with the slippage of large amounts of earth into the water creating huge waves.

However, the ecological impact of the Three Gorges Dam project is not all bad. For example, it has the ability to generate cleaner energy for at least 10 percent of China's population, from the largest hydrostation in the world. It is reducing air pollution and carbon dioxide emissions from fossil fuel combustion (mainly coal) and will also diminish China's reliance on imported energy. Commerce ships and commercial fishing boats can travel a considerable distance along the river. Seasonal flooding downstream has been lessened as well, while water available for irrigation for land below the dam has increased.

The controversy over the building of the Three Gorges Dam will continue well into the future, as there are no definitive answers and the pros and cons are both valid.

California Water Project

With the growth of Southern California, especially including Los Angeles and San Diego, the demand for freshwater in the region has increased dramatically. Since Southern California is in an arid and semiarid climate without a large natural freshwater source, a water diversion project was constructed, diverting water from other parts of California to meet the needs for Los Angeles and the rest of the Southland. A huge network of aqueducts, pipelines, pumps, and dams was built to transfer water from northern and eastern California and Arizona to Southern California. Starting in 1916, water was diverted from the Owens River Valley and then from the Colorado River. Then in 1941, due to a continually expanding population, a new aqueduct was added to the Owens Aqueduct, bringing water from Mono Basin north of the Owens Valley. In the 1950s, the aqueduct was expanded once again to access water from Northern California.

The massive diversion and consumption of water from these regions has had a devastating impact on the local ecosystems, including the drying of Owens Lake and subsequent desertification of much of the Owens Valley. Lack of water traditionally used for agriculture sparked anger and violence from local farmers, and resulted in the farmers sabotaging part of the aqueduct in 1924. Los Angeles was taking their water and destroying their lives and their livelihood. Farmers' concerns failed to stop water diversion; in fact, even more was taken, as groundwater was eventually also pumped to feed the aqueduct.

The Mono Basin experienced a similar fate. Water from the creeks that fed Mono Lake was diverted to the aqueduct, thus reducing water flow into the lake. The water level dropped and became more saline and alkaline (basic). This change in the water led to dramatic ecosystem alteration in and around Mono Lake. For example, brine shrimp populations declined and migratory bird populations left the area. Because of the drop in water level, a land bridge was exposed, making the eggs of some nesting birds easy food for some predators, impacting the birth rate of species such as the gull.

In 1994, pointing to the devastation of the Mono Basin, the Audubon Society and the Mono Lake Committee (among other concerned groups), were able to gain protection for Mono Lake and its streams. The water level has since risen and the potential for drought and desertification were avoided.

However, the Owens Valley and Owens Lake were slower to gain protection. After extensive court battles and litigation between the city of Los Angeles and the Owens Valley, in 2006 courts ordered that some water be returned to the Valley. The river is now flowing and the aquatic ecosystem and the land along its banks is returning to life, slowly.

Human

China: One-Child Policy

In 1979, China was experiencing food shortages and famine, so it instituted a "one-child" policy to reduce stress on the food supply. This policy required that people of the ethnic Han majority in China have only one child. This law does not apply to minority groups or many rural areas. Among other penalties, the consequences of having more than one child without a permit is a heavy fine. There have been reports that people have lost jobs, land, livestock, healthcare, and other privileges. Forced abortions and sterilizations are also said to have occurred, and extensive measures have been taken to collect unpaid fines. Couples who delay childbearing or who have only one

child are rewarded in various ways, including longer maternity leave, higher salaries, better healthcare, and priority in school enrollment.

Because of social and cultural pressures, many Chinese families prefer a male child. This combined with the opportunity to have only one child, leads to prenatal sex discrimination, in which a high number of female children are aborted. In an attempt to alleviate this issue, it is now illegal to determine the sex of a baby prior to birth, although some places still offer this practice illegally. Male preference has altered China's sex ratio, which is now 120 males for every 100 females, leaving many males without partners.

While low or declining population growth has many benefits, there are negative consequences as well. Because there are fewer working-age individuals and more elderly, there is more pressure on younger people to take care of their aging parents. There is also a smaller labor market and fewer people to enter the military. The aging population also takes an economic toll, as more money is required to care for the retired and elderly.

The "one-child" policy has seen great success in reducing the population and growth rate in China. It has also reduced pressures on food supplies. Economic stability is prevalent as people have been able to spend and invest money rather than spending it on child rearing. Because of its success, the "one-child" policy has been reinstated for at least the next ten years.

Easter Island: Tragedy of the Commons

The civilization of Easter Island ended due to destruction of the local environment. Off the coast of South America in the Pacific Ocean, Easter Island was once covered with dense forest and, until 2,500 years ago, was home to a thriving society. Unfortunately, the people who lived on Easter Island overused their resources—namely, the timber—and started to deplete their supplies.

The trees provided shelter, fuel, tools, boats, and nets, and were used for many other functions, providing the basis of the civilization's survival. As timber became scarce, people were unable to make canoes and rope, which affected their ability to fish and travel away from the island. When resources were depleted even further, food sources declined. With a lack of vegetation and trees, freshwater levels declined, erosion became prevalent, and crop yields declined. Famine spread, fueling both the death of the islanders and fighting over the remaining food and resources. Eventually, clashes and theft became commonplace. When the remaining people were found on Easter Island in 1722, they were living in caves, hungry, on treeless land.

The decline of the civilization on Easter Island is an example of a "tragedy of the commons," in which an unregulated resource is overexploited and used unsustainably, ultimately depleting the resource beyond recovery. Because it is in every individual's best interest to exploit rather than conserve, over time resources are lost and all suffer. There are many modern examples of tragedies of the commons.

Biosphere 2

To help further study the interconnectedness of agents within ecosystems, and the ecosystems themselves, a man-made closed, self-contained network of ecosystems was created with the intention of having eight people live there for two years. This facility, called Biosphere 2, was started outside Tucson, Arizona, in 1991. Designers imagined that the ecosystems would naturally recycle air, nutrients, and water necessary for survival for all living organisms found in Biosphere 2. It included more than 4,000 organisms making up a savanna, tropical rain forest, desert, freshwater and saltwater wetlands, an ocean with a coral reef, and lakes and streams.

Unfortunately, the extensive planning failed to correctly predict the complicated interactions, and carbon dioxide levels quickly rose to toxic levels, as oxygen was consumed quickly by bacteria in the soil. Nitrogen oxide also rose to toxic levels. Both the carbon cycling and nitrogen cycling were failing. Due to unpredicted levels of cloudiness in Arizona, photosynthesis levels dropped. Also, excess nutrients ended up in the water supply as nutrients were leached from the soil. Species extinctions also occurred rapidly and in large numbers. Insects were killed off by local ants that entered the facility from the outside ecosystem; most pollinators eventually died off and 19 small animal species went extinct, as did some bird species. Other species became pests, proliferating in the environment. These included

cockroaches and vines. Although there were many roadblocks and difficulty in growing crops, the inhabitants were still able to produce 80 percent of their food supply.

The human occupants were able to survive in the closed environment for the entire two-year plan for the project, despite the setbacks, and without the desired complete closure to outside influences. A leading-edge experiment, Biosphere 2 served as a basis for many unique studies and research. The experiment also demonstrates the massive complexity and non-replicable structures of Earth's natural ecosystems.

Events

Bhopal Chemical Disaster

Union Carbide Chemical Co., Bhopal, India, created what is often referred to as the Bhopal disaster or Bhopal gas tragedy. The Bhopal disaster is history's worst chemical industrial catastrophe. A leak of methyl isocyanate (MIC) gas and other chemicals developed on the night of December 2, 1984, exposing several thousand people to the toxic fumes and chemicals. The official immediate death toll related to the release of the gases was 2,259 and the confirmed death toll was 3,787. Other agencies estimated the death toll at 15,000. In 2006, the government confirmed that the leak, in fact, caused 558,125 fatalities.

Chernobyl Nuclear Disaster

The Chernobyl disaster is the worst nuclear reactor disaster in history. Although the city of Chernobyl was part of the Union of Soviet Socialist Republics (USSR) until 1991 when the USSR dissolved and Chernobyl became part of the Ukraine. The disaster occurred on April 26, 1986, when reactor number four suffered a power output surge during an unauthorized system test. When an attempt was made to perform an emergency system shutdown, a more extreme power output spike occurred, which ruptured the reactor vessel and caused a series of explosions. The graphite moderator was exposed to the air and ignited. The resulting fire sent a plume of radioactive fallout into the atmosphere, covering an extensive area. Over 350,000 people were eventually evacuated from the worst contaminated areas. Twenty-eight emergency responders died in 1986 from Acute Radiation Syndrome and 19 more died later as a result of exposure. It is estimated that 4,000 deaths will ultimately be attributed to the accident due to increased cancers.

Cuyahoga River Fire

The Cuyahoga River is located in northeast Ohio and is most famous for being "the river that caught fire." In fact, there have been 13 reported fires on the river—one of the country's most polluted—the first being in 1868. The largest fire occurred in 1952, causing over $1 million in damages. On June 22, 1969, the river caught fire again, this time making national news when *Time* magazine described it as the river that "oozes rather than flows." The river was filled with chemicals from the many manufacturers along its banks. The 1969 Cuyahoga River fire helped spur water control legislation that resulted in the Clean Water Act, the Great Lakes Water Quality Agreement, and the creation of the federal Environmental Protection Agency.

Deepwater Horizon Oil Spill

The *Deepwater Horizon* oil spill (also referred to as the BP oil spill or the Gulf of Mexico oil spill) was a major oil spill in the Gulf of Mexico that flowed for approximately three months in 2010. The broken well was capped, but the impact of the spill continued. It is the largest accidental marine oil spill in the history of the petroleum industry. The spill originated on April 20, 2010, when the *Deepwater Horizon* drilling rig exploded. The well was capped on July 15, 2010, but not before an estimated 5 million barrels of crude oil had been released. The spill caused extensive damage to the marine life in the Gulf of Mexico and the habitats along the coast.

The spill created a threat to the environment due to the toxicity of the petroleum, depletion of dissolved oxygen, and the use of the oil dispersant, Corexit. Eight U.S. National Parks in the area are threatened. More than 400 species live

in the islands and coastline of the mainland, and 8,332 species live in the Gulf spill area, including four species of sea turtles, 1,200 fish, 200 birds, 1,400 mollusks, 1,500 crustaceans, and 29 marine mammals. As of August 13, 2010, 4,678 dead animals had been collected. The oil spill has also had a harsh impact on the local fishing industry, tourism industry, and other businesses dependent on the Gulf.

Exxon Valdez Oil Spill

The *Exxon Valdez* tanker struck a reef in Prince William Sound on March 24, 1989. The oil tanker was bound for Long Beach, California, when it ran aground and spilled 260,000 to 750,000 barrels of crude oil. It is considered to be one of the worst environmental disasters caused by humans. It was the largest oil spill in U.S. waters until the *Deepwater Horizon* oil spill in the Gulf of Mexico in 2010, although the spill ranks low on the list of worldwide spills.

The *Exxon Valdez* oil spill occurred in a very remote location with limited access. The area was accessible only by boat, plane, or helicopter, which made it difficult to respond to the spill. Clean-up efforts also were hampered by the amount of coastline, rocky coves and inlets, and cold temperatures. The spill covered 1,300 miles of coastline and 11,000 square miles of ocean. The region is a major habitat for salmon, sea otters, seals, and seabirds. The immediate effects included the estimated deaths of 100,000 to 250,000 seabirds, at least 2,800 sea otters, approximately 12 river otters, 300 harbor seals, 247 bald eagles, 22 killer whales, and billions of salmon and herring eggs.

In response to the oil spill, the U.S. Congress passed the Oil Pollution Act in 1990. The law included a gradual phase-in of double-hull ships that provide an additional layer between the oil tanks and the ocean. The law includes a provision that prohibits any ship that has caused an oil spill of more than one million gallons in any marine area from operating in Prince William Sound.

Fukushimi Daiichi Nuclear Disaster

The most recent global nuclear event occurred at the Fukushimi Daiichi plant in Japan as a consequence of an offshore earthquake and resulting tsunami. The plant was damaged after the earthquake, aftershocks, and a tsunami impacted the costal facility, rendering it nonfunctioning. Multiple hydrogen explosions occurred as well, weakening the structure even further.

At the time of the writing of this book, the nuclear disaster is still not under control. Due to the damaged instruments and the danger of entering the reactors, it is not yet known what is actually happening inside and if nuclear fuel is leaking out of the core. Radiation levels are being monitored throughout the entire country and globally to ensure radiation is not increasing to harmful levels in both the atmosphere and ocean. Residents have been evacuated within a 12-mile radius of the nuclear plant. Because there is still so much unknown about this disaster and the seismic activity in the region near Japan continues, the short-term and long-term consequences and impacts on ecosystems, human health, and the economy are still unknown.

Hurricane Katrina

Hurricane Katrina was one of the deadliest hurricanes in U.S. history, and one of the costliest. At least 1,836 people died in the hurricane and the resulting floods, and total property damage is estimated at $81 billion. The Category 3 storm made landfall on the morning of August 29, 2005, in southeast Louisiana, causing damage from central Florida to Texas. The worst-hit area was between New Orleans, Louisiana, and Biloxi, Mississippi. Most life was lost in New Orleans, which flooded as the levee system failed and waters from Lake Pontchartrain combined with the waters from the storm, flooding 80 percent of the city and most of the local parishes.

Hurricane Katrina also had a profound effect on the environment. The storm surge caused substantial beach erosion, and several barrier islands were moved closer to the coastline. The Chandeleur Islands region was damaged the year before by Hurricane Ivan and was completely eliminated by Hurricane Katrina and Hurricane Rita. The lands that were lost were breeding grounds for marine mammals, birds, turtles, and fish. Over 20 percent of local marshlands were permanently covered with water from the storm. Breton National Wildlife Refuge lost half its area in the storm. This was vital habitat for several sea turtle species, the Mississippi sand hill crane, red-cockaded woodpecker, and the Alabama beach mouse.

The marshlands along much of the Gulf coast had been filled in for use as farmland and for the construction of towns and cities. Previously, the natural marshlands helped provide a natural protection for the coastline by absorbing much of the energy from hurricanes. But with the marshlands filled in, hurricanes can travel further inland where they can create more damage.

Kissimmee River Dredging

The Kissimmee River originally stretched 103 miles between Lake Kissimmee and Lake Okeechobee. The river is a major drainage system for the Florida Everglades ecosystem. During the 1947 hurricane season, two major hurricanes produced heavy rain and flooding in most of central and southern Florida. Florida requested assistance in controlling future floods and, in 1954, the U.S. Congress authorized the canalization of the river. From 1962 to 1970, the U.S. Army Corps of Engineers dredged a straight canal down the length of the twisting Kissimmee Valley, shortening the 103-mile distance between the two lakes to 56 miles.

The project damaged the river and surrounding lands, including parts of the Everglades. The fast-moving water sped the process of draining the surrounding land, which dried faster than rains replaced the water. As a result, 40,000 acres of floodplain below Lake Kissimmee dried out, reducing waterfowl habitats by 90 percent, and reducing the number of herons, egrets, and wood storks by two-thirds. Largemouth bass populations also declined. Prior to the channelization, the Kissimmee was not a major source of pollution to Lake Okeechobee. But without the winding distance and slow flow, surrounding lands were not able to effectively filter river water. In the 1970s, the straightened river contributed 25 percent of the nitrogen and 20 percent of the phosphate of the lake's pollutants.

As scientists began to realize the environmental damage of the straightened river, efforts were proposed to return the oxbows that slowed the water flow. In 1992, Congress approved efforts to restore the Kissimmee River to its original flow and modifications began in 1997, with the goal of completing the project by 2011, with 43 miles to be restored. Wildlife has returned to much of the restored sections of the river. Sandbars have returned, dormant plants have reestablished themselves, increased levels of dissolved oxygen in the water have increased populations of insects, mollusks, and crayfish, which, in turn, have increased the populations of fish, birds, and alligators. The entire food chain has benefited from the restoration. The Kissimmee River restoration is considered to be one of the world's rare successes of ecosystem restoration.

London Fog Air Pollution

The London Fog, also referred to as the Great Smoke of 52 or the "Big Smoke," was a severe air pollution event that occurred from December 5 to December 9, 1952. The event occurred as a result of increased coal burning during periods of cold weather, combined with windless conditions that allowed airborne pollutants to collect.

At the time, it was not thought to have been a significant event—London had experienced other smog events in the past. But in the following weeks, medical reports estimated that 4,000 had died and 100,000 became ill due to the effects of the smog on the respiratory system. Recent research suggests that the actual number of fatalities was probably closer to 12,000. The event led to several changes, including the U.K. Clean Air Act of 1956.

Love Canal Waste Dumping

William Love envisioned a canal connecting the two levels of the Niagara River that were separated by the Niagara Falls. He believed that such a canal would provide much needed hydroelectric power to the area, and later he envisioned a shipping lane that would bypass the falls and reach Lake Ontario. Love dug a canal approximately 1 mile long, 50 feet wide, and 10 to 40 feet deep before he stopped. The canal filled with water and became a swimming hole in the summer and a skating pond in the winter.

In the 1920s, the canal became the dumping site for the municipality of Niagara Falls. In 1942, Hooker Chemical Company was granted permission by the Niagara Power and Development Company to dump waste in Love Canal. The canal was drained and lined with thick clay. Hooker placed 55-gallon metal barrels full of hazardous chemicals

in it, which were buried 20 to 25 feet deep. In 1947, Hooker purchased the canal and a 70 foot-wide bank on either side of the canal. The dumpsite was closed in 1953. During the time the canal was open, 21,000 tons of chemicals were added to the canal dumpsite. The canal was covered with a clay cap and then a layer of topsoil. Vegetation began to grow atop the dumpsite.

The local school board purchased the site shortly after it was closed due to an increase in the population of Niagara Falls. The Hooker Chemical Company initially tried to tell the school district of the chemicals below the surface but the district refused to believe the company and nevertheless proceeded to purchase the land. In the agreement, Hooker included a section that explained the site's potential dangers. In so doing, Hooker believed they were releasing themselves from all liability. Despite the disclaimer, the board began construction of a new school in 1954 on part of the site. The city of Niagara Falls constructed sewers for a home development, also on a part of the site. While building the sewer system, construction crews broke through the clay cap and breached the canal walls. Additionally, dirt was moved from atop the cap for fill in other locations, and holes were punched to build water lines and a highway. This allowed toxic wastes to escape into the surrounding areas when rainwater flowed through the toxic dump.

In the summer of 1978, an informal door-to-door survey showed a higher than normal number of birth defects and other anomalies near the dump. The New York State Health Department followed up with the initial findings to discover a high number of miscarriages. The dumpsite was declared an emergency on August 2, 1978, and limited evacuations were ordered. Further testing revealed the size of the dumpsite to be larger than originally thought and the evacuation zone was enlarged. Of the children born between 1974 and 1978, 56 percent of them showed some signs of birth defects. Of the 900 families in the area, over 800 were forced to move or chose to move out of the area.

Santa Barbara Oil Spill

The Santa Barbara oil spill occurred in January and February of 1969 in the Santa Barbara Channel. It was the largest oil spill in U.S. waters until the *Exxon Valdez* in 1989. The source of the oil spill was a blowout on January 28, 1969, on Union Oil's Platform A. The well was capped within minutes but rupture of the ocean floor allowed an estimated 80,000 to 100,000 barrels of crude oil to spill into the channel and eventually drift onto beaches from Goleta to Ventura and the northern shores of four Channel Islands. The spill had an impact on marine life in the channel, killing thousands of sea birds, and marine mammals such as dolphins, elephant seals, and sea lions. The coverage by the media ultimately resulted in numerous environmental legislations over the next several years, forming the framework of the modern environmental movement in the United States. The oil spill, along with other events, helped create legislation that led to the formation of the Environmental Protection Agency, as well as policies including the National Environmental Policy Act and the Clean Water Act. In California, the California Coastal Commission was formed and the California Environmental Quality Act (CEQA) was passed in response to the Santa Barbara oil spill.

Three-Mile Island Nuclear Disaster

Caused by a loss of reactor coolant, the Three-Mile Island accident was a partial core meltdown in a pressurized water reactor on March 28, 1979. It is the worst nuclear accident in U.S. history. The accident released 13 million curies of radioactive gases but less than 20 curies of the dangerous I-131 (iodine-131) isotope. The initial mechanical failure was followed by human failure to quickly recognize and correct the problem. In the end, the reactor was brought under control and a total meltdown was avoided. Studies concluded that the amount of released radioactive material was small. Studies also predicted an undetectable increase in cancer cases.

Public reaction to the event was probably influenced by the release of the movie *The China Syndrome* 12 days before the accident. The movie depicted an accident at a nuclear power plant. The accident at Three-Mile Island crystallized the anti-nuclear movement in the United States and was a contributing factor in the decline of new reactor construction.