ENVIRONMENTAL QUALITY

25th ANNIVERSARY REPORT

THE COUNCIL ON ENVIRONMENTAL QUALITY

Environmental Quality

The Twenty-fifth Anniversary Report
of the Council on Environmental Quality

Printed on Recycled Paper

This report will be available on the White House web site (http://www.whitehouse.gov/CEQ).

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ACKNOWLEDGMENTS

This edition of Environmental Quality, the 25th in the series, focuses broadly on environmental developments over the past quarter century and more specifically on developments in the 1994-95 period. A few notable developments that occurred in 1996 are mentioned here briefly; they will be discussed in more detail in the 1996 report.

Under the direction of CEQ Chair Kathleen McGinty, Chief of Staff Shelley Fidler and Deputy Chief of Staff Wesley Warren, this edition was edited by Robert Livernash, who also served as the primary author. Carroll Curtis coordinated data collection and prepared the figures and tables.

Many individuals assisted in drafting chapters. In particular, we wish to acknowledge: Carolina Katz of the World Resources Institute, for the chapters on environmental justice and the environmental aspects of human health; Harvey Doerksen of the Interior Department, for the chapter on ecosystems; Michalann Harthill of the Interior Department, for the chapter on biodiversity; Kurt Zwally of the Department of Energy, for the chapters on climate change and transportation; Brad Hurley, for the chapter on ozone; Nilda Mesa of CEQ, for the chapter on the National Environmental Policy Act; and Dinah Bear of CEQ, for the chapter on forestry.

The review process was skillfully coordinated by Barbara Matzner and Nancy Carson, along with CEQ interns Nancy Yeager, Manlio Goetzl, Michael Terrell, and Glen Babcock. Carolyn Mosley provided invaluable administrative support. Editorial assistance was provided by Roseanne Price and Nita Congress. Roseanne Price, Rosemarie Philips, and Barry Walsh helped in the revision of several chapters.

At the White House Publishing Branch, Steve Jewell and Bill McIntosh coordinated the preparation of the manuscript for printing, and Tina Robertson did the design and typesetting. The cover design was created by Antonia Walker.

We would like to thank the members of the Interagency Committee on Environmental Trends (ICET), especially Charles Terrell from the Department of Agriculture and Tim Stuart from the Environmental Protection Agency, for their assistance in coordinating chapter reviews.

We also wish to thank Ray Clark of CEQ, who supervised the early planning for the report, and Holly Kaufman, who initiated the writing of the report and conducted a series of background interviews with former CEQ chairs and other leading environmental figures, which helped us think about the past 25 years of environmental protection.

TO THE CONGRESS OF THE UNITED STATES:

I am pleased to transmit to the Congress the Twenty-fifth Annual Report on Environmental Quality.

As a nation, the most important thing we can do as we move into the 21st century is to give all our children the chance to live up to their God-given potential and live out their dreams. In order to do that, we must offer more opportunity and demand more responsibility from all our citizens. We must help young people get the education and training they need, make our streets safer from crime, help Americans succeed at home and at work, protect our environment for generations to come, and ensure that America remains the strongest force for peace and freedom in the world. Most of all, we must come together as one community to meet our challenges.

Our Nation's leaders understood this a quarter-century ago when they launched the modern era of environmental protection with the National Environmental Policy Act. NEPA's authors understood that environmental protection, economic opportunity, and social responsibility are interrelated. NEPA determined that the Federal Government should work in concert with State and local governments and citizens "to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans."

We've made great progress in 25 years as we've sought to live up to that challenge. As we look forward to the next 25 years of environmental progress, we do so with a renewed determination. Maintaining and enhancing our environment, passing on a clean world to future generations, is a sacred obligation of citizenship. We all have an interest in clean air, pure water, safe food, and protected national treasures. Our environment is, literally, our common ground.

William J. Clinton

THE WHITE HOUSE

STATEMENT FROM THE CHAIR

Twenty-five years ago with the passage of the National Environmental Policy Act (NEPA), our nation's leaders understood the need to bring people together to face our common challenges. NEPA declared that the federal government should work in concert with state and local governments and the citizens of this great Nation "to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans."

After all, the environment, as President Clinton has said, is literally our common ground. Our families and communities have a common interest in protecting it, and there is no doubt we have made great progress in 25 years. Our air and water are cleaner, our children are healthier, and we have put more land into conservation.

Over the past 25 years, we have also engaged in a national dialogue about the best ways to protect the environment. In the course of this dialogue, we have all learned something. We have come to appreciate NEPA's prescience in emphasizing widespread participation in the decisionmaking process and in taking a wider view of environmental problems. Fittingly, this 25th anniversary edition of the CEQ annual report looks back over the past 25 years to consider what we have done and where we are heading.

For 25 years, NEPA has been at the forefront of our nation's efforts to protect the environment. When national forest mismanagement threatened communities in the Pacific Northwest, we used NEPA to solve the problem. The President's Northwest Forest Plan works because of the collaboration of five federal agencies, the states of Washington, Oregon and California, local governments, tribes and people in the region—collaboration done under the NEPA umbrella. NEPA helped us develop an ecosystem-based forest management plan and an economic assistance plan that protect our natural heritage and provide a stable economic future for the people of the region.

But despite all of our progress in 25 years, our common ground—the environment—has become a battleground. Somehow, nearly half of the Environmental Protection Agency's work is not the product of our collective will on the environment, but rather, the product of judicial decree. Somehow, we have become a country in receivership, with the courts managing our forests, our rivers and our rangelands.

President Clinton and Vice President Gore are determined to find a better way. The Administration is building an environmentalism where government acts as a partner, not just as a policeman. The Administration is moving toward collaboration, not just endless confrontation.

Consider the Endangered Species Act. It is designed to be preventive medicine, but too often in the past it has been misused as emergency medicine. It is supposed to be about enriching wildlife habitat, but too often in the past it has been about desperate measures taken in crisis at the last moment as the last of a particular species teeters on the brink of extinction. By failing to look ahead, our nation's leaders failed faithfully to execute the Act and invited "train wrecks" that unnecessarily pit short-term economic interests against the environment.

This Administration has taken a different route. Rather than allowing crises to build, we're getting out ahead of the curve. We are reaching out to private landowners in partnership and helping them to be good stewards of the land. With 70 percent of critical wildlife habitat on private land, we have to work with—not against—private landowners to protect fish and wildlife. We are doing that with Habitat Conservation Plans (HCPs), voluntary agreements that enable us to preserve the land and protect wildlife while giving landowners the certainty they need to effectively manage their land. The Administration has completed 170 HCPs and is currently negotiating nearly 300 more all across the country. This compares to just 14 that were in place when President Clinton came into office. With these agreements, we are avoiding the train wrecks that might otherwise have been just around the bend.

As the agencies go about the habitat conservation planning process, NEPA—with its emphasis on public review and comment—is the umbrella under which they work. The challenge of harmonizing our economic, environmental and social aspirations, important throughout CEQ's history, is today more pressing than ever. By bringing people together rather than driving them apart, we can unleash the good will, the creative energy, the enthusiasm and drive that are essential to achieving the productive harmony and wholeness called for in NEPA.

We are making progress, and in a way that has meaning for more than just the environment. We are building an environmentalism that builds community; we are building a conservation ethic that builds our sense of citizenship and rekindles our proud connection to this great land.

With respect to environmental policy there are three concepts that help describe where we have been and where we are going: subject, stakeholder and citizen.

Too often in the past, the government treated people as subjects—dictated to from Washington through command and control regulation. Today, we understand people to be stakeholders in the issues with which we deal and we are inviting them in to share with us the benefit of their views and experience. In these processes, stakeholders come to the table with their special knowledge and special expertise to defend their special interest.

Clearly, our policies are better informed because of this input. But the question arises: Can we go farther? Can we begin to act as NEPA truly intended? Can we, in short, begin to bring people together as citizens not to defend their special interest, but to define the common interest? Our work over the past few years has been an effort—a beginning at least—to do just that.

President Clinton and Vice President Gore believe that government should be a partner that helps give people the tools they need to make the most of their own lives. We must create more opportunity, demand more responsibility and work together as one community to meet our common challenges. This is the central bargain of American life, and it translates directly to environmental protection. To succeed in meeting our environmental challenges we need to create the opportunity for people to collaborate, to work together to improve their families' health, the quality of their surroundings and the fabric of their communities.

For example, people in the South Bronx are using environmental considerations to rebuild their neighborhood. For 25 years, an abandoned rail yard was a cancer on the community. It was polluted, covered with trash and debris, and a hangout for criminals and drug dealers. Today, a local community development corporation, an environmental organization, a paper company and local publishers have joined together to build a paper plant on that rail yard. With highly sophisticated production, energy efficiency and pollution prevention technology, the Bronx Community Paper Company will be the largest manufacturing facility built in New York City since World War II.

The Bronx Community Paper Company will not use trees to produce paper. Instead, it will recycle a great untapped resource—the vast amount of paper generated in New York offices every day. It will help fund a dormitory for up to twenty local students who do not have stable homes; a health care, child care, literacy and job training center; local libraries and even a revolving loan fund for housing and business development. The Bronx Community Paper Company is located in an Empowerment Zone and the project sponsors credit President Clinton's recycling executive order with helping to create the market conditions for the effort to succeed. The Bronx Community Paper Company is a prime example of what local groups, businesses and government can do when they work together.

We must continue to find new ways to achieve better results, and we will get better results if the community is involved. With Project XL, for example, the Administration is saying to business: if you can get superior environmental performance at a lower cost than under the traditional rules, EPA will let you find the best way to do it. But with this new opportunity comes accountability: Project XL requires that the community be part of the plan. The community must have a seat at the table and they must be part of the decisions that are made.

When Alexis de Tocqueville toured this country more than a century and a half ago studying what makes our democracy work, he said that the most vital force of our democracy is the community groups, those organizations and associations that are alive with the plans and the dreams of people working together. Today, people across the country yearn for ways to be engaged in a meaningful way to better their lives and the lives of their neighbors.

We are beginning to see that communities can be engaged more meaningfully in environmental policy, and because of that, we are beginning to see the next era of environmental programs. Throughout all of our efforts, the National Environmental Policy Act will provide the road map for the Clinton Administration. Almost alone among environmental laws, it rejects single media and single dimension solutions. Instead it seeks to ensure that agencies consider the impacts of their activities and make informed decisions based upon that analysis. By providing a mechanism for the federal government and states, local governments, tribes, businesses and individuals to work together for the common good, NEPA will help us build an environmental ethic based on community rather than conflict, partnership rather than polarization.

We are looking ahead to the future with renewed emphasis on one of the country's oldest and most forward-looking environmental laws, the National Environmental Policy Act, and we know we are on the right track.

Kathleen A. McGinty
Chair

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
WASHINGTON, D.C. 20503

LETTER OF TRANSMITTAL

The President:

Sir: The Council on Environmental Quality herewith transmits its Environmental Quality Report for the years 1994 and 1995 in accordance with section 201 of the National Environmental Policy Act of 1969 (42 U.S.C. 4341).

Sincerely,

Kathleen A. McGinty
Chair

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Part I

America and the Environment:

Past, Present, and Future

CHAPTER ONE

America and the Environment: *A 25-Year Retrospective*

Over the past 25 years, Americans have witnessed remarkable changes in policy and perspectives about the environment.

It was not so long ago that most environmental problems were thought to be largely local in nature and to have short-term, benign effects. Even when the effects were neither short-term nor benign, as in the case of coal mine workers' exposure to coal dust, there was in some quarters a willingness to accept such conditions as an unalterable part of life.

In this 25-year period, we have learned that environmental problems can be local, regional, or global in scale, and that many effects are both long-term and life-threatening. Furthermore, we have learned that some environmental problems actually threaten the most fundamental global systems and cycles.

In response, we have taken action on numerous fronts. For example, in just 25 years, we have:

- substantially reduced most conventional air and water pollution;
- taken international action to phase out chlorofluorocarbons (CFCs), after

Reflections on 25 Years

"When something is complicated, you don't get a revolution overnight. When the Surgeon General first said smoking is hazardous to your health, not a single scientist in this country that I know of challenged it. This was a very simple proposition; not complicated like the environment. Still, it took us 25 years to stop smoking in airplanes and restaurants. There is no other issue like the environment that has the political, economic, technical, and cultural ramifications and that involves every discipline of science. If it took us 25 years to quit smoking in airplanes, do you expect that we would have solved all the problems in the environment? When you contrast that, it's revolutionary what has happened in the past 25 years."

Gaylord Nelson (U.S. Senate, Wisconsin, 1963-81) learning they could deplete the stratospheric ozone layer;

- made significant progress in reducing children's average blood lead levels, after learning that lead can have devastating impacts on children's intellectual development;
- made significant strides in encouraging farmers to adapt new practices that reduce soil erosion and nutrient and pesticide runoff into streams; and
- found that industrial emissions of toxic pollutants can often be reduced or avoided through changed practices and better management.

Over this same period, we have struggled to define what we are talking about, to develop a better sense of what needs to be done, to determine how far we have to go to protect ourselves and the planet, and to try to develop methods to measure our progress. To some extent, this will always be a work in progress, as new information and new research continually increase our understanding of the impact of human activities.

We have witnessed a substantial broadening of the definition of environmental quality. The term now means far more than simply cleaner air and water, safe drinking water, healthy ecosystems, safe food, toxic-free communities, safe waste management, and the restoration of contaminated sites.

Today, the term connotes a stewardship ethic: that is, an active effort to manage our lands and communities in ways that minimize environmental damage.

The stewardship ethic is also an effort to reconcile environmental goals with economic goals. In particular, in the words of the World Commission on Environment and Development, the term "sustainable development" denotes development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." There are important social dimensions to this term: bringing communities into the decisionmaking process, ensuring that the disadvantaged are not disproportionately affected by environmental problems, and strengthen-

Reflections on 25 Years

"Twenty-five years ago, almost nobody knew what the word 'ecology' meant. Twenty-five years ago, there were few graduates of any environmental science or law program. There has been a major increase in courses and graduates. People trained in those fields have implemented and enforced the rules and regulations. Industry hired a lot of these people. Some have combated the environmental movement, but many have helped it. There are still companies who will oppose environmental regulation, so we have to keep educational programs going."

Russell Peterson (CEQ Chair, 1973-76)

ing efforts to inform and educate the public about the environment.

We have gone back to looking at the fundamentals: the links between population, economic growth, and the environment. What we have found is that population and economic growth inevitably affect the environment, but there are a host of ways to reduce those impacts.

Many are "win-win" choices. For example:

- Improvements in energy efficiency reduce pollution, may reduce costs, and (depending on relative prices) may reduce our dependence on imported energy.
- Capture or substitution of solvents often can cut costs for companies and reduce harmful pollutants.

Certainly, "win-win" solutions are not always possible. In such cases, as in the realization that overcapitalization was an important factor in the depletion of cod and haddock fisheries in the Northeast, programs to minimize adverse economic impacts should be part of the bargain.

We have learned that it is better to prevent an environmental problem before it happens rather than clean it up later. Many American companies have made great progress in changing production processes to prevent pollution. Although motivated by many factors in addition to preventing pollution, the switch by many American farmers to low-till and no-till farming practices greatly reduces soil erosion and helps protect clean water.

In cases where pollution is inevitable, we have found many ways to reuse or recycle waste. In fact, these practices are expected to absorb most of the additional waste we generate as our population grows over the next few decades.

We have learned that cooperation can often lead to faster progress than confrontation, though we cannot abandon the need for fundamental compliance with basic national standards that protect human health and the environment and strong enforcement of these standards to ensure that noncompliance does not lead to a competitive advantage. At the same time, simplified permitting, reduced paperwork requirements, and alternative performance-based strategies all symbolize a new process of constructive engagement between government, industry, individuals, and communities.

A LOOK BACK

Beginning in the mid- to late 1800s, the nation began changing from a primarily rural, agricultural society to a primarily urban, industrial society. Accompanying this transition, municipalities and industry were spewing tons of pollutants into the air and water and paying little attention to the consequences.

Public concerns about the quality of the environment, which date back to about the turn of the century, began to reach a critical mass in the 1960s. Initially, much of the worry was about the local effects of pollution. Many remembered the temperature inversion and dense smog that occurred in the small industrial town of Donora, Pennsylvania, in 1948, killing 20 people and causing vary-

Reflections on 25 Years

"Twenty-five years ago, two great rivers of concern had not yet converged: public health, especially the causes of cancer on the one hand, and nature conservation—wilderness, forests, parks, and rivers protection on the other. Those constituencies began to converge in the latter 1960s and became and continue to be a powerful political force. That's what changed politically in this country and put the environment on the map in a way that will keep it there. That convergence occurred for a reason. The environment was something you could taste and smell and was making people sick. The rivers were putrid and waste from all kinds of industrial facilities and waste-water treatment plants was manifest."

William Reilly (EPA Administrator, 1989-93)

ing degrees of illness among 43 percent of the people in the area.

In Los Angeles, the number of automobiles in the city had tripled between 1940 and 1960, immersing that poorly ventilated city in clouds of noxious auto exhaust fumes. By the 1960s, Los Angelenos were outraged about pollution levels in the city.

In 1962 Rachel Carson, who spent most of her professional life as a marine biologist and writer with the U.S. Fish and Wildlife Service, published *Silent Spring*.

Silent Spring was really a story about unanticipated consequences. In 1960, U.S. Fish and Wildlife Service scientists found DDT in the tissues of fish where there had been mass spraying for the control of the spruce budworm in a Western creek. More significantly, when they examined fish in a creek 30 miles away from the spraying, they also found DDT.

In the summer of 1960, at the national wildlife refuges in Tule Lake and Lower Klamath in California, refuge staff found hundreds of dead and dying fish-eating bird species—herons, pelicans, grebes, and gulls. Plankton, fish in the lakes, and the birds were all found to contain residues of toxaphene, DDD (a close relative of DDT), and DDE. Follow-up studies found that these pesticides lingered in the tissues of fish and birds long after spraying, and that DDT was thinning the eggs of birds and dangerously disrupting their reproduction. Carson reported that in the 1950s, a retired banker named Charles Broley observed that the production of young bald eagles was declining along the western coast of Florida. Between 1952 and 1957, about 80 percent of the nests failed to produce young.

Carson's book proved a revelation, showing the public that some pesticides were poisoning both people and wildlife, that these poisons were lingering in tissues long after spraying events, that they were turning up in areas that had never been sprayed, and that they were threatening to quickly wipe out species by destroying their ability to reproduce.

Silent Spring was attacked by the chemical industry, which spent hundreds of thousands of dollars attempting to discredit the author and the book. President Kennedy, however, set up a special panel to study the problem; the panel's report completely vindicated Carson's thesis.

At about the same time, the public was getting more bad news about the condition of the nation's rivers, lakes, and estuaries. Rivers such as the Potomac were described as "open cesspools," and beach closures and shellfish contamination were common events. Industries were pouring new man-made chemicals into rivers, with uncertain effects. The Cuyahoga River in Cleveland erupted in flames, becoming a vivid symbol of the state of many of America's waterways.

In January 1969, the blowout of an oil rig in Santa Barbara, California, spread a coat of oil across hundreds of square miles of beaches and sanctuaries. In setting the conditions to permit oil leasing in the channel, the federal government had largely ignored the need to protect commercial, recreational, aesthetic, and ecological values of the area.

By 1970, all these events had created a broad political and public consensus that more had to be done to protect both the environment and the public from the hazards of pollution.

One of the first legislative accomplishments was the passage of the National Environmental Policy Act (NEPA), which was signed into law by President Richard Nixon on New Year's Day, 1970. In addition to creating the Council on Environmental Quality (CEQ), the act

Reflections on 25 Years

"The results of NEPA have been altogether a plus, but it has fallen short of what we had hoped. One of its greatest strengths has been environmental impact statements (EISs), because one, they can be reviewed in the courts, and two, they led to better decisions about proposed projects. By requiring the impact analysis, we were able to change some policies, partly because the public, for the first time, got its foot in the door. A notice goes in the Federal Register about the intent to do an impact statement. Then the statement has to circulate for public review. NEPA also includes, by reference, the Freedom of Information Act."

"In the days before NEPA, the Corps of Engineers or the Forest Service or another agency would have a public hearing on a proposal, but they had it when everything about the project was already set. If people objected to the project, they'd be told, "Sorry, we're too far down the road, we can't change it, but we wanted to inform people." The bulldozers were sometimes even beginning to roll when they had their public hearings. NEPA put a stop to that."

Lynton Caldwell (Social Scientist, author) imposed an important new directive on the entire federal establishment. NEPA required that all federal agencies would now have to consider and describe the environmental consequences of their major decisions—including alternative courses of action (see Chapter 3, “National Environmental Policy Act”).

Earth Day, on April 22, 1970, attracted millions of Americans to events around the country, calling for action to protect the environment. But many still wondered if this was a long-term movement or a passing fad. A front-page story in *The Washington Post* noted: “The next several months will show whether Earth Day was the high-water mark of another short-lived protest movement or the manifestation of a new political coalition that must be reckoned with for years to come.” It did not take long to realize that 1970 did mark the beginning of a new political coalition.

The White House moved ahead in the early 1970s with a long list of initiatives, including creation of the Environmental Protection Agency and the National Oceanic and Atmospheric Administration; major new legislation on air and water pollution controls; national standards for drinking water; laws to restrict ocean dumping and to control noise; considerable expansion of wilderness areas; and protections for endangered species.

During the Ford Administration, CEQ published some of this country’s first assessments of the economic costs of pollution control, examining at all income levels who pays and who benefits. CEQ also has consistently explored how to use the market for the most efficient reductions in pollution, and its report on the costs of sprawl provided local governments with solid information on the environmental, economic, and social consequences of suburban growth. Past annual reports have included seminal chapters on global climate change (1970), tropical deforestation (1978), and the importance of biological diversity (1980).

Along with political momentum, the crisis atmosphere created a sense of anxiety among members of the public that—combined with a relatively defensive position generally taken by the business community—led to a polarization of the various groups involved and a strong mood of distrust. This polarization tended to lead to adversarial situations, with litigation as the end result. The adversarial nature of these issues continued through the 1970s and into the 1980s and 1990s. Generally, the adversarial posture was characteristic of the parties most directly involved, while the public as a whole continued to support environmental progress.

Some Key Issues

Agreeing that more had to be done still left unresolved many difficult questions about how to go about it. For example, should environmental protection be mostly a federal or a state responsibility?

As described by a recent National Academy of Public Administration (NAPA) report, cities and states interested in controlling pollution faced a potentially difficult trade-off with economic growth, since factories could always threaten to move to an area with less costly environmental regulations. “Smokestack chasing” on the part of local economic development officials created a “race to the bottom” that made it difficult for state or local governments to regulate pollution.

Through the 1960s there was a growing determination that federal intervention was a way to avoid this problem. In the Air Quality Act of 1967, the federal government directed states to establish air quality regions and called for the federal government to establish scientific criteria for regulating air pollutants. This act did not authorize a federal regulatory role, and most of the states declined to implement provisions of the 1967 law and the original Clean Air Act of 1963.

The federal government finally assumed a national regulatory role with the passage of the Clean Air Act of 1970, which called for national ambient air quality standards and required state implementation plans (see Chapter 10, “Air Quality”).

Similarly, water pollution legislation gradually moved towards a stronger federal role. The 1965 Water Quality Act required states to set water quality standards for interstate waterways within their borders, but most states lacked the capacity to set their own standards and had trouble resolving problems created by the interstate nature of waterways. Congress finally passed the Federal Water Pollution Control Act of 1972, which established a national goal that all surface waters should be “fishable and swimmable.”

The act gave states and the Environmental Protection Agency, which was created in July 1970, the authority to regulate industrial point sources of pollution and municipal wastewater treatment facilities.

In terms of the federal budget, one of the most important federal commitments was the program of grants to municipalities for the construction of wastewater treatment facilities. The construction grants program proved to be a massive investment by the federal government: between 1972 and 1995, EPA provided $66 billion to municipalities under this program. Of EPA’s initial budget of $1.4 billion, about 80 percent was construction grant money.

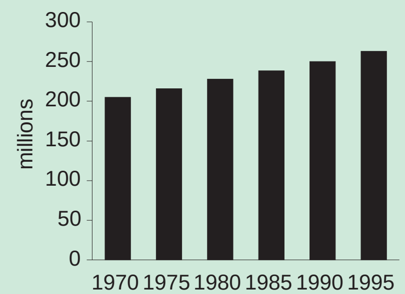
With the passage of these two major laws for water and air quality, the question of federal-state relations had largely been answered. The people, through their representatives in government, directed the federal government to take the lead in setting standards and goals for the country, assume a substantial share of the financial burden, and work with the states to implement those laws.

A second question was: What were the most effective ways to reduce pollution?

The early federal approach is usually described as “command- and-control,” in which federal agencies issued directives to the states and industries and expected them to obey those directives. The term is also associated with the federal government’s early emphasis on technology standards, which required facilities to install specified control technologies.

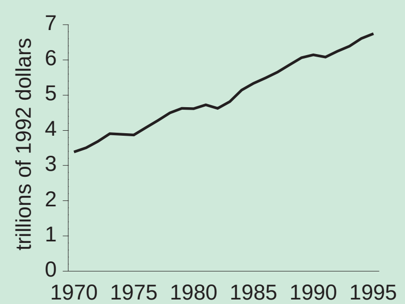
According to the NAPA study and many other analyses, command-and-control approaches, with the help of a strong monitoring and enforcement effort, have

Figure 1.1 U.S. Population, 1970-1995



Source: See Part III, Table 1.

Figure 1.2 U.S. Gross Domestic Product, 1970-1995



Source: See Part III, Table 9.

been successful in controlling large point sources of pollution such as industrial facilities or mass-produced products such as cars. They have been somewhat less successful when the targets are more numerous and diverse and there are many control options.

As the strengths and weaknesses of this approach have become clearer, a host of new approaches have emerged that can be an effective complement to the traditional approach. Some of these approaches are discussed later in this chapter and in the next chapter.

REVIEWING THE RECORD

Driving Forces

Population growth, economic activity, and rising per capita income all tend to put pressures on the U.S. environment.

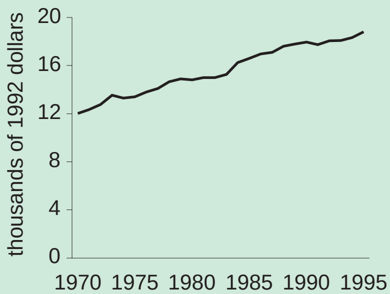
For example, from 1970 to 1995 U.S. population rose from about 205 million people to 263 million people, or 30 percent (Figure 1.1). There were substantial changes in distribution, with population shifts toward the South and West.

The principal measure of economic activity, gross domestic product, grew (in constant 1992 dollars) from about $3.4 trillion in 1970 to more than $6.7 trillion in 1995 (Figure 1.2). GDP per capita (in constant 1992 dollars) grew from $16,520 in 1970 to $25,700 in 1995; over the same period, per capita disposable personal income rose from $12,022 to $18,800 (also in constant 1992 dollars) (Figure 1.3).

Rising numbers and wealth both result in rising consumption, which shows up in a variety of forms, such as increased demand for energy and natural resources, more cars on the road and a doubling in vehicle-miles traveled, and more solid waste.

In the face of these pressures, the record of improvement in many environmental, energy, and natural resource areas is impressive, as briefly reviewed below.

Figure 1.3 U.S. Per Capita Disposable Personal Income, 1970-1995



Source: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (GPO, Washington, DC, November 1996), and earlier issues.

Air Quality

Overall, between 1970 and 1994 the combined emissions of the six principal pollutants declined 24 percent. (Trends for four of these pollutants are shown in Figure 1.4.)

Carbon monoxide (CO). From 1970 to 1994, emissions of carbon monoxide declined from 128 to 98 million tons per year, or 23 percent. During the 1985-94 period, national average CO concentrations were down 28 percent and emissions were down 15 percent.

Lead (Pb). The transition to unleaded gasoline in automobiles has resulted in a drastic decline in emissions, which are down 98 percent over the 1970–94 period and 75 percent over the 1985–94 period.

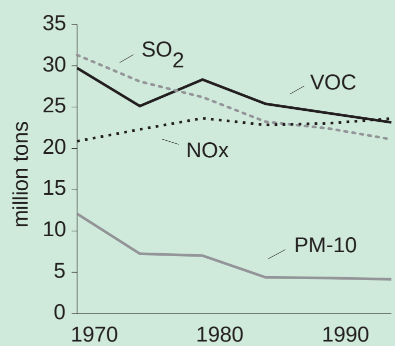
Nitrogen oxides (NOx). Over the 1970–94 period, emissions of NOx are up 14 percent, from 20.6 to 23.6 million tons per year. Since 1985, emissions from highway vehicles decreased 7 percent while fuel combustion emissions increased 8 percent.

Ozone. High levels of ozone persist in many heavily populated areas, including much of the Northeast, the Texas Gulf Coast, and Los Angeles. It is estimated that about 50 million people lived in counties with ozone levels above the national standard in 1994.

Particulate Matter (PM). Over the 1970–94 period, particulate emissions declined about 78 percent. During the 1988–94 period, emissions were down 12 percent and concentrations down 20 percent. Emissions from sources such as fuel combustion, industrial processes, and transportation declined by 17 percent during the 1985–94 period.

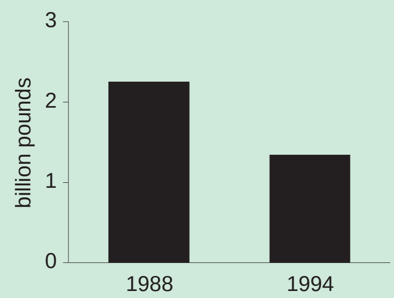
Sulfur Dioxide (SO_2). Over the 1970–94 period, emissions of sulfur dioxide are down 32 percent. During the 1985–94 period, emissions were down 9 percent and concentrations were down 25 percent.

Figure 1.4 U.S. Emissions of Selected Pollutants, 1970-1994



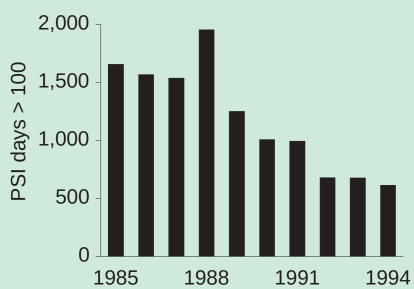
Source: See Part III, Table 27.
Note: NO_x=nitrogen oxides. PM-10=particulate matter with a diameter of 10 microns or less. SO_2=sulfur dioxide. VOC=volatile organic compounds.

Figure 1.5 U.S. Emissions of Air Toxics, 1988 and 1994



Source: See Part III, Table 72.

Figure 1.6 U.S. Urban Air Quality, 1985-1994



Source: See Part III, Table 33.
Note: PSI=Pollutant Standards Index. PSI days > 100 are within the unhealthy range. See notes for Table 33. Data are for all 1,204 trend monitoring sites.

TRI Air Emissions. Data on annual air emissions, starting with the 1987 reporting year, have been collected annually for the Toxics Release Inventory (TRI). The reports have been submitted annually since 1987 by manufacturing facilities with 10 or more employees. Not all chemicals are listed under TRI reporting requirements, although chemical coverage was greatly expanded for the 1995 reporting year and now includes almost 650 chemicals and chemical categories.

Over the 1988–1994 period, total TRI-reported air emissions declined by over 40 percent, from about 2.3 billion pounds in 1988 to about 1.3 billion pounds in 1994 (Figure 1.5). Of the TRI listed chemicals, 10 account for over half of all reported releases to air. Of these chemicals, all but hydrochloric acid have declined since 1988.

Overall Trends. The Pollutant Standards Index (PSI) is an overall assessment of air quality for a given day. These values are reported daily in all cities with populations over 200,000. A PSI value over 100 indicates that at least one criteria pollutant exceeded air quality standards on a given day (Figure 1.6). Between 1985 and 1994, the total number of PSI days greater than 100 decreased 72 percent nationwide (excluding Los Angeles and Riverside, California). PSI days greater than 100 decreased 35 percent in Los Angeles and 27 percent in Riverside.

Water Quality and Aquatic Resources

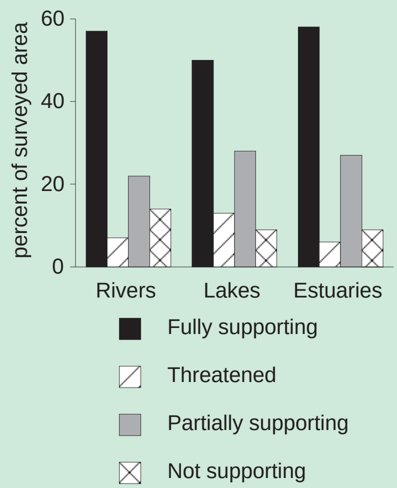
Since passage of the Clean Water Act in 1972, most of the conspicuous water pollution from point sources has been eliminated. More than 57,000 industrial facilities now operate under a pollution control permit.

During the 1972–92 period, population and pollutant loads arriving at treatment plants each rose about 30 percent, yet biochemical oxygen demand (BOD) and total suspended solids (TSS) from treatment plants declined by 36 percent (Figure 1.7). Direct industrial discharges of toxic pollutants are down dramatically since 1972.

EPA's 1994 National Water Quality Inventory is based on surveys conducted during 1992 and 1993. The inventory included 17 percent of the nation's total river miles, 42 percent of the nation's total lake area, and 78 percent of the nation's total estuarine area.

The survey of rivers found that 57 percent of all river miles showed good water quality and broadly met the standards associated with their designated use, while 7 percent were in good condition but threatened by future degradation. About 22 percent were in fair condition, partially supporting their designated uses. Another 14 percent showed poor quality (Figure 1.8). Bacteria and siltation were the problems most often found, each affecting 34 percent of all impaired rivers. Pollutants from agricultural activities were identified in 60 percent of all impaired miles.

Figure 1.8 Overall Use Support in U.S. Surface Waters, 1994

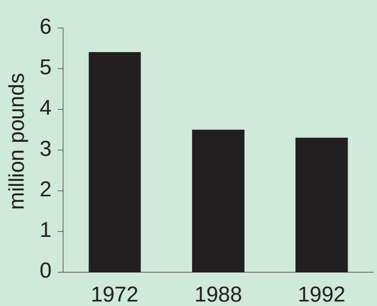


Source: See Part III, Table 38.
Note: Based on an assessment of 17% of U.S. river and stream miles, 42% of U.S. lake acres, and 78% of U.S. estuary square miles.

The lake survey found 50 percent of the nation's lake area in good condition, 13 percent in good condition but threatened, 28 percent in fair condition, and 9 percent in poor condition. Leading pollutants included nutrients, which were found in 43 percent of all impaired lake acres, followed by siltation (28 percent), oxygen-depleting substances (24 percent), and metals (21 percent).

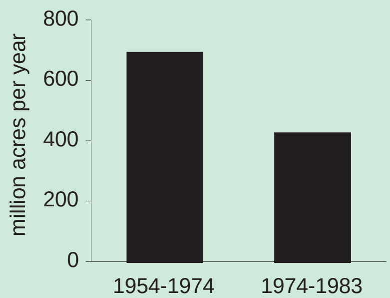
The survey of the nation's total estuarine area found 57 percent in good condition, 6 percent in good condition but threatened, 27 percent in fair condition, and 9 percent in poor condition. Nutrients and bacteria were the pollutants most often found in impaired estuaries.

Figure 1.7 U.S. BOD Discharge From Sewage Treatment Plants, 1972-1992



Source: U.S. Environmental Protection Agency.
Note: BOD=biochemical oxygen demand.

Figure 1.9. Average Annual U.S. Wetlands Losses, Mid-1950s to Mid-1980s



Source: See Part III, Tables 48.
Note: Data exclude wetlands in Alaska and Hawaii.

In all three cases, less than 1 percent of rivers, lakes, and estuaries had such poor water quality that use support was not attainable due to various biological, chemical, physical, or economic/social conditions.

The conversion of wetlands (both federal and nonfederal) to other uses has slowed considerably over the past several decades, dropping from an average of 690,000 acres per year in the 1954–74 period to about 423,000 acres annually in the 1974–83 period (Figure 1.9). During the 1982–92 period, it is estimated that 156,000 acres were lost annually on nonfederal lands (estimates for federal lands during this period are not yet available).

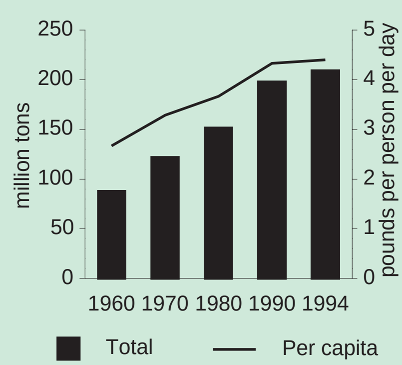
Of the 1.56 million acres of nonfederal wetlands lost over the 1982–92 period, about 1.4 million acres became uplands and about 200,000 acres became deepwater habitat. During the same period, about 769,000 acres of deepwater or upland habitat became wetland. Thus, though absolute losses were estimated at 156,000 acres annually, the average "net" loss of wetlands on nonfederal lands averaged 70,000 to 90,000 acres annually.

Solid and Hazardous Waste

In absolute terms, municipal waste generation has grown steadily and is expected to continue to grow (Figure 1.10). From 1960 to 1994, waste generation increased from 88 million tons to 209 million tons, and projections indicate that it will rise to 262 million tons by the year 2010. Per capita generation, which rose from 2.7 pounds per day in 1960 to 4.4 pounds per day in 1994, is projected to hold steady at 4.4 pounds through the year 2000, but increase to 4.7 pounds by the year 2010.

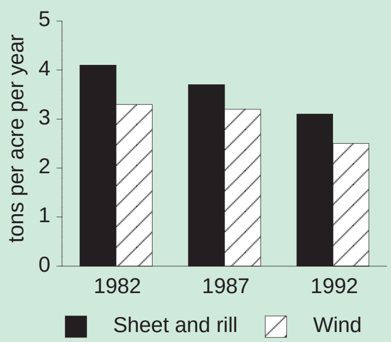
By September 1995 EPA had identified 40,094 potentially hazardous waste sites across the nation, including sites potentially contaminated with radioactive waste. About 94 percent of these sites

Figure 1.10 U.S. Total and Per Capita Solid Waste Generation, 1960-1994



Source: See Part III, Table 67.

Figure 1.11 Erosion on U.S. Cropland, 1982-1992



Source: See Part III, Table 54.

have been assessed by EPA to determine if further action is needed. To clear the way for the economic redevelopment of sites that are not of federal concern, the Clinton Administration by 1995 had removed more than 24,000 sites from the Superfund inventory, leaving 15,622 remaining in the inventory.

The Superfund law's National Priorities List (NPL) identifies the nation's most seriously contaminated hazardous waste sites, which are given highest priority for Superfund cleanup. By September 1995, a total of 1,374 sites had been listed or proposed for listing. Work was underway at 93 percent of these sites and permanent cleanup construction was in process or complete at 60 percent.

In the last few years, studies, plans, and designs have been completed and the pace of cleanups has quickened considerably. Through 1995, permanent cleanup construction had been completed at 346 sites, or 25 percent of the sites on the NPL since the inception of the program. In 1994 and again in 1995, nearly twice as many Superfund cleanups were completed in 12 months as were completed in the program's entire first decade.

Agriculture

Conservation tillage practices, which reduce soil erosion, were used on less than 5 percent of planted acreage prior to 1970, rose to about 20 percent in 1989, and exceeded 35 percent by 1994.

The Conservation Reserve Program (CRP) is a voluntary program under which farmers temporarily convert highly erodible and other environmentally sensitive cropland to soil-conserving uses, such as grass or trees. Since the first CRP signup, in 1986, farmers have enrolled more than 36 million acres in the program, or roughly 13 percent of the nation's cropland.

Erosion reduction because of the CRP is about 700 million tons annually for the entire CRP cohort—nearly 19 tons per acre per year. CRP also provides benefits in terms of wildlife habitat and populations, water quality, and wetland and forest area. Additionally, the program has reduced federal outlays for farm deficiency payments, strengthened farm income, and helped balance the supply and demand for agricultural commodities.

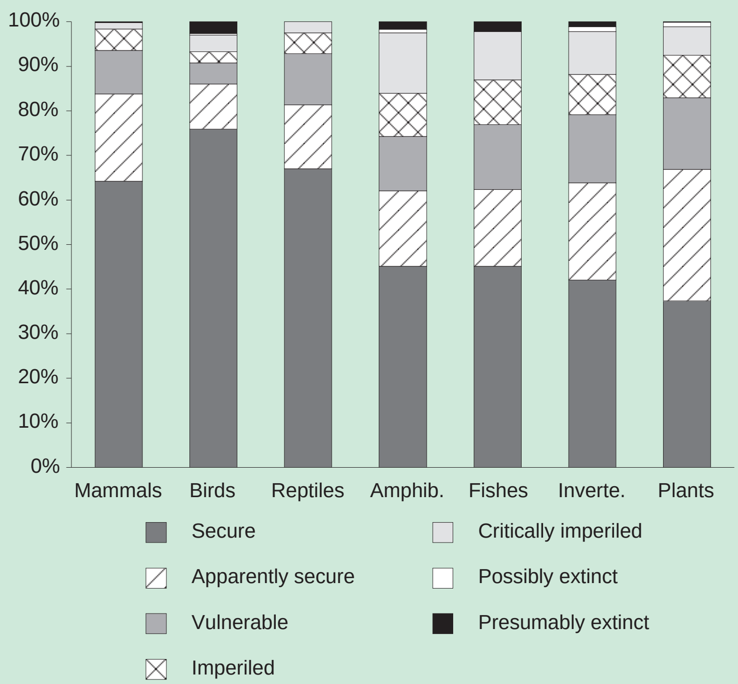
The average annual rate of sheet and rill erosion on cropland was 3.1 tons per acre in 1992, nearly 25 percent below 1982's average annual rate of 4.1 tons per acre. Cropland wind erosion declined commensurately during the period, from 3.3 to 2.5 tons per acre annually (Figure 1.11). Preliminary results of a special erosion study conducted in 1995 suggests that the downward trend in soil erosion on cropland is continuing.

Pesticides

In its early years, EPA concentrated its pesticide regulation efforts on the chlorinated hydrocarbons that were recognized as acutely toxic, persistent, and bioaccumulating in man and wildlife. Since then, most organochlorines have been either banned (aldrin, benzene, hexachloride, DDT, DDD, dieldrin, endrin, toxaphene) or severely restricted (chlordane, heptachlor). Inorganic arsenicals, another class of toxic pesticides, have been restricted to wood preservative uses.

Organophosphates, which can be acutely toxic and could possibly have longer term nervous system effects, have also become a focus of EPA regulatory action. Many of these chemicals are no longer on the market and others are now

Figure 1.12 Status Ranks for U.S. Species by Conservation Category, 1995



Source: The Nature Conservancy, *Priorities for Conservation: 1996 Report Card for U.S. Plant and Animal Species* (TNC, Arlington, VA, 1996).
Note: Fishes refers to freshwater species. Plants refers to vascular species. Data are based on number of species ranked within each group: mammals, 433; birds, 759; reptiles, 279; amphibeans, 237; freshwater fishes, 815; invertebrates, 1,728; and vascular plants, 18,156.

classified as "Restricted Use," which limits their use to certified applicators.

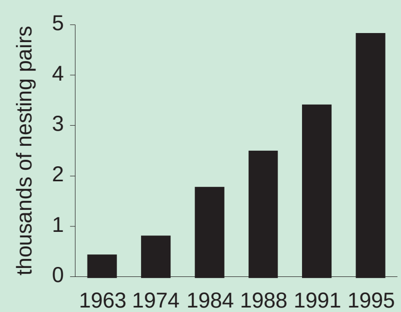
Over the past 25 years, EPA has taken specific actions to educate consumers and agricultural workers on the proper use of pesticides in order to reduce their potential risks from day-to- day exposures to these chemicals. Steps include efforts to improve labelling; the creation of child-resistant packaging for pesticides; and the development and dissemination of educational materials. EPA's Worker Protection Standard, which went into full effect in January 1995, also represents a major strengthening of national efforts to safeguard agricultural workers.

In 1988, a reregistration program was started to reassess the hundreds of pesticides approved before 1984 and bring them up to today's more stringent scientific standards. Hundreds of chemicals (in thousands of products) have been canceled, while about 100 chemicals have been formally approved for continued use.

Ecosystems and Biodiversity

The Nature Conservancy and state agency-based Natural Heritage Network maintain databases with information on more than 28,000 U.S. species and an additional 11,000 subspecies and varieties. In 1996, the Conservancy reported on the conservation status of 20,481 native U.S. species. This represents 13 major groups of plants and animals that have been classified and studied in sufficient detail to allow a status assessment for each of their species.

Figure 1.13 Bald Eagles in the Coterminous United States, 1963-1995



Source: U.S. Department of the Interior, Fish and Wildlife Service, Endangered Species Program.

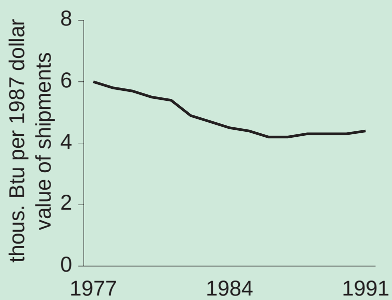
Based on their global rarity, the report found that almost one third (32 percent) of the species surveyed were in some danger. About 1.3 percent were presumed or possibly extinct, 6.5 percent were classified as critically imperiled, another 8.9 percent imperiled, and 15 percent were classified as vulnerable (Figure 1.12).

Among raptors, populations of ospreys, bald eagles, and peregrine falcons have increased in numbers as they recover from past effects of pesticides. Following the ban on DDT, the bald eagle has increased from a low of 400 nesting pairs in 1963 to 4,712 pairs in 1995 (Figure 1.13).

Energy and Transportation

The reduction in energy intensity that has occurred over the last two decades has been driven by energy efficiency advances on the demand side and a shifting of the economy away from energy-intensive industry. According to Department of Energy estimates, energy effi-

Figure 1.14 U.S. Industrial Energy Use, 1977-1991



Source: See Part III, Table 89.

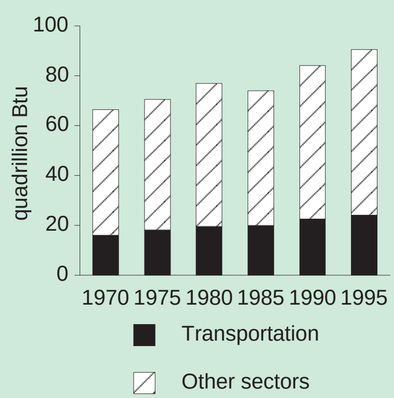
ciency and conservation efforts from 1973 through 1991 curbed the pre-1973 growth trend in primary energy use by about 31 quads (a quad is equivalent to 1 quadrillion British Thermal Units, a common measurement of energy use). Of the 31 quads in savings, it is estimated that about 56 percent comes from industry, 21 percent from residential buildings, 5 percent from commercial buildings, and 18 percent from transportation.

Between 1977 and 1991, industry reduced the amount of energy required for every dollar of output by 36 percent, with about two thirds of these savings coming from improvements in energy efficiency (Figure 1.14). When energy prices began to fall in the mid-1980s, the rate of efficiency improvement slowed. Between 1970 and 1980, energy intensity declined by 2.5 percent per year, but the rate of decline has dropped below 1 percent in recent years.

Transportation energy use as a percentage of total energy use has remained relatively constant, accounting for just over one fourth of U.S. energy consumption. In absolute terms, however, energy consumption by the transportation sector has risen from about 16 quads in 1970 to about 24 quads in 1995, or 50 percent (Figure 1.15). Cars and trucks alone account for about 20 percent of total U.S. energy use. Almost two thirds of total U.S. petroleum consumption is in the transportation sector.

Since 1949, transportation energy consumption has increased at an average annual rate of 2.4 percent, though growth has not been uniform. Energy use in transportation has risen slowly over the past 15 years. Corporate average fuel efficiency (CAFE) standards for light-duty vehicles became effective in 1975, and this and other factors (such as rising gas prices) improved the efficiency of the light-duty vehicle fleet significantly between 1975 and 1985. However, increased vehicle-miles traveled have more than offset any increases in average vehicle fuel economy. Transportation

Figure 1.15 U.S. Energy Use, 1970-1995



Source: See Part III, Table 85.

energy use is the nation's largest source of air pollution. Energy use in vehicles is expected to continue to rise throughout the beginning of the 21st century.

The Unfinished Agenda

Despite the progress that has been made on some fronts, many challenges remain. In some cases, the pressures posed by population growth have been difficult to overcome. Partly as a result of the growth in the number of automobiles on the road, total emissions of nitrogen oxides (NOx) have increased since 1970, which has contributed to a continuing problem with ground-level ozone in many cities. Population and development pressures have played a role in the continuing degradation of coastal zones and estuaries and the wide-scale destruction of critical habitats, though in many cases creative policymaking and careful management can at least partially overcome such conflicts.

In addition, about 40 percent of the nation's rivers, lakes, and estuaries still don't meet basic clean water standards; wetlands losses on nonfederal lands were about 70,000-90,000 acres per year during the early 1990s; and localized cases of waterborne disease continue to threaten drinking water safety.

A few problems escaped attention under the early command- and-control approaches. The most notable was nonpoint source water pollution, such as pesticide and fertilizer runoff from farms and stormwater runoff in urban areas.

A few problems were late-bloomers, including the realization that indoor air pollutants such as environmental tobacco smoke and radon pose significant human health risks.

Finally, there was the growing realization that human activities could be affecting the global environment. In this realm, the emerging issues have included stratospheric ozone depletion, deforestation, declining marine fishery resources in some species and regions, and new evidence that some air emissions were affecting global climate. Since 1972, for example, worldwide generation of carbon dioxide, a common "greenhouse" gas, has increased by 8 percent. Most scientists now believe that such emissions have contributed to an increase in global temperature.

NEW GLOBAL IMPERATIVES

By about the mid-1980s, a combination of factors contributed to some fundamental changes in thinking about environmental policy and the roles of government, business, and the public.

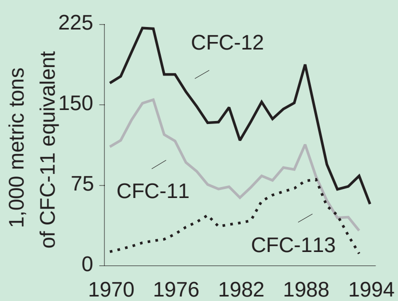
First, there was a strenthening perspective that some environmental problems were actually global in nature and that human activities were capable of altering global systems. The most visible global problems were the role of CFCs in depleting the ozone layer and of carbon dioxide emissions from fossil fuels in contributing to climate change. Other significant problems included the decline of many regional fisheries and the widespread loss of tropical forests and biodiversity.

Global and domestic environmental problems differ in three fundamental ways. First, global problems cannot be solved by U.S. action alone. Second, global problems cannot be measured by monitoring in the U.S. alone. Third, global problems are generally less visible to U.S. citizens than most domestic environmental problems.

There was a growing recognition that such problems required more global cooperation than ever before. In many cases, this has presented a difficult political challenge, since these problems have serious implications for economic growth generally, require long-term coordination among nations, and raise difficult concerns about the tradeoffs between growth and environmental protection.

Given these political difficulties, the global community has made remarkable progress in working towards solutions. The 1985 Vienna Convention for the Protection of the Ozone Layer and the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer are in place as agreements that will phase out the use of CFCs, and the Framework Convention on Climate Change has provided a starting point for the difficult effort to reduce global emissions of carbon dioxide and other greenhouse gases.

Figure 1.16 U.S. Production of Selected Chlorofluorocarbons, 1970-1994



Source: See Part III, Table 71.

Note: 1994 data for CFC-11 and CFC-113 not available.

The effort to phase out CFCs is an interesting case study of the benefits of cooperation, of the new role of the federal government as a facilitator of solutions, and of the new economic opportunities provided by environmental protection requirements.

Case Study: The CFC Phaseout

One of the unsettling characteristics of modern economies is the speed with which useful chemical compounds can spread into every nook and cranny of the industrial world. Only later are some found to have unforeseen environmental consequences.

An important example has been the introduction of CFCs and their rapid adaptation for a variety of industrial purposes, the discovery of their harmful effects on the stratospheric ozone layer, and the global consensus and agreement that emerged to phase these chemicals out. The consensus was embodied in the Montreal Protocol, which called for the ultimate phaseout of CFC production. An important milestone was reached on January 1, 1996, when chemical manufacturers stopped producing chlorofluorocarbons for consumption in the United States, except for a few essential uses (Figure 1.16).

According to a recent study by Elizabeth Cook of the World Resources Institute, there were several important ingredients to this success. First, an environmental goal, which can be adjusted to reflect new information, is crucial; it can send clear signals to the private sector and prompt needed investments. The phaseout of CFC production provided such a goal. Second, market-based instruments, such as marketable permits and excise taxes, created an efficient, responsive, and flexible policy framework for controlling ozone-depleting substances. Third, entrepreneurial government initiatives helped industry by removing regulatory barriers, creating opportunities for inter-industry problem-solving, and fostering collaboration among typically opposed groups. Fourth, scientific advances and public education both helped move the process forward.

CFCs have an unusual combination of properties. They are nonflammable, nontoxic, inexpensive to make, easy to store, and chemically stable. In the late 1940s, the invention of an inexpensive valve designed to take advantage of CFC characteristics—such as their ability to be stored under relatively low pressure—marked the beginning of the aerosol age. CFCs also proved valuable as solvents. For example, they could be used to clean semiconductor circuitry without damaging the plastic mounting boards. They were widely used in vehicular air conditioning and for blowing foams of all kinds, including those in fire extinguishers, foam insulation, and that used to make disposable hamburger cartons and coffee cups.

In June 1974, University of California at Irvine scientist F. Sherwood Rowland and Mario J. Molina, a colleague at Irvine, published a paper theorizing that CFCs, after decomposing in the stratosphere, would release chlorine atoms that would react with and destroy the Earth's thin layer of ozone molecules. If CFC emissions continued at the 1972 rate of about 800,000 tons per year, about half a million tons of chlorine would be released in the stratosphere within 30 years, destroying between 20 and 40 percent of the ozone layer.

In 1976, a National Academy of Sciences report validated the ozone-depletion theory. With this evidence in hand, federal regulators took action. By March 1978, the federal government had banned the use of CFCs in "non-essential" aerosols after December 15, 1978, but continued to allow "essential" uses. The decision to exempt essential uses defused much of the opposition to the broader objective of banning CFCs from the vast majority of aerosols.

The spray can debate proved to be just the beginning. To deal comprehensively with the problem, much more had to be done about the manufacture and use of CFCs in other countries, the use of CFCs in other industrial processes, and the use of other chlorine-bearing compounds similar to CFCs.

The Debate Goes Global

The 1982 discovery of the ozone hole over the Anarctic helped reignite international negotiations over CFCs. In 1985, the Vienna Convention for the Protection of the Ozone Layer established a framework for later international agreements and set up new international institutions to deal with the problem. By September 1987, representatives of 24 countries had agreed to the Montreal Protocol. As originally drafted, the agreement was intended to halve the production and use of CFCs in the industrialized countries between 1986 and the year 2000. The reductions were in three stages: a freeze at 1986 levels by 1990; a 20-percent reduction by the end of 1993; and a further 30- percent cut by the end of 1999. In later negotiations at London in 1990 and Copenhagen in 1992, the phase-out date for most CFCs was pulled back to 1996. The agreements also cover other ozone- depleting substances, including HCFCs, halons, methyl bromide, carbon tetrachloride, and methyl chloroform. These other substances will continue to be phased out over the next several decades. By 1993, over 140 countries had ratified both the Vienna Convention and the Montreal Protocol.

Because of the disparate uses of CFCs, each industrial sector presented a different challenge. The government response involved a wide range of approaches, encompassing national and local legislation, regulations, bans, new product reviews, and economic instruments.

In the case of foam packaging made with polystyrene, EPA in February 1988 rounded up the key players—four environmental organizations, nine packaging manufacturers, two trade organizations, and two chemical companies—to talk about economically and environmentally acceptable alternatives that could be adopted by the entire industry.

With EPA acting as a facilitator, the working group hammered out a voluntary phase-out agreement over the next two months. Under it, foam manufacturers would end CFC use by December 31, 1988; HCFC-22 would become an "interim alternative," and companies committed themselves to adopt any new, safe, and economically feasible blowing agent within 12 months of FDA approval. The agreement also encouraged the development of a substitute within five years. To promote enforcement of the voluntary agreement, the industry agreed to public monitoring of CFC and HCFC-22 consumption.

In the case of devising "no-clean" technology that re-engineered the soldering process to eliminate the need for CFCs to clean electronic components, an important breakthrough occurred in October 1989, when nine giant multinational companies, in partnership with EPA, formed the Industry Cooperative for Ozone Layer Protection. Through this public-private partnership, companies exploring no-clean technology would share and publicize developments, tour each other's facilities, conduct tests, distribute results, and jointly publish technical papers.

Cooperation among competitors, particularly large multinationals, helped defuse skeptics and persuaded other companies to join in or suffer competitive disadvantages as chemicals became scarcer and more expensive. The willingness of large companies to work cooperatively made it possible to commercialize and implement no-clean technologies rather quickly.

The Government's Role

The federal government played an important role both as a policy-maker and as a catalyst. The government established pollution permits, which companies could trade, and excise taxes. EPA catalyzed action by diverse interests by trying to remove barriers and to help industry identify and use cost-effective solutions.

EPA officials in 1988 decided that the most efficient way to meet the CFC (and halon) consumption limits would be to set up a marketable permits program and assign allowances to the companies that produced or imported CFCs based on the size of each firm's market share in 1986. Companies were required to report both changes in the chemicals used and trades among companies of allowances to EPA. Any swaps had to balance larger quantities of less-potent chemicals with smaller volumes of strong ozone depleters.

In practice, companies have traded permits with each other and have shifted permits among their own operations domestically and internationally. As the use of CFC-11 and CFC-113 declined, companies increasingly traded their allowances into CFC-12, which was still in demand for use in the motor vehicle air-conditioning industry.

The system has three notable advantages. It lowered costs to both industry and the government. It gave companies great flexibility in responding to market demands, and it allowed the United States to quickly adapt to the changing requirements of the Montreal Protocol.

EPA officials thought that the permit system's consumption caps would restrict demand, push up prices, and encourage users to adopt alternatives. As it turned out, an "ozone-depleter" tax enacted by Congress in 1989 gave CFC producers and users an incentive to stay well below the consumption caps. The tax, which raised $2.9 billion in its first five years from manufacturers and importers, took effect in 1990 with a $1.37 per pound base rate on CFCs and halons and called for escalating rates over time. (One unfortunate effect of the tax is that it helped stimulate a black market in CFCs. An estimated 10,000 to 22,000 tons of CFCs illegally entered the United States in 1994 and 1995. Violations of restrictions on CFC imports must be subject to swift and strong punishment to effectively deter future noncompliance.)

The CFC phase-out is a remarkable story of effective policymaking and constructive cooperation among adversaries. The policy framework set a firm goal, gave industry flexibility in meeting it, and put a high priority on lowering public and private compliance costs. It utilized a combination of regulatory and market-based approaches. Of course, these efforts had significant costs: they altered investment strategies, required some firms to take some steps sooner than they might have ordinarily, and forced some to use more expensive alternatives. But these costs would have almost certainly been higher under a regulatory strategy blind to market signals and the strengths of the public and private sectors. And, through the introduction of new practices, many industries are now reaping huge savings.

THE CHANGING ROLE OF THE PUBLIC

In recent years many communities have embarked on a new course of growth that uses the concept of sustainability as a benchmark.

A vital part of the effort is the participation of community residents in identifying a community's needs and working toward a collaborative solution. Bringing all elements of a community—individuals, elected officials, members of the business community, environmental groups, and civic organizations—together offers the best chance for lasting solutions.

Community participation is now an important focus for many cities. In Seattle, a local citizens' group led an effort to measure the progress or decline of key social, economic, and environmental indicators that were identified by the community as priorities. In the New York City area, residents of the South Bronx are playing a lead role in planning to revitalize their community.

Chattanooga is a particularly striking success story. Chattanooga's plight in the 1960s was similar to that of many other cities: suburban sprawl, loss of traditional manufacturing jobs, racial conflicts, poor schools, and a decaying urban infrastructure had all contributed to the city's decline. On top of that, Chattanooga in 1969 was dubbed the "worst polluted city" in America. Air pollution was so bad that drivers often had to switch on their headlights in the middle of the day.

Today, Chattanooga is widely recognized as one of the nation's best environmental turnaround stories. How did it happen? The city's business, political, and environmental leaders, along with the community as a whole, all played a role. Rather than an onerous burden, environmental improvements proved to be an economic opportunity for the city. The city's new electric buses are made by a new local firm that has also received orders from cities in several other states. Cleaning up the city's air spawned a new local manufacturer of air pollution "scrubbers." The city's leaders increasingly see environmental improvements as an opportunity to attract new businesses and new investments.

Community participation was another big part of Chattanooga's success. The 1984 Vision 2000 Project brought together some 1,700 members of the community to talk about their vision of the city in the year 2000. The project came up with 34 goals that generated some 223 city projects, including construction of the Tennessee River Park and the Tennessee Aquarium. By 1992, 85 percent of the goals had been met. Some $739 million has been invested in the city, about two thirds from private sources.

Chattanooga's vision of its future isn't unique. Other cities such as Portland, Oregon, and states like Minnesota have begun to use broad-based goal-setting and benchmarking projects. In Portland, communities are working together to plan for the region's rapid population growth. With the help of coordinated decisonmaking and the use of urban growth boundaries, these communities are preserving open space and prime farmland to help maintain the area's quality of life.

Many other communities—including Charleston, South Carolina, and Savannah, Georgia—are using design control and making historic preservation a priority. Preservation of existing buildings provides a double benefit, saving both energy and materials and preserving a community's sense of continuity.

State, local, and community efforts to build new partnerships and look for innovative new solutions to community problems provide both a challenge and an opportunity at the federal level. Most federal agencies, including the Departments of Energy, Interior, Defense, Agriculture, and others, are pursuing these opportunities.

One such effort is EPA's new National Environmental Performance Partnership System (NEPPS). Under this program, a state performs a self-assessment of its environmental programs and negotiates an agreement with EPA on environmental and public health priorities and on how federal and state resources will be used to address them during the coming year. The program encourages local governments and the public to get involved in defining the way environmental protection works. This approach brings EPA, states, and the public together to evaluate public health and environmental problems in the state, set priorities, and develop a plan to address them. The program also provides states with increased flexibility to address local environmental conditions with the help of public information and public involvement.

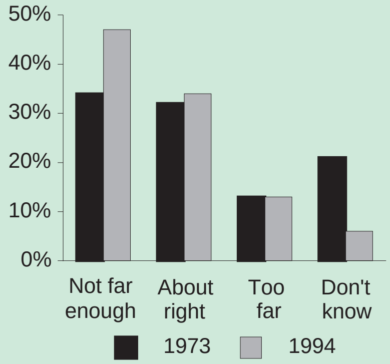
Public Support for Environmental Protection

In one important respect, the role of the public has not changed much since 1970. The American public has remained generally supportive of environmental protection and environmental protection laws and regulations.

Periodically since 1973, Roper Starch Worldwide Inc. has been asking this question: "There are different opinions about how far we've gone with environmental protection laws and regulations. At the present time, do you think environmental protection laws and regulations have gone too far, or not far enough, or have struck about the right balance?" In October 1973, 13 percent of respondents said laws and regulations had "gone too far," 34 percent said "not far enough," 32 percent said they had "struck about the right balance," and 21 percent said "don't know." In September 1994, 13 percent said "gone too far," 47 percent said "not far enough," 34 percent said "struck about the right balance," and 6 percent said "don't know" (Figure 1.17).

Cambridge Reports/Research International has asked a similar question since 1982: "In general, do you think there is too much, too little, or about the right amount of government regulation and involvement in the area of environmental protection?" Large majorities have responded that involvement is either too little or about right. About 10 percent of respondents said "too much" through the

Figure 1.17 Public Response to Surveys on "How Far Have Environmental Laws and Regulations Gone?"



Source: Roper Starch Worldwide Inc.

1980s, but recently that percentage has risen.

Support seems to be increasing for the view that both economic growth and a cleaner environment are simultaneously obtainable. Through the 1970s and 1980s, according to polls by Cambridge Reports/Research International, about half of all Americans thought we could have both; more recently, about two thirds agree with this view.

Forging a New Paradigm

Over the past 25 years a great deal has been learned about environmental problems and strategies to deal with them. Though a number of residual problems remain, the effort was generally successful and has almost certainly provided benefits well in excess of the costs.

Out of this experience, a new paradigm has emerged that can complement traditional approaches and help us build on proven means to protect human health and the environment. This new paradigm emphasizes goal-setting, economic incentives, pollution prevention, a more holistic approach to environmental problems, simplification of regulations, more flexible problem-solving, and a more interactive approach with stakeholders and the community at large. Some of these new approaches are the subject of the second chapter, which looks ahead to our environmental future over the next 25 years.

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CHAPTER TWO

America and the Environment:

The Changing Role of Government

Environmental policy in the United States is in a period of consolidation and reinvention that emphasizes using better science to get better results at less cost, with more flexibility, and with greater public participation in the decisionmaking process.

The federal government is taking an active role in leading this effort, while at the same time maintaining its traditional role in monitoring and enforcing existing federal environmental laws. Without strong enforcement of basic standards, market-based incentives and other new approaches would have little chance of success.

The foundation of this reinvention effort is summed up in three pivotal recent reports, which provide an overall framework and goals for the near-term future in the United States and describe some innovative new tools to reach those goals.

- *Sustaining America*, the report of the President's Council on Sustainable Development (PCSD), presents the best thinking of a multitude of stakeholders and a philosophical framework for the future. The report includes a "We Believe Statement" that summarizes the council's thinking about environmental protection over the next 25 years (Box 2.1).

- The Clinton Administration's *Reinventing Environmental Regulation* runs along parallel lines, providing many of the working policy proposals that are likely to be a focus of future environmental policymaking (Box 2.2).

Reflections on 25 Years

"Whether we like it or not, continued economic and population growth guarantee that environmental issues are going to become more urgent and complex, not less."

Russell Train (CEQ Chair, 1970-73)

Box 2.1.
The President's Council on Sustainable Development—We Believe Statement

1. To achieve our vision of sustainable development, some things must grow—jobs, productivity, wages, capital and savings, profits, information, knowledge, and education—and others—pollution, waste, and poverty—must not.
2. Change is inevitable and necessary for the sake of future generations and for ourselves. We can choose a course for change that will lead to the mutually reinforcing goals of economic growth, environmental protection, and social equity.
3. Steady progress in reducing disparities in education, opportunity, and environmental risk within society is essential to economic growth, environmental health, and social justice.
4. The United States made great progress in protecting the environment in the last 25 years, and must continue to make progress in the next 25 years. We can achieve that goal because market incentives and the power of consumers can lead to significant improvements in environmental performance at less cost.
5. Economic growth based on technological innovation, improved efficiency, and expanding global markets is essential for progress toward greater prosperity, equity, and environmental quality.
6. Environmental regulations have improved and must continue to improve the lives of all Americans. Basic standards of performance that are clear, fair, and consistently enforced remain necessary to protect that progress. The current regulatory system should be improved to deliver required results at lower costs. In addition, the system should provide enhanced flexibility in return for superior environmental performance.
7. Environmental progress will depend on individual, institutional, and corporate responsibility, commitment, and stewardship.
8. We need a new collaborative decision process that leads to better decisions, more rapid change, and more sensible use of human, natural, and financial resources in achieving our goals.
9. The nation must strengthen its communities and enhance their role in decisions about environment, equity, natural resources, and economic progress so that the individuals and institutions most immediately affected can join with others in the decision process.
10. Economic growth, environmental protection, and social equity are linked. We need to develop integrated policies to achieve these national goals.
11. The United States should have policies and programs that contribute to stabilizing global human population; this objective is critical if we hope to have the resources needed to ensure a high quality of life for future generations.
12. Even in the face of scientific uncertainty, society should take reasonable actions to avert risks where the potential harm to human health or the environment is thought to be serious or irreparable.
13. Steady advances in science and technology are essential to help improve economic efficiency, protect and restore natural systems, and modify consumption patterns.
14. A growing economy and healthy environment are essential to national and global security.
15. A knowledgeable public, the free flow of information, and opportunities for review and redress are crtically important to open, equitable, and effective decisionmaking.
16. Citizens must have access to high-quality and lifelong formal and nonformal education that enables them to understand the interdependence of economic prosperity, environmental quality, and social equity—and prepares them to take actions to support all three.

Box 2.2
Reinventing Environmental Regulation

The Clinton Administration's *Reinventing Environmental Regulation* includes 10 principles:

1. Protecting public health and the environment are important national goals, and individuals, businesses, and government must take responsibility for the impact of their actions.
2. Regulations must be designed to achieve environmental goals in a manner that minimizes costs to individuals, businesses, and other levels of government.
3. Environmental regulations must be performance-based, providing maximum flexibility in the means of achieving our environmental goals, but requiring accountability for the results.
4. Preventing pollution, not just controlling or cleaning it up, is preferred.
5. Market incentives should be used to achieve environmental goals, whenever appropriate.
6. Environmental regulations should be based on the best science and economics, subject to expert and public scrutiny, and grounded in values Americans share.
7. Government regulations must be understandable to those who are affected by them.
8. Decisionmaking should be collaborative, not adversarial, and decisionmakers must inform and involve those who must live with the decisions.
9. Federal, state, tribal, and local governments must work as partners to achieve common environmental goals, with nonfederal partners taking the lead when appropriate.

- The three-volume report of the Interagency Ecosystem Management Task Force—*The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies*—describes the challenges and benefits of developing a natural resource management approach focused on restoring the health, productivity, and biological diversity of ecosystems.

As these reports make clear, there are an attractive array of new tools available to support environmental protection efforts. And, as the ecosystem management task force report demonstrates, some exciting new approaches to environmental management are available as well.

In any given environmental management or policy issue, many of these new tools are simultaneously evident. In the case of broad new approaches such as ecosystem management or Comprehensive Conservation and Management Plans, nearly all of these tools may play an important role.

NEW TOOLS

New tools for environmental protection fall into four general categories: (1) decisionmaking; (2) technological innovation; (3) economic systems; and (4) regulatory systems.

First, there are many opportunities to *improve decisionmaking*, including: using sound science and computer applications to improve our understanding of the environment and make the latest research easily accessible; using risk assessment and other tools to better define priorities and target high-risk areas; and encouraging public participation to build better consensus about decisions.

There are opportunities to improve the *efficiency of technological systems*, including encouraging the introduction of new technologies that reduce impacts on human health and the environment.

There are opportunities to improve the *efficiency of economic systems*, including looking for market-based systems such as emissions trading to get more benefits at less cost.

Finally, there are opportunities to improve the *efficiency of regulatory systems*, including simplifying paperwork and reducing the administrative burden on the regulated community where consistent with human health and the environment, and developing alternative performance-based strategies that build more flexibility and innovation into the system.

Improved Decisionmaking

In the area of decisionmaking, three prominent new tools include: (1) the use of computers, telecommunications, and geographic information systems to assess the environment and disseminate information about the environment; (2) the effort to assess the risks to human health inherent in contaminants and target those contaminants that pose the greatest risk; and (3) the effort to encourage the broadest possible public participation in the decisionmaking process.

In the first case, there are numerous examples of federal agencies applying sophisticated new information-gathering techniques.

- In the region around Camp Pendleton, California, a federally supported team of investigators spent two years studying biodiversity, landscape planning, and alternative futures for the region. The research strategy assumed that the major stressors causing biodiversity change were related to urbanization, including population growth and development. A computer-based Geographic Information System (GIS) was developed to describe the region, an 80 kilometer by 134 kilometer rectangle that encompasses five major river drainage basins. Analytical models used the digital data to evaluate the complex dynamic processes at work in the area and the possible impacts on biodiversity resulting from changes in land use. Future change was studied at four scales: several restoration projects, a subdivision, a watershed, and the region as a whole.

  Future scenarios look at regional development to the year 2010 and to subsequent “build-out.” The first scenario is based on current plans developed by local governments and Camp Pendleton. Five alternative scenarios provide a method to explore and compare the impacts of different land use patterns on biodiversity. Alternative 1 uses the dominant spread pattern of low-density growth, while Alternative 2 uses the spread pattern but introduces a conservation strategy in the year 2010. Alternative 3 includes proposals to encourage private conservation of biodiversity. Alternative 4 focuses on multi-centered development, while Alternative 5 concentrates growth in a single city.

Models for the region's soils, hydrology, and fire also are included. Biodiversity is assessed in three ways: a landscape ecological pattern model; potential habitat models for 10 selected species; and a species richness model. Taken together, the models and various alternatives can help illuminate the risks and benefits of a range of growth alternatives for the region and provide some helpful tools for managing the urbanization process.

- The Interior Department's Office of Surface Mining (OSM) has developed an Acid Mine Drainage GIS. The system is being used as a tool to determine if acid mine drainage is likely to occur at a given location. OSM encourages the automated sharing of digital geospatial information between state and federal agencies, industry, and the public. This shared information between the stakeholders assists in reaching a science-based consensus to identify priorities for acid mine drainage cleanup and prevention efforts.

- The Department of Energy has substantially strengthened its focus on electronic distribution of data. Nearly everything the Energy Information Administration (EIA) now produces is available electronically. EIA also has begun releasing preliminary information, based on the fact that nearly four out of five customers said they would be satisfied with an earlier release of 95-percent accurate data.

Environmental Risk Assessment and Priority Setting. The use and production of food, energy, industrial and consumer goods, the generation of waste, and many other activities all expose Americans to a variety of risks, both to their health and to the health of the environment. Many of these exposures are minute, and on any

Reflections on 25 Years

"We are now confronting, because of our industrialized society, an entirely different variety and much more insidious and complex form of pollution, namely toxics. We measure pollutants now, not in tons, but in parts per million, trillion, or quadrillion. The challenge that we've not yet been able to meet adequately is the causal relationship between a pert per million, trillion, quadrillion, of a given pollutant, and its effect on our health and that of our kids. That is where a good deal of our research needs to be."

Michael Deland (CEQ Chair, 1989-93)

given day have no discernible impact. After months, years, or decades, however, the cumulative impact of repeated exposures may result in health problems in some individuals.

Environmental risk is defined as the probability of occurrence of a particular adverse effect on human health or the environment as a result of exposure to an environmental hazard. An environmental hazard may be a hazardous chemical in the environment, but could also be a natural hazard or a hazardous technology such as a dam. Many health concerns are associated with environmental pollutants. Cancer is the best known, but reproductive impairments, birth abnormalities, asthma and other forms of airway hyperactivity, and effects on all the organ systems of the body also warrant serious attention.

In 1993, the Environmental Protection Agency (EPA) conducted about 7,500 risk analyses. About 80 percent (6,000) of these were quick "screens" to look for chemicals that required more intensive review. About 250 were major projects requiring more than four weeks of staff time. Many other federal agencies also conduct risk assessments, including the Occupational Safety and Health Administration, the National Institute for Occupational Safety and Health, the Food and Drug Administration, the Department of Agriculture, the Department of Defense, and the Department of Energy.

EPA's various statutes generally require some form of hazard assessment or risk analysis as a basis for regulation, but the statutes are fragmented and contain differing requirements for how the agency is supposed to use risk information in regulations. Some laws, such as parts of the Clean Air Act, direct the agency to set standards for pollutants at levels that will protect people's health, but bar the administrator from considering the standards' cost to society. Other laws require EPA to set technology-based standards, which require no analysis of the risks posed by the pollution. A third group, including the pesticides, safe drinking water, and toxics acts, require a formal comparison of risks and costs.

Congress and the Administration have struggled to reconcile these issues over the last several years. An important watershed in this debate is Executive Order 12866, which President Clinton signed on September 30, 1993. The order states:

"In deciding whether and how to regulate, agencies should assess all costs and benefits of available regulatory alternatives, including the alternative of not regulating. Costs and benefits should be understood to include both quantifiable measures (to the fullest extent that these can be usefully estimated) and qualitative measures of costs and benefits that are difficult to quantify, but nevertheless essential to consider. Further, in choosing among alternative regulatory approaches, agencies should select those that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity), unless a statute requires another regulatory approach."

The executive order is relatively broad. It assumes and encourages a comparative evaluation of a range of options. The order is an internal management tool and therefore does not raise the issue of judicial review. It also requires consideration of the degree and nature of risk.

Risk assessment helps provide a foundation for the effort to focus on high-priority risks and compare benefits and costs of new regulations. For example, the 1996 amendments to the Safe Drinking Water Act eliminate the requirement for EPA to establish regulations for 25 contaminants every three years and replaces it with a requirement to examine five priority contaminants every five years to determine whether regulation is warranted. If EPA decides to regulate a contaminant and determines that the benefits of a national safety standard are not justified by the costs, it is given the flexibility to set the standard at a level that is justified while maximizing health risk reduction.

On a variety of other fronts, EPA is attempting to strengthen its emphasis on high-risk pollutants:

- In March 1996, EPA exempted 31 low-risk pesticide ingredients from registration with EPA, changing a long-standing requirement.
- In November 1995, EPA proposed a new hazardous waste identification rule that will refocus the regulatory program on high-risk wastes. This rule will exempt wastes that do not pose a significant public health threat from the hazardous waste management regulatory system. Businesses handling these low-risk wastes could save as much as $75 million annually.
- In September 1995, EPA issued a new policy on the frequency of inspections of wastewater discharges under the Clean Water Act's National Pollution Discharge Elimination System. The new policy will allow inspectors to reduce their visits to facilities that handle lower risk materials and have good compliance track records.

Overall, both Congress and the Administration are moving towards a greater emphasis on pollutants that pose the highest risk to public health and the environment, a stronger emphasis on cost-effective regulation and priority setting, and the use of a broad definition of risks, costs, and benefits.

Public Participation. There are many examples of the benefits of broad participation in the decisionmaking process, some of which are described in Chapter 1, "America and the Environment: A 25-Year Retrospective."

In addition to facilitating these processes, many federal agencies are forming partnerships with professional societies, educational institutions, and community groups to develop and implement coordinated strategies supporting environmental education.

Technology Innovation

The federal government is also playing an important role in applying new technologies to environmental protection and in encouraging the introduction of technologies that prevent or reduce environmental pollution.

An interesting example of the value of technology is the recent cooperative effort to control the sea lamprey population in Lake Erie.

Rebuilding stocks of lake trout has been particularly challenging because of losses caused by sea lamprey, which during their parasitic phase attach themselves to and feed off of trout and other predators. Sea lamprey control measures were reasonably effective from about 1970 to the mid-1980s, allowing for the restocking and recovery of lake trout. At the St. Marys River in Sault St. Marie, however, the elimination of municipal and industrial discharges into the river significantly increased water quality and enabled lamprey populations to make a comeback. By the early 1990s, the St. Marys was producing more young lamprey than all other Great Lakes spawning tributaries combined. The effect on lake trout was devastating; in 1995, the catch of wild young-of-the-year lake trout was the lowest in 10 years.

The effort to control the sea lamprey population in the St. Marys is a remarkable story of collaboration and creativity. Many people and institutions contributed to this effort:

- By about 1993, the National Biological Service (NBS) Lake Huron Station had completed development of a chemosterilant for male sea lampreys that did not affect the animal's reproductive behavior.
- By 1990, the Global Positioning System (GPS), originally developed for the military, had become widely available for nonmilitary navigation and mapping. A few years later, the Fish and Wildlife Service developed a deep-water quantitative sampling device and GIS mapping for estimating and plotting densities of larval sea lamprey.
- During the mid-1980s, the Army Corps of Engineers developed an oil spill model to aid in contingency planning for oil containment in the St. Marys River.
- In 1994, federal, state, and Canadian agencies signed an agreement and partnership on lamprey-trapping structures with the Canadian Great Lakes Power Company and the Army Corps of Engineers power stations.

The Fish and Wildlife Service's deep-water sampling revealed that the distribution of young lamprey was very patchy in the St. Marys. With funds from the Great Lakes Fishery Commission, a small fleet of boats was equipped with GPS navigation and GIS computers to map the lamprey distribution. The Corps of Engineers oil spill model was modified for use as a lampricide model. Larval mapping demonstrated that treatment of just the lamprey "hot spots," using GPS-guided delivery systems, could provide reasonable lamprey control by treating as little as 20 percent of the river at a fraction of the cost of traditional treatment.

Trapping at the power plants at Sault St. Marie is currently removing about 40 percent of the adult lamprey spawning run. The trapped males are being chemosterilized at the NBS Lake Huron Biological Station and released back to the river. Initial findings suggest these males mate successfully with normal females and neutralize their reproduction.

Pollution Prevention. Pollution prevention represents an important new opportunity to get more growth with less waste. More than a dozen states have passed pollution prevention laws, and the Congress also has endorsed the approach in the 1990 Pollution Prevention Act.

State pollution prevention laws generally include pollution reduction goals, plans, facility assessments, and provisions on information and technical assistance. Many states help facilities conduct voluntary assessments to identify pollution sources. Firms then must draft plans, based on these assessments, that lay out a pollution-reduction strategy.

Some states provide technical assistance and information. In Arizona and Nevada, Resource Conservation and Recovery Act (RCRA) grants were used to set up university-based pollution prevention centers where firms can get help. Connecticut also has established a business loan program.

Other efforts also are underway to look broadly at the environmental impact of entire industrial sectors.

For example, the Great Printers Project seeks to create a business environment conducive to pollution prevention for an entire industrial sector. The project is a partnership led by the Environmental Defense Fund, Council of Great Lakes Governors, and Printing Industries of America. The team includes Great Lakes regulatory and economic development agencies, the U.S. Environmental Protection Agency, state and federal technical assistance providers, printers, suppliers, and customers.

The team analyzed regulations, permit and reporting requirements for all environmental media, barriers and possible incentives to pollution prevention, and general environmental protection. It determined what kinds of technical, financial, and regulatory assistance would be useful and how it should be provided. It examined the factors—customer demands, regulatory requirements, and access to technology and financial resources—that can lead printing companies away from pollution prevention at the source.

In July 1994, the team released its consensus recommendations. The recommendations affected everyone involved in the printing process—printers, print buyers, suppliers, distributors, government regulators, and technical assistance organizations. Implementation activities are now underway in four pilot states: Illinois, Michigan, Minnesota, and Wisconsin.

The project focuses on supporting print shops committed to furthering Great Printers principles to:

- comply with applicable environmental, health, and safety laws;
- go beyond compliance by employing the most environmentally sound practices to (1) maximize reduction of waste at the source, (2) reuse or recycle waste that cannot be prevented, and (3) maximize energy efficiency in the print shop;
- seek to continuously improve on environmental performance through periodic assessments of operations, materials, and products, and by draw-

ing on information and ideas from employees, print buyers, suppliers, and neighbors; and

- measure and report on progress.

Key components of the program include: generating customer demand to create a market for environmentally superior printing; improving access to technology and financial resources for printers; and simplifying government requirements so that printers can readily understand, meet, and exceed their environmental obligations.

For example, EPA created the Printers National Environmental Assistance Center to provide a central source of accurate and current environmental compliance and pollution prevention information for the printing industry. The center has created a World Wide Web site on the Internet to efficiently share information with printers.

Improved Economic Efficiency

There are opportunities to improve the *efficiency of economic systems*, including looking for market-based systems such as emissions trading to get more benefits at less cost and developing alternative performance-based strategies that build more flexibility and innovation into the system.

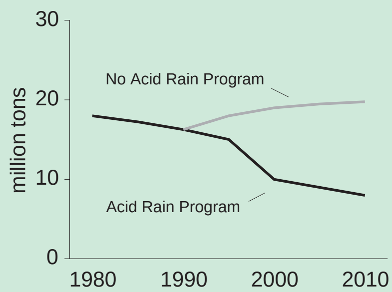
Emissions Trading Programs. Emissions trading among stationary sources is an increasingly important regulatory tool. Under this system, a company that reduces emissions below the level required by law can receive emissions credits that can be used for higher emissions elsewhere. Companies can trade emissions among sources within a company as long as combined emissions stay within a specified limit. Companies also can trade emission credits with other companies that are sources of such emissions or save earned emission credits for future use or trade.

Ozone Trading. The current ozone control program has focused on a combination of technology-based mandatory measures and state plans that historically have discouraged flexible emissions trading programs. EPA recently issued regulations and guidance to encourage development of economic incentive programs, helped develop an emissions trading market in Southern California, and sponsored demonstration projects in the Northeast and elsewhere.

EPA proposed in August 1995 a model rule for emissions trading of smog-creating pollutants. Under this policy, a company that exceeds its required pollution reductions would have the opportunity to sell its “surplus” reductions (or “credits”) to companies that find credits a more cost-effective way to comply with these requirements. Once trading is allowed in a state plan, companies could freely engage in trades without prior approval as long as reporting and public health standards are being met.

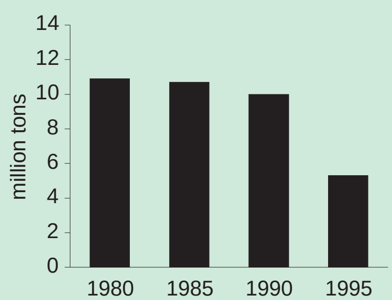
Expanding use of market-based emissions trading on a local and regional level will give companies broad flexibility to find the lowest cost approaches to emissions reductions. The rule would encourage experimentation with new trading options, including allowance-based trading systems in which total emissions are

Figure 2.1 U.S. Utility SO_2 Emissions, 1980-2010



Source: U.S. Environmental Protection Agency, Acid Rain Program.
Note: Data are based on estimates and projections.

Figure 2.2 U.S. SO_2 Emissions, 1980-1995



Source: U.S. Environmental Protection Agency, Acid Rain Program.
Note: Data are from 445 Phase I affected utility units whose combined emissions were 3.4 million tons below the required level in 1995.

capped, which are already under development in some areas.

Acid Rain Trading. The 1990 amendments to the Clean Air Act created an acid rain control program that is designed to reduce emissions of sulfur dioxide and nitrogen oxides, the primary causes of acid rain. The law sets as its primary goal the reduction of annual SO_2 emissions by 10 million tons below 1980 levels (which were about 18 million tons) in the year 2010 (Figure 2.1). The 1990 amendments also set a goal of reducing NOx by 2 million tons from 1980 levels by the year 2000.

It requires a two-phase tightening of the restrictions placed on fossil fuel-fired power plants. Phase I, which began in 1995, affects 445 mostly coal-burning units in the eastern and midwestern states. In 1995, SO_2 emissions from these units were measured at 5.3 million tons annually, 40 percent below the required level and less than half their emissions in the 1980s (Figure 2.2). The reductions seem to be providing immediate benefits; according to a study prepared for the U.S. Geological Survey, rainfall acidity at some sites in the Midwest, Northeast, and Mid-Atlantic regions dropped by 10-25 percent in 1995.

Phase II, which begins in the year 2000 and affects over 2,000 units, tightens annual emissions limits on larger plants and also sets restrictions on smaller plants. The program affects existing utility units serving generators with an output capacity greater than 25 megawatts and all new utility units.

Under the trading program, affected utility units were allocated allowances based on their historic fuel consumption and a specific emissions rate. Each allowance permits a unit to emit 1 ton of SO_2 during or after a specified year. For each ton discharged in a given year, one allowance is retired and can no longer be used. Allowances may be bought, sold, or banked. In 1995, 5.3 million allowances were deducted, which represents 61 percent of all 1995 allowances issued. During Phase II, the Clean Air Act sets a cap of 8.95 million allowances for total annual allowance allocations to utilities. This cap will ensure that environmental benefits will be achieved and maintained.

The cost of reducing a ton of SO_2 from the utility sector continues to decline: scrubber costs have dropped about 40 percent below 1989 levels, removal efficiencies have improved from about 90 to 92 percent in 1988 to about 95 percent or more in new retrofits, and expected increases in cost associated with the increased use of low sulfur coal have not materialized. These reductions in cost are being reflected in allowance prices, which have dropped from $150 per ton to about $80 per ton in mid-1996. About 99 percent of all allowance trades are processed within 5 days, and 81 percent are processed within 24 hours.

The NOx program focuses on coal-fired electric utility boilers. As with the SO_2 program, it is implemented in two phases (1996 and 2000), but it does not "cap" NOx emissions or utilize an allowance trading system. Utilities have two options: compliance with an individual emissions rate for a boiler or averaging of emissions rates over two or more units to meet an overall emissions rate limitation. These options give utilities flexibility to meet the emissions limitations in the most cost- effective way and allow for the further development of technologies to reduce the cost of compliance.

Effluent Trading. Another promising opportunity is the introduction of effluent trading in watersheds. Under an effluent trading program, a discharger that can reduce water pollution discharges below the minimum level required to meet water quality standards can sell its excess pollution reductions to other dischargers within the same watershed. Effluent trading can allow dischargers to take advantage of economies of scale and the treatment efficiencies that vary from discharger to discharger, and it could provide an economic incentive for dischargers to go beyond minimum pollution reductions. Trading programs also could be established for other sources of water pollution, including non-point sources (e.g., runoff from farms) and indirect dischargers (companies whose wastewater is treated by a municipal sewage treatment plant).

To get the process started, EPA is developing a framework promoting different types of effluent trading and providing technical analyses of the total amount of permissible pollution in a watershed.

EPA has estimated potential cost savings for three types of effluent trading: $611 million to $5.6 billion for point source/nonpoint source trading; $8.4 million to $1.9 billion for point source/point source trading; and $658 million to $7.5 billion for trading among indirect dischargers.

Regulatory Efficiency

Many federal agencies are accelerating efforts to evaluate existing regulations and create opportunities to attain environmental goals at lower economic costs. For example:

- The Bureau of Land Management, in cooperation with the Western Utility Group and the Forest Service, has instituted measures to streamline the receipt and processing of rights-of-way applications on public lands, including processing of applications by telephone and fax.
- At the Department of Energy, the Building Standards and Guidelines program has developed a line of products to assist in compliance with the most commonly used residential energy building energy code, the Model Energy Code. These materials give the home builder a great deal of flexibility in determing how the model codes are implemented. This allows home builders to quickly and simply substitute a more cost-effective design and still retain code compliance.

Alternative Performance-Based Strategies. In March 1995, the President and Vice President proposed a series of demonstration projects designed to provide the opportunity to implement alternative management strategies for facilities, industrial sectors, communities, and federal agencies.

Under Project XL, EPA in partnership with the states will provide a limited number of responsible companies the flexibility to replace the requirements of the current system at specific facilities with an alternative strategy developed by the company. The strategy must:

- provide environmental performance that is better than full compliance with current laws and regulations;
- be "transparent," so that citizens can examine assumptions and track progress;
- not create worker safety or environmental justice problems;
- be supported by the community surrounding the facility; and
- be enforceable.

Project XL is a response to the growing recognition that more flexible approaches involving pollution prevention can often provide substantial cost savings and enhanced environmental quality. In addition, the project promotes a more cooperative relatonship between regulators, the facility, and the community.

A dozen companies and state agencies currently are participating in the program. For example, Merck and Company is pursuing a comprehensive single permit approach to control air pollution at its Elkton, VA, facility.

Department of Justice enforcement actions can sometimes also provide opportunities to foster such efforts. In some instances, each of several alternatives may be legitimate means for achieving compliance with legal requirements, but some of these approaches may provide more environmental benefit than others. To encourage the defendant to secure compliance by a more environmentally beneficial alternative, the Environment and Natural Resources Division will sometimes agree as part of a settlement to allow a longer compliance schedule in return for a defendant's enforceable promise to install the more environmentally beneficial compliance option.

NEW APPROACHES

In the next few decades environmental protection and resource conservation efforts are likely to move towards more holistic approaches, including either ecosystem-based management or sectoral strategies.

The ecosystem approach provides a framework for working with all stakeholders in a region to ensure the conservation of important ecological values.

As described at greater length in the chapter on ecosystems, ecosystem-based approaches present many difficult challenges. The Interagency Ecosystem Management Task Force identified several recurring barriers and opportunities that federal agencies face in implementing the ecosystem approach and in participating in ecosystem partnership efforts initiated by others. For example, existing practices are generally characterized by specific missions, stratified organizational structures, and the subdivision of problems into narrowly defined tasks. Coordination among federal agencies is hampered by procedural requirements, budget structures, data inconsistencies, traditional agency cultures, and political alliances. Taken together, these barriers suggest that developing ecosystem-based management will be a slow process.

The goal of the ecosystem approach is to restore and maintain the health of ecological resources together with the communities and economies that they support. The inclusion of people and their economic needs is a fundamental part of the approach. The ecosystem approach should highlight potential conflicts between human activity and a sustainable environment early enough to resolve them when there are still options available, and to prevent them from becoming crises.

For example, the Clinton Administration established an ecosystem effort in the Pacific Northwest forests based on five principles articulated by the President: (1) protecting the long-term sustainability of forests, wildlife, and waterways; (2) never forgetting the human and economic dimensions of the problems; (3) making efforts that are scientifically sound, ecologically credible, and legally responsible; (4) producing a predictable and sustainable level of timber sales and non-timber resources that will not degrade or destroy the environment; and (5) ensuring that the federal government works with and for the people.

Reflections on 25 Years

"Why rush to save it all now? You can't put an ecosystem in a zoo. When it's gone, it's gone, period. We can't put an ecosystem back together again, at least with any method we can conceive at the present time."

Prof. E.O. Wilson, Harvard University

The Administration's forest plan represents an entirely new way of doing business. It includes: (1) an ecosystem-based management plan for 25 million acres of federal land in the region; (2) an economic assistance plan; and (3) a blueprint for improved agency coordination. Such a comprehensive approach was probably the only viable alternative for breaking the impasse caused by years of competition and conflict in the region.

Both the forest plan and the Administration's current approach to the groundfish crisis in the Northeast include economic assistance to those adversely affected by the new policies.

Habitat Conservation Plans

Initially intended to deal with a single rare species, Habitat Conservation Plans (HCPs) increasingly are being broadened and expanded to include other rare or declining species and the habitat that supports them all. State and local governments are often involved in planning and implementation. These changes help to minimize socio-economic effects, to assure fair treatment for landowners, and to strengthen partnerships between federal and non-federal entities.

In essence, HCPs are a way to allow economic use of private lands while conserving critical habitat for at-risk species. They provide more certainty to the landowner than the traditional processes. Under the "no surprises" policy of the Secretary of the Interior and the Secretary of Commerce, landowners who develop HCPs will not be subject to later demands for more money or land to conserve those species, even if circumstances change. A "deal is a deal," and development can proceed without the prospect of additional mitigation requirements for covered species.

A highly visible and widely publicized example of a habitat conservation plan is under way in Orange County, California. Development pressures in the area are intense, land values are high, and the area's coastal sage scrub vegetation provides habitat for the endangered California gnatcatcher and many other species. A significant amount of this land is owned by the Irvine Corporation, which has acted as the major partner with the U.S. Fish and Wildlife Service and the California Department of Fish and Game in the development of a regional land use and conservation plan. This plan provides for sub-regional planning by landowners and local governments, with guidance from an independent state scientific review panel, and approval by state and federal agencies.

In the southeastern states, private timber firms were becoming increasingly frustrated by harvest limitations resulting from the need to protect habitat for the red-cockaded woodpecker. The companies felt that they often would not know in advance what the restrictions would be, and could not take the constraints into account in their planning. Led by firms such as the Georgia Pacific Corporation and International Paper, plans are being developed to provide much greater certainty for timber managers regarding what they can and cannot do, and where.

Comprehensive Conservation and Management Plans

A number of programs authorized by the Clean Water Act—the National Estuary Program, the Great Lakes Program, and the Chesapeake Bay Program—all go beyond national pollution control standards to address a wide array of site-specific problems and consider population and development pressures as well as pollution.

The National Estuary Program, which was authorized by the Clean Water Act Amendments of 1987, identifies nationally significant estuaries that are threatened by pollution, development, or overuse.

The program is managed by EPA but emphasizes collaboration with other federal agencies, state agencies, local governments, and private citizens. If an estuary is selected for the program, EPA convenes a management conference that includes representatives of EPA, state, federal, and regional agencies, local governments, affected industries, educational institutions, and the general public.

The group's main tasks are to identify and rank an estuary's major problems and to create a Comprehensive Conservation and Management Plan (CCMP) that would reduce pollution and restore the estuary. The plan can go beyond Clean Water Act requirements and can reach activities, such as land use, that are not directly regulated under the act.

For example, the CCMP for Galveston Bay, Texas, provides a blueprint for restoring and maintaining the Galveston Bay ecosystem. Unlike traditional resource management, the plan begins with stakeholder agreement on the problems and emphasizes an ecosystem approach to managing Galveston Bay. The ecosystem approach emphasizes the interconnectedness of bay processes. Effective solutions to the bay's problems must account for these diverse processes and operate at a systems level. Similarly, at the level of bay governance, the plan emphasizes integrated regional planning and management.

Sectoral Strategies

Rather than basing environmental policy on particular environmental media or chemicals, sectoral policy looks more broadly at how specific industrial sectors generate, prevent, and control pollution. Underlying this approach is the assumption that similar sectors can identify common emissions problems and find common solutions, which can help regulators fashion improved regulations and streamline permitting.

For example, EPA's "Common Sense Initiative" is focusing on looking at all the rules applicable to air, water, land, and toxics in six sectors: automobile assembly; computers and electronics; iron and steel; metal finishing and plating; petroleum refining; and printing. Participants include trade groups, state and local regulatory agencies, national and grassroots environmental groups, and labor and environmental justice organizations.

The aim of the initiative is to look for opportunities to give industry the incentives and flexibility to develop innovative technologies that meet and exceed environmental standards while cutting costs, and to look for ways to change the permitting system to encourage innovation. The Clinton Administration will make regulatory reform and pollution prevention a central focus of CSI.

EPA also is pursuing sector-wide enforcement agreements. For example, the Toxic Substances Control Act requires reporting of specific information on volumes of toxic chemicals released. EPA had been pursuing 51 cases involving more than 200 natural gas processor facilities for violating this requirement. In October 1995, EPA concluded an industry-wide settlement. As part of the settlement, the natural gas processing industry agreed to put in place controls that will prevent these types of violations in the future.

This settlement marked the first time EPA has worked with an industry association to develop a national agreement to successfully resolve multiple violations.

CONCLUSION

Human history provides many examples of communities and civilizations that have collapsed after the loss of a natural resource base. For example, the Hohokam people of Arizona built a vibrant agricultural system and watered the land with an advanced system of aqueducts, yet the Hohokam disappeared half a millennium ago because they watered incorrectly amd poisoned the land with salt buildup. The name Hohokam means “those who have gone.”

Today, there are virtually no more places to go. Competition and conflict over natural resources must give way to cooperation, sharing, and maintaining reasonable and sustained uses of natural resources.

Ecosystem management, CCMPs, and sectoral pollution control strategies all provide useful new ways to resolve conflicts in constructive ways and to avoid the kinds of resource crises that have destroyed so many civilizations in the past. They recognize the dual goals of healthy regional economies and healthy natural settings.

At their best, such mechanisms fulfill the fundamental goal of sustainable development: leaving future generations with an environment and resources at least as abundant and healthy as we enjoy today.

Reflections on 25 Years

“The most important challenge facing mankind is exponential population growth. But I’d put right alongside of it the absence of a guiding environmental ethic. You could freeze the population at the current level, or reduce it to half of what it is, but if the culture isn’t guided by an environmental ethic, we’re going to continue to make the same mistakes.”

Gaylord Nelson (U.S. Senator, Wisconsin, 1963-81)

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CHAPTER THREE

National Environmental Policy Act

The National Environmental Policy Act (NEPA) is the foundation of modern American environmental protection. While U.S. conservation efforts began more than one hundred years ago, and continued throughout the twentieth century, NEPA focused environmental concerns within a comprehensive national policy.

One quarter of a century ago, NEPA set forth clear goals for agencies to foster "productive harmony" between "man and nature," so as to "fulfill the social, economic, and other requirements of present and future generations of Americans." Under NEPA, for the first time, agencies were required to prepare environmental analyses—with input from the state and local governments, Indian tribes, the interested public and other federal agencies—when considering a proposal for a major federal action.

With these provisions, NEPA set forth an inclusive, comprehensive vision for the environment. NEPA 25 years ago anticipated today's calls for enhanced local involvement and responsibility, sustainable development, and government accountability.

BACKGROUND[1]

The birth of NEPA and the Council on Environmental Quality (CEQ) originated from the growing public alarm that the environment was rapidly deteriorating—if not in crisis—and that few existing laws or public institutions could reverse the trend. By 1969, a bipartisan political coalition in both Congress and the White House came together to take action to remedy the situation.

Environmental crises—such as the drought and dust storms in the 1930s—had pushed conservation issues into the forefront at various times in American history. However, as of 1969, no unified framework or Presidential-level institution yet had been developed to integrate natural resources, pollution control, and socioeconomic factors into a national policy.

Beginning in 1959 with Montana Senator James Murray, various legislative proposals were submitted to create a council of natural resource advisors, modeled after the Council of Economic Advisers, in the Executive Office of the President. In 1967, Washington Senator Henry M. Jackson, Chairman of the Senate Interior and Insular Affairs Committee, and Michigan Representative John S. Dingell, Chairman of the Subcommittee on Fisheries and Wildlife Conservation of the House Merchant Marine and Fisheries Committee, introduced legislation to create a Presidential advisory board or council.

Over the next few years, Congress held hearings and published reports on the environment in response to the public outcry that had mounted over a number of environmental emergencies throughout the 1960s. Rachel Carson's *Silent Spring* raised public concerns on the effects of the pesticide DDT, the Cuyahoga River caught fire, smog in Los Angeles was severe, the Bureau of Reclamation was proposing to build a dam on the Colorado River that would flood the Grand Canyon, and Lake Erie was proclaimed dead.

Professor Lynton K. Caldwell of Indiana University, serving as consultant to Jackson's Interior Committee, was instrumental in shaping NEPA. Historically, agency missions focused on projects and public works. With no statutory authority to do otherwise, agencies had little incentive to consider the environmental consequences of their actions. Caldwell devised the mechanism of environmental impact statements (EISs) as a way of forcing agencies to institutionalize environmental analyses into their decision-making. Following Jackson's contentious Committee hearings on the proposal to dam the Colorado River above the Grand Canyon[2], Jackson included an EIS requirement—referred to as a "detailed statement"—in what became NEPA.

"[R]efreshingly brief and of almost Constitutional tone,"[3] NEPA provided that national policy was "to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans." NEPA amended federal agency charters to incorporate this policy into each agency's statutory mission. The act required all federal agencies to identify and assess the potential environmental impacts of their major proposals, and to identify alternatives to those proposals. The act also established the Council on Environmental Quality.

By 1969, Congress passed Jackson and Dingell's NEPA with bipartisan support. In his floor remarks, Senator Jackson stated:

> *What is involved is a congressional declaration that we do not intend, as a government or as a people, to initiate actions which endanger the continued existence or the health of mankind: That we will not intentionally initiate actions which do irreparable damage to the air, land and water which support life on earth.*[4]

In the House, Representative Dingell said:

> *[W]e can now move forward to preserve and enhance our air, aquatic, and terrestrial environments . . . to carry out the policies and goals set forth in the bill to provide each citizen of this great country a healthful environment.*[5]

In submitting the conference report to the Senate, Jackson reminded his colleagues that "an environmental policy is a

Box 3.1
NEPA Glossary

Section 102(2)(C) of the National Environmental Policy Act of 1969 requires federal agencies to prepare a “detailed statement” for proposed major actions which significantly affect the quality of the human environment. The statement must include the environmental impacts of the proposed action, alternatives to the proposed action, and any adverse environmental impacts which cannot be avoided should the proposal be implemented. In 1978 the CEQ issued binding regulations which implement the procedural provisions of NEPA. The following are key terms:

- **Environmental Assessment (EA).** A concise public document that analyzes the environmental impacts of a proposed federal action and provides sufficient evidence to determine the level of significance of the impacts.

- **Finding of No Significant Impact (FONSI).** A public document that briefly presents the reasons why an action will not have a significant impact on the quality of the human environment and therefore will not require preparation of an environmental impact statement.

- **Environmental Impact Statement (EIS).** The “detailed statement” required by Section 102(2)(C) of NEPA which an agency prepares when its proposed action significantly affects the quality of the human environment.

- **Record of Decision (ROD).** A public document signed by the agency decision-maker at the time of a decision. The ROD states the decision, alternatives considered, the environmentally preferable alternative or alternatives, factors considered in the agency’s decision, mitigation measures that will be implemented, and a description of any applicable enforcement and monitoring programs.

- **Categorical Exclusion (CATEX).** Categories of actions which normally do not individually or cumulatively have a significant effect on the human environment and for which, therefore, an EA or an EIS is not required.

- **Cumulative Impact.** The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable actions regardless of what agency, federal or nonfederal, or what person undertakes the action.

policy for people. Its primary concern is with man and his future.”[6] President Richard Nixon signed NEPA into law on January 1, 1970.

NEPA has to date served as a model for over 25 states and nearly 90 countries.

Implementation

Environmental groups initially pressed CEQ to act as a judge of all federal agency EISs. With approximately 70 federal agencies falling under NEPA’s purview, CEQ's small staff was quickly faced with the prospect of being overwhelmed.[7] Instead, CEQ staff developed guidelines for agencies to follow in preparing EISs, placing the responsibility of complying with NEPA squarely with the agencies, as Congress had intended. During the Ford Administration, over the course of 18 months, CEQ staff began a study of federal agency EIS preparation. When the report was completed, it was made available to newly-elected President Jimmy Carter, who then issued an executive order requiring CEQ to promulgate regulations, so as to streamline the NEPA process. Executive Order 11991 called for the regulations to "make the environmental impact statement process more useful to decisionmakers and the public; and to reduce paperwork and the accumulation of extraneous background data, in order to emphasize the need to focus on real environmental issues and alternatives."[8]

The regulations are binding on all federal agencies. In the preamble to the regulations, then-CEQ Chairman Charles Warren stated that the EIS:

> *has tended to become an end in itself, rather than a means to making better decisions . . . [EISs have] often failed to establish the link between what is learned through the NEPA process and how the information can contribute to decisions which further national environmental policies and goals.*[9]

Accordingly, the new regulations were "designed to gear means to ends—to ensure that the action-forcing procedures of Section 102(2) of NEPA are used by agencies to fulfill the requirements of the Congressionally mandated policy set out in Section 101 of the Act."[10] Chairman Warren insisted that the regulations have the consensus of agencies and interested groups, which ensured that the regulations would be supported over the long term.

The courts also played a critical role from the beginning in ensuring that agencies would not ignore NEPA and its environmental analysis requirements. In one of the earliest and most influential cases, *Calvert Cliffs v. Atomic Energy Commission*,[11] Judge Skelly Wright ruled that the Atomic Energy Commission (AEC) failed to comply with NEPA even though it had prepared an EIS. Although the policy provisions in Section 101 of NEPA were found to be flexible and within an agency's discretion, Section 102's procedural requirements were not. Wright called for the AEC to consider less environmentally damaging alternatives and to analyze potential environmental impacts fully, rather than have environmental data merely "accompany" an application through the decisionmaking process.

The Supreme Court further clarified agency responsibilities in stating that agencies must take a "hard look" at the environmental consequences of proposals before proceeding with them.[12] The "hard look" must satisfy two aims of NEPA: to provide enough information to the agency regarding potential environmental impacts to ensure a "fully informed and well-considered decision," and to ensure that the agency will inform the public that environmental concerns have been considered during the decisionmaking process.[13]

Throughout the 1970s, courts were split on whether NEPA imposed a duty on agencies other than the procedural requirements of Section 102(2), or whether NEPA was intended to change agency decisionmaking substantively.[14] The Supreme Court addressed this issue in two cases in 1978 and 1980, finding that while NEPA set forth "substantive goals," NEPA's mandate to agencies was "essentially procedural . . . to ensure a fully informed and well-considered decision, not necessarily a decision the judges of the Court of Appeals or of this Court would have reached had they been members of the decisionmaking unit of the agency."[15]

Nonetheless, these and subsequent decisions by the Supreme Court emphasized that environmental quality is an integral part of every agency's mission and must be considered when pursuing other national policy objectives.[16] Moreover, courts have found that it is the process of generating information, disclosing that information to the public, and consulting with the public, Indian tribes, and interested federal, state and local agencies during the decisionmaking process that promotes agency consideration of social, economic and environmental factors. As the Supreme Court pointed out, "[T]he requirement that agencies prepare detailed impact statements inevitably bring[s] pressure to bear on agencies 'to respond to the needs of environmental quality.'"[17]

TRENDS IN NEPA IMPLEMENTATION

Several major trends in NEPA implementation have become apparent since the CEQ regulations were issued.[18]

First, the overall number of lawsuits filed under NEPA has generally declined. In 1974, 189 cases were reported to be filed. In 1994, 106 NEPA lawsuits were filed. In general, for the last twelve years, the number of NEPA lawsuits filed annually has consistently been just above or below 100.[19]

In addition, agencies today prepare substantially more environmental assessments (EAs) than EISs. However, because agencies are not required to report the number of EAs they prepare, accurate data are not readily available. Moreover, comparisons between numbers of EISs and EAs are not exact. Annual EIS numbers represent draft, revised, supplemental, and final EIS documents, rather than representing projects for which several NEPA documents may be prepared. In contrast, EAs are usually only prepared once, and so tend to correspond to actual projects. Nonetheless, since the CEQ regulations were promulgated, all signs point to a significant increase in EAs and a decrease in EISs. The annual number of draft, revised, supplemental, and final EISs prepared has declined from approximately 2,000 in 1973 to 465 in 1993 and 532 in 1994, averaging 488 annually between 1990-1994. By 1993, a CEQ survey of federal agencies estimated that about 50,000 EAs were being prepared annually.

An agency's decision to prepare an EIS is important because an EIS tends to contain more rigorous analysis and more public involvement than an EA. The primary purposes of an EA are to determine whether there may be a significant impact from a federal proposal (thus requiring preparation of an EIS) and to aid an agency's compliance with the act when no EIS is required. On the other hand, an EIS assesses the potential impacts of alternatives once an agency has determined that a proposed action may have significant impacts. While some agencies—such as the Department of Energy, the Department of the Army, and the U.S. Forest Service—provide for a public comment period on environmental assessments, many do not.

Another significant trend is that agencies increasingly identify and propose measures to mitigate adverse impacts from a proposed action during preparation of an EA. If an agency finds that such mitigation will prevent a project from having significant impacts on the environment, the agency can then conclude the NEPA process by issuing a finding of no significant impact (FONSI), rather than preparing an EIS. Early identification of potential impacts and measures to mitigate them tends to save time and money.

A particularly encouraging trend is that of agencies seeking input from other agencies and the public earlier in the planning process, and often well before scoping. The extent to which an agency integrates its planning process with NEPA's framework will dramatically improve the approval time, cost and ultimate viability of a proposal. Some agencies have begun to employ systems designed to foster interdisciplinary and interagency cooperation before a proposal has been fully developed. NEPA has not generally been used to coordinate federal activities on an ecosystem-wide scale, but its procedures to promote collaboration are consistent with an ecosystem-based approach. Some agencies, such as the Tennessee Valley Authority, use NEPA as a general planning framework for the ecosystem approach through programmatic EISs, which are designed to analyze whole programs instead of individual projects. In some cases, agencies are making use of agreements with other agencies and states to outline planning and proposal development responsibilities, jurisdiction, and dispute resolution mechanisms.

Finally, once a project is approved, agencies have not tended to collect long-term data on the actual environmental impacts of those projects. Nor do agencies tend to gather data on the effectiveness of mitigation measures. While NEPA and the CEQ regulations do not require mitigation measures be implemented (unlike some state "little NEPA" laws), the CEQ regulations do require agencies to adopt a monitoring and enforcement program with respect to mitigation measures in a Record of Decision, and to make available to the public the results of that monitoring.[20] Some agencies are increasingly using monitoring after project approval to gather data for future planning, as well as to adapt project management to new information or changing conditions. This approach has enabled these agencies to increase their flexibility in implementing programs over the long term.

International Trends in Environmental Impact Assessments

One of the most important and rapidly-evolving trends internationally is the application of environmental impact analysis to policies, plans, and programs. This approach, called strategic environmental assessment, or SEA, addresses the environmental considerations and consequences of proposed policy, plan, and program initiatives before specific projects have been identified. Variations on this approach have been widely proposed and in some cases recently adopted in Australia, Canada, New Zealand, western Europe, and Hong Kong.

The purpose of SEA is to integrate environmental and sustainability factors in a flexible manner into the mainstream of policy-making. Although an SEA scheme should be consistent with the generally accepted principles of environmental impact analysis, not all countries have adopted the specific procedures called for under environmental impact analysis statutes.

SEA is still at a relatively early, formative stage. Many practical questions remain to be answered about effective procedures, methods and institutional frameworks. However, employed well, SEA may serve a number of goals. SEA may incorporate sustainability considerations by addressing the cause of the environmental problems at the policy source, rather than just treating the final symptoms or impacts. SEA may also serve as an early warning mechanism to identify cumulative effects by dealing with them regionally, rather than on a project-by-project basis. Finally, SEA may serve to focus and streamline project environmental impact assessments by ensuring that questions of project need have been answered and alternatives have had environmental scrutiny at the policy or program level.

In the years to come, the scope and form of SEA will depend upon its function, the policy and institutions that are in force, and the extent to which other processes are used for similar purposes.

CEQ Awards

The Council on Environmental Quality annually recognizes federal agencies that have integrated NEPA into their routine decisionmaking processes. The “Federal Environmental Quality (FEQ) Award” was established in 1992 in partnership with the National Association of Environmental Professionals (NAEP). The awards recognize agencies for a particular NEPA analysis and the best-sustained NEPA program that best meets the award criteria (Box 3.2).

In 1996, CEQ and the NAEP announced that the U.S. Army Corps of Engineers and the Minerals Management Service (MMS) had won the FEQ award for 1995. In 1995, the U.S. Army Corps of Engineers and the U.S. Department of Energy were chosen to receive the award for the year 1994. The winners were selected by a committee chaired by CEQ. Other members of the committee

Box 3.2
Criteria for Federal Environmental Quality Awards

1. The goal of reinventing environmental regulations includes strategies for innovation, partnering, flexibility and cost reduction. How does the project/program reflect this goal and provide for these four strategies?
2. How does the agency engage in cooperative consultation with other federal, state, local agencies, and Indian tribes?
3. How is the public participation process managed?
4. How does the agency ensure editorial excellence, including readablilty and brevity?
5. Does the agency use an interdisciplinary approach to environmental impact analysis preparation?
6. How does the agency ensure scientific integrity of the environmental analysis?
7. How much time elapsed between the project scoping meeting and the issuance of the final environmental impact statement? For a NEPA program, what is the average length of time the agency requires to issue a final environmental impact statement?
8. What innovative approaches were used in the environmental impact analysis for the action? What innovative approaches have been institutionalized by the agency?
9. How does the action Record of Decision reflect the purposes and policies of the National Environmental Policy Act? How has the agency institutionalized the environmental values embodied in NEPA?
10. Has the agency monitored the environmental effects of the action? Does the agency have a monitoring and mitigation program for the NEPA program? How does the agency ensure that mitigation detailed in the environmental impact analysis is honored?
11. What was the cost of the action's environmental impact analysis? How did the action manager control the cost of the environmental impact analysis? Does the agency have cost control methods in place? What are those methods?

included the President of NAEP, the National Governors' Association, the non-governmental organization American Rivers, and the U.S. Environmental

Protection Agency. The awards were presented at the NAEP annual conferences.

In 1996, the Corps of Engineers won the FEQ award for its project, "Houston-Galveston Navigation Channels—Supplemental Environmental Impact Statement." The project was done in partnership with the Port of Houston Authority and the Galveston Wharves. The project involved dredging over 53 miles of channel and disposing of 350 million cubic yards of dredged material. The Supplemental EIS team developed scientific models to assess the potential environmental effects and employed mitigation that was responsive to public concerns. In 1995, the Corps of Engineers won the FEQ award for its project, "Programmatic Environmental Impact Statement Joint Task Force Six Activities Along the U.S.-Mexico Border." The project was organized in response to the National Drug Control Strategy, and provides technical, logistical, operational, and engineering support to federal, state, and local law enforcement agencies throughout the southwestern United States.

In 1995, the Minerals Management Service won the FEQ award for the management program they began in 1973 with the preparation of an EIS to ensure that oil and gas development near the Flower Garden Banks Marine Sanctuary would be compatible with protection of that resource. The program has been sustained for the last 23 years by supplementing the original EIS or preparing new NEPA analyses. The Department of Energy won the FEQ award in 1995 for the year 1994 for the continued improvement of its NEPA Compliance Program. Secretary Hazel O'Leary has taken bold steps to reinvent DOE's NEPA program and has brought a change of culture and instilled in senior managers a commitment to openness and public participation in environmental decisionmaking.

These case studies show that when the public is involved throughout the NEPA process, opportunities are created to resolve conflicts and eliminate delay. The NEPA process helped forge partnerships in place of adversarial relationships.

CEQ Oversight and Federal Agency Implementation

One of CEQ's more important roles is in NEPA outreach and training initiatives, for both the public and private sector. As the agency charged with overseeing federal agency implementation of the procedural provisions of NEPA, CEQ's interpretations and perspectives are often requested. In addition to assisting agencies and the public in making the NEPA process more efficient and accessible, CEQ's participation in training courses and outreach programs ensure that it consistently hears about issues and concerns that are critical to those most affected by the NEPA process.

NEPA Conferences. In October of 1994, CEQ convened a workshop with all the federal agency NEPA liaisons at the White House Conference Center. The purposes of the workshop were to seek input from the agencies on how well NEPA was working within their agencies and to identify ways CEQ could help make the process more effective and efficient. Presentations and small focus groups focused on using NEPA as a tool for an ecosystem approach to management, methods, tools and techniques available to increase the effectiveness of assessing cumulative impacts, and to address how agencies could ensure they addressed the environmental justice concerns reflected in Executive Order 12898.

In 1995, CEQ co-hosted a conference with the Department of Energy to commemorate the 25th anniversary of NEPA. Its theme, "New Visions, Better Decisions," reflected Secretary of Energy Hazel O'Leary's personal commitment to ensuring that DOE took a new approach to the NEPA process which would streamline management, and improve the integration of NEPA into decisionmaking. In her keynote address, Secretary O' Leary stressed that NEPA is an activity that is not set apart from decisionmaking; rather, it is an activity to inform and drive decisions, while facilitating DOE's effective engagement of the public. She also encouraged initiatives to improve the timeliness and cost-efficiency of the NEPA process.

Also in 1995, CEQ co-hosted with the Federal Highway Administration (FHWA) a 25th anniversary workshop to explore ways to streamline transportation planning and decisionmaking, improve the FHWA NEPA process, and balance social, economic, and environmental considerations. FHWA personnel acknowledged that the department had become proficient at writing documents, but also acknowledged they needed to improve the linkage between NEPA Section 101 (the policy) and Section 102 (the analysis and documentation). The workshop's goals were to: (1) evaluate the FHWA's performance over the past 25 years in carrying out its NEPA responsibilities and to refocus FHWA attention on Section 101 of the Act; (2) create collaboratively a set of goals and objectives to improve FHWA performance; and (3) find innovative ways to focus FHWA's efforts so as to protect environmental resources, preserve communities and neighborhoods, and integrate social, economic, and environmental interests in order to build sustainable transportation infrastructure.

Consultation and Education. In 1994 and 1995, CEQ worked with professional organizations and academic institutions to provide training and information to environmental professionals on NEPA. CEQ also received input from them on their experience with the implementation of NEPA. As it has since 1992, CEQ joined with Duke University to sponsor a semi-annual NEPA course aimed at mid- and senior-level professionals at the Nicholas School of the Environment. CEQ also participated in environmental law and NEPA seminars with such organizations as the American Law Institute/American Bar Association and the Smithsonian Institution. In addition, CEQ provided faculty for the NEPA courses offered by such institutions as UCLA, the Environmental Law Institute, and the Department of Justice's Legal Education Institute.

Environmental Justice. On February 11, 1994, President Clinton issued Executive Order 12898, directing federal agencies to incorporate environmental justice principles into their day-to-day operations. The order promotes nondiscrimination and public participation in federal programs involving human health and the environment. The Presidential Memorandum accompanying the Executive Order also directed agencies to include the analysis of environmental effects on minority and low-income populations in the NEPA process where appropriate, and to improve opportunities for community input during the NEPA process. CEQ has developed draft guidance for agencies to incorporate and address environmental justice concerns in their NEPA processes. EPA and other agencies have developed guidances more specifically tailored to their programs and activities. For more information, see Chapter 6, "Environmental Justice."

NEPA-NHPA Integration. Since late 1995, CEQ has been working with the Advisory Council on Historic Preservation to revise their regulations to allow agencies to meet their obligations under Section 106 of the National Historic Preservation Act (NHPA) through the NEPA process. This initiative is aimed at streamlining both the NEPA process as well as the NHPA process, while ensuring the protection of historic resources. Draft regulations are pending.

Grazing Pilot Project. CEQ and the U.S. Forest Service have set up a small team to develop more efficient NEPA and grazing permitting processes. The U. S. Forest Service manages 191 million acres of forest and grassland in 33 states, much of which is made available to private citizens for grazing cattle and sheep. The Forest Service is required to prepare environmental impact analyses prior to making land use planning decisions related to grazing.

Nearly 78 million acres of national forest lands are managed for rangeland vegetation objectives. Through a forest plan, each forest manager determines the quantity of land to be allotted for grazing for that forest. An individual forest may contain from zero to several hundred grazing allotments. Grazing permits may cover any number of allotments, while allotments may have more than one permittee. However, many allotments have only one permittee.

The Forest Service traditionally conducted its NEPA analyses on allotment decisions. But preparing the NEPA analyses at this level is often both too cumbersome and not informative enough to the decisionmaker, who may not receive adequate information about the cumulative impacts of particular allotment decisions on the surrounding environment.

In response, CEQ and the Forest Service put together a team to develop more efficient alternatives to the existing system. Under the team's grazing pilot project, the Forest Service is working on a landscape-based analytical system to integrate the environmental analyses for adjacent allotments, addressing the environmental effects in one analysis, rather than in separate analyses for each individual allotment.

NEPANet. CEQ established a World Wide Web site as a tool for giving the public better access to environmental information. Within the web site is NEPANet, which contains the statute, CEQ regulations, "40 Most Frequently Asked Questions Concerning CEQ's NEPA Regulations," Scoping Guidance Memorandum, and CEQ Guidance on Incorporating Pollution Prevention. Additionally, this web site contains the entire contents of this Annual Report, as well as the text of the 1993 Annual Report. NEPANet is linked with an EPA database which provides a summary of EISs filed with EPA. A list of NEPA training courses is also included in the web site. Finally, NEPANet offers agencies links to environmental databases in all the 50 states and it offers the public a link to all agency-specific NEPA data sets. Access the CEQ web site through http://www.whitehouse.gov/CEQ.

Cumulative Effects Handbook. CEQ's experience suggests that perhaps the most ecologically devastating environmental effects may not result from individual projects, but the combined effects of numerous projects, termed cumulative effects. Continuing degradation of the human environment—in spite of the improved federal decisionmaking resulting from NEPA—may in part be attributed to these incremental, or cumulative, effects. CEQ has been working on a handbook to assist practitioners in identifying appropriate methods to assess these effects as they plan projects. The handbook is in final draft form.

Agency NEPA Regulations. Federal agencies are required by CEQ regulations to adopt procedures based on the CEQ regulations, and tailored to the regulatory and program activities of the individual agency. Each agency is required to consult with CEQ while developing or revising their procedures and before publishing them in the Federal Register for public comment. Relying on the experience of 25 years of NEPA implementation, CEQ's recent consultations have focused on streamlining the NEPA process. For example, CEQ has worked with agencies to identify activities that should be categorically excluded from the full NEPA process because they do not normally result in significant environmental impacts. CEQ has also worked with agencies through its regulatory consultation mechanism to reduce unnecessary and redundant paperwork such as EIS implementation plans, and has worked to encourage the integration of reviews under other statutes such as section 404 of the Clean Water Act, section 7 of the Endangered Species Act, and section 106 of the National Historic Preservation Act.

In 1994 and 1995, the agencies that consulted with CEQ regarding major revisions in their NEPA procedures included the Department of Energy, Department of Housing and Urban Development, Food and Drug Administration, Tennessee Valley Authority, Department of the Army, Army Corps of Engineers, U.S. Forest Service, National Park Service, and Bureau of Land Management.

SELECTED NEPA LITIGATION

As in previous years, most NEPA cases decided during 1994 and 1995 involved claims that an agency had failed to prepare an EIS when one was required or that the analysis that had been prepared was inadequate under NEPA and the CEQ regulations. However, some decisions were particularly noteworthy because they further delineated differences between federal circuits, reaffirmed past case law, or raised issues in a new context. Generally, federal courts continued to balance agencies' responsibility to take a "hard look" at the environmental impacts of their proposed actions with a high degree of deference to agencies' analyses of technical issues. (See Appendix A for an expanded selection of case summaries and NEPA statistical tables.)

The issue of whether Forest Service Land and Resource Management Plans (LRMPs), required under the National Forest Management Act of 1976, are justiciable was the subject of sharply differing court opinions in 1994 and 1995. In *Sierra Club v. Robertson*, 28 F.3d 753 (8th Cir. 1994), the appellate court concurred with the Forest Service's characterization of LRMPs as programmatic statements of general management practices that do not constitute decisions to undertake any particular site-specific activity. Thus, the court found that there was no injury-in-fact and that the plans were immune from judicial review arising as the result of claims under NEPA. However, in *Sierra Club v. Marita*, 46 F.3d 606 (7th Cir. 1995), the Seventh Circuit disagreed, finding that LRMPs clearly authorized certain projects to be undertaken, were concrete enough to meet the Supreme Court's most recent standing requirements, and therefore present sufficient injury-in-fact and are ripe for judicial review.

The adequacy of perhaps the most well-known EIS prepared in the context of forest planning during this period—commonly referred to as the President's Forest Plan or the Pacific Northwest Forest Plan—was upheld by Judge Dwyer in *Seattle Audubon Society v. Lyons*, 871 F. Supp. 1291 (W.D. Wash. 1994). This EIS, prepared for standards and guidelines for management of habitat within the range of the northern spotted owl, was the first judicial test of the Clinton Administration's direction to implement an interagency ecosystem management approach within the context of current environmental statutes. The court rejected arguments that such an approach was illegal, commended the new-found interagency cooperation, and stated that there was no way the agencies could comply with the environmental laws without planning on an ecosystem basis. The court went on to uphold the EIS in the face of a number of NEPA challenges to agency objectivity, the range of alternatives, sufficiency of the discussion of cumulative effects, the discussion of monitoring and mitigation measures, public involvement, and the economic effects of the plan. The court warned, however, that the promised monitoring was "central to the plan's validity. If it is not funded, or not done for any reason, the plan will have to be reconsidered." Id. at 1324.

In *Public Citizen v. Kantor*, 864 F. Supp. 208 (D.D.C. 1994), the Court reaffirmed its earlier decisions to the effect that trade agreements are not subject to judicial review under NEPA because there is no "final agency action" to review. This decision, dealing with the General Agreement on Tariffs and Trade (GATT), again focused on the President's role in the conducting international trade negotiations and in submitting an agreement to Congress.

The significance of new circumstances in requiring additional NEPA analysis was highlighted in *Alaska Wilderness Recreation & Tourism Ass'n v. Morrison*, 67 F.3d 723 (9th Cir. 1995). This case involved proposed timber sales that had been analyzed in an EIS at a time when two timber companies held long-term (50 year) timber sales contracts to operate in the Tongass National Forest. When one of those contracts was cancelled by the Forest Service, plaintiffs sued to require the agency to reconsider the proposed sales by evaluating additional alternatives in light of the cancellation of the contract. The Forest Service argued that it was simply substituting parties and that the environmental effects of the sales had been adequately analyzed. However, the Court agreed with plaintiffs' argument that cancellation of the contract presented the Forest Service with an opportunity to consider a broader range of alternatives for the affected areas than the EIS analyzed when the contract was still in force.

Finally, the issue of whether NEPA applies to a decision to designate critical habitat for an endangered or threatened species under the Endangered Species Act was first decided by an appellate court in *Douglas County v. Babbitt*, 48 F.3d 1495 (9th Cir. 1995). The court found that it did not. It based its holding on determinations that ESA procedures displace NEPA's requirements, that NEPA does not require an EIS for actions that preserve the natural physical environment, and that ESA itself furthers the goals of NEPA.

ENDNOTES

[1] Much of the information in this section appears in Boyd Gibbons, *CEQ Revisited: The Role of the Council on Environmental Quality*, Henry M. Jackson Foundation (1995).

[2] In contrast, in March 1995, the Bureau of Reclamation completed a highly visible environmental impact statement on the re-operation of the Glen Canyon Dam. The EIS was a major cooperative effort among twelve state, federal and tribal entities, as well as many other interested parties. As part of the effort, significant research was conducted in the Grand Canyon below the dam to evaluate the impacts of various operational alternatives, including researching the interrelationships among the resources within a watershed.

[3] Gibbons, at 5.

[4] 115 Cong. Rec. 40416 (1969).

[5] *Id.*, at 40924. Both Jackson's and Dingell's remarks were quoted in the Supreme Court's decision in *Metropolitan Edison Co. v. People Against Nuclear Energy*, 460 U.S. 766, 772-73 (1983).

[6] Quoted in Gibbons, at 5.

[7] As of June 30, 1971, 1380 draft or final EISs were filed with CEQ. (2nd Annual Environmental Quality Report, August 1971.)

[8] 3 C.F.R. sec. 123, 42 Fed. Reg. 26967, sec. 2(g) (1977).

[9] 43 Fed. Reg. 230 at 55978 (as quoted in eds. Clark and Canter, *Environmental Policy and NEPA*; Welles, H., "The CEQ NEPA Effectiveness Study: Learning From Our Past and Shaping Our Future" (expected publication date 1996)).

[10] 43 Fed Reg. 230 at 55980 (as quoted in Welles (expected pub. 1996)).

[11] 449 F.2d 1109 (D.C. Cir. 1971).

[12] *Kleppe v. Sierra Club*, 427 U.S. 390, 410 n.21 (1976).

[13] *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council*, 435 U.S. 519, 553, 558 (1978); *Baltimore Gas & Electric Co. v. Natural Resources Defense Council*, 462 U.S. 87, 97 (1983).

[14] Compare *National Helium Corp. v. Morton*, 455 F.2d 650 (10th Cir. 1971), with *Environmental Defense Fund v. Corps of Engineers*, 492 F.2d 1123 (5th Cir. 1974).

[15] *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council*, 435 U.S. 519, 558 (1978). *See also Strycker's Bay Neighborhood Council v. Karlan*, 444 U.S. 223 (1980).

[16] *See, e.g., Robertson v. Methow Valley Citizens Council*, 109 S.Ct. 1835 (1989).

[17] *Robertson v. Methow Valley Citizens Council*, 109 S.Ct. 1835, 1845 (1989).

[18] With the twenty-fifth anniversary of NEPA, and in support of the President's efforts to reinvent government and ensure common sense reform, CEQ has been studying how effectively NEPA has fulfilled its goals over the years.

[19] 1995 figures will be published in the Twenty-sixth Annual Report.

[20] 40 C.F.R. secs. 1505.2(c) and 1505.3.

Part II

Environmental Conditions and Trends

CHAPTER FOUR

Population and the Environment

At the most fundamental level, human activity clearly and profoundly affects the environment. For example, the simple act of lighting a campfire has environmental implications in terms of resource use (the wood used to build the fire), energy (the heat created by the fire), and waste generation (the emissions of ash and carbon dioxide and the waste left when the fire has burned out).

Assessing the environmental impact of such a simple event entails consideration of many factors. Was the fire lit in an area with abundant or scarce wood resources? How many other people are lighting fires in the same area? Have some people figured out a way to burn wood more efficiently, thus reducing the need for the resource? Do some people have sufficient resources to burn a fire continuously, while others can only burn a fire at night?

And what is the collective impact of *all* the residents of a particular region, or of the 263 million Americans, or 5.7 billion people living on the earth today? If only one person lights a fire, the impacts in terms of resource use, emissions, and wastes, are negligible. If 1 million or 1 billion people *each* light a fire, the local and global impacts are far more significant.

BACKGROUND

Importance of Demographics

Population size, distribution, mobility, age structure, and rate of growth all affect the environment. (See Box 4.1.) They affect what resources are used, where, when, how, at what rate, and with what attendant waste or conservation. For example, an increase in population will heighten demand for food, energy, water, health care, sanitation, and housing. Or, if 1 million people live on an island, but 80 percent are concentrated along its fragile coastline, that is going to have serious environmental impacts. For another example, because resources are not evenly distributed around the globe, some populations might have abundant coal deposits, while others may rely primarily on natural gas or oil—again, with serious environmental impacts.

Population data and demographics information thus can be a useful tool for understanding trends in some environmental problems. In the case of radon, for example, knowing population size and rate of change will help in estimating national or regional exposure rates; and migration effects can indicate the potential for increasing radon exposure in certain geographic regions.

Box 4.1
Population-Environment Linkages

Population—its size, distribution, and composition—can have a variety of effects on the environment. *The Population-Environment Connection*, a recent report of the Batelle Seattle Research Center prepared for the Environmental Protection Agency, provides some useful summaries of these effects.

Municipal Waste

- Even if per capita generation of municipal solid waste remained constant, population growth would lead to greater waste generation. However, per capita rates have been steadily increasing, further increasing pressures on the waste management system.
- There is some evidence that urban residents generate more municipal solid waste than rural residents, at least for some types of products.
- There is some evidence that smaller households generate more waste per person than large households. Household size has decreased and is likely to stay low in the near future.
- Construction wastes, which are not included in municipal solid waste, may also be affected by household size through the demand for new housing.

Drinking Water

- Increasing population size implies increasing demand for drinking water.
- Increasing population size within a watershed also implies greater potential for contamination of surface and groundwater sources.
- Population distribution affects local and regional demand for water and the distribution of sources of pollution.
- Population growth distributed among areas poorly served by sewer and water systems may have a greater impact on water quality than population growth in areas that are better served.
- Population growth concentrated near sensitive areas may also have a disproportionate effect on water quality.

Coastal and Estuarine Areas

- Increasing population size along a coastal or estuarine area implies greater potential for pollution of water resources.
- Increasing population also implies greater potential for habitat/land use alteration.
- Population growth in upstream areas can adversely affect estuarine and coastal water quality.
- Population distribution affects the distribution of sources of pollution.
- Population growth near sensitive areas may have a disproportionate effect on water quality.
- Increasing numbers of elderly may fuel retirement-driven migration to coastal states.
- Changes in household size and composition may augment effects due to population increases.
- Measures of income distribution may serve to identify greater recreational or second home buying in the coastal and estuarine zone.

Social Characteristics

Beyond the effects of demographics on resources—and the effects of available resources on a population's choice—a population's social characteristics also affect the environment. These factors include government policies, equitable access to capital and technology, and the efficiency of industrial production.

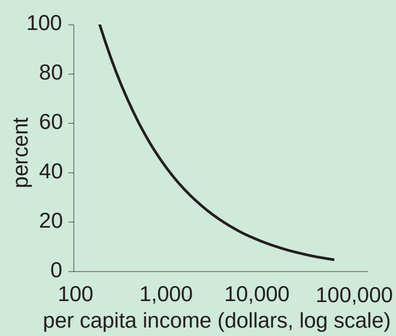
Government Policies. Federal, state, and local government policies can play a significant role in either mitigating or exacerbating the impact of human activities on the environment. Much federal environmental policymaking has profoundly altered the impact of population growth. For example, as discussed in Chapter 19, "Transportation," pollution caused by the rising number of vehicle-miles traveled in America has been substantially offset by reductions in pollutants emitted from new vehicles. On the other hand, many federal policies have encouraged the use of automobiles. In addition, infrastructure planning—transportation, electricity, sewer, and water systems—has generally tended to encourage growth outside of central cities.

Demographic factors have played a relatively minor role in government-backed environmental protection policies. For example, the U.S. National Environmental Policy Act (NEPA) acknowledges the relationship between population dynamics and environmental quality, stressing the "profound influences" of population growth and high-density urbanization on the natural environment. One of the declared duties of the federal government under NEPA is to "achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities." As part of the environmental impact statement process, however, there is no requirement that agencies assess population growth or other demographic effects. As a result, NEPA as currently implemented has not generally led to an awareness of population-environment linkages.

Similarly, the Environmental Protection Agency has traditionally used demographic information in its analysis of exposures to environmental risks, but has less frequently considered the ways in which demographic factors can be drivers of environmental change. However, certain offices have begun to explore ecosystem risks using models in which population growth, migration, or affluence are factors affecting sensitive ecosystems.

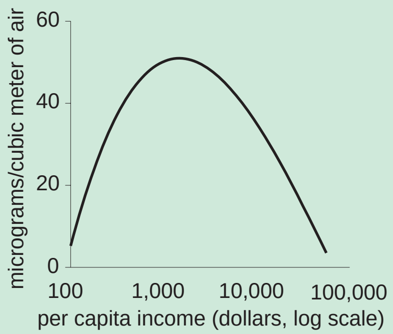
Income. Environmental problems tend to change with changes in national income. The World Bank, in its *World Development Report 1992*, describes

Figure 4.1 World Population Without Safe Water, 1980s



Source: World Bank, *World Development Report 1992.*
Note: Based on cross-country regression analysis.

Figure 4.2 World Urban SO_2 Concentrations, 1980s



Source: World Bank, *World Development Report 1992.*
Note: Based on cross-country regression analysis.

three patterns of change as national income increases.

- Some problems, such as the provision of sanitation and rural electricity services, tend to decline because of the increasing availability of resources to address these problems (Figure 4.1).

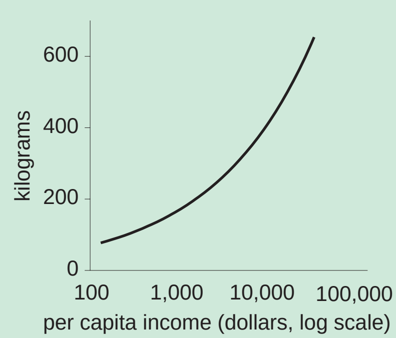
- Some problems, including most forms of air and water pollution, initially worsen but then improve as incomes rise (Figure 4.2). This occurs when countries deliberately introduce policies to ensure that additional resources are devoted to solving environmental problems.

- Some problems worsen as income increases. Emissions of carbon and of nitrogen oxides and municipal wastes are current examples (Figure 4.3). The costs of abatement tend to be relatively high, and, in most countries, individuals and firms have few incentives to cut back on wastes and CO_2 emissions.

The report emphasizes that countries can choose policies that result in much better (or much worse) environmental conditions than those in other countries at similar income levels. What seems unavoidable, however, is that rising national and per capita incomes stimulate greater personal consumption—which has a host of implications for resource use, energy, and waste. It also raises several difficult and controversial issues. One concerns equity between the industrialized and developing countries, since people in industrialized countries (such as the United States) consume far more than those in developing countries and have contributed disproportionately to global problems such as the buildup of carbon dioxide in the atmosphere. Another issue concerns the environmental impact of rising consumption in developing countries.

Technological Advances. Technological changes also can significantly alter the population-environment linkage. For example, industrial efficiency improve-

Figure 4.3 World Municipal Waste Per Capita, 1980s



Source: World Bank, *World Development Report 1992.*
Note: Based on cross-country regression analysis.

ments are offsetting rising consumption caused by population growth. Wood use is a case in point. Many sawmills today produce twice as much usable lumber and other products per log input as they did a century ago. In addition, engineering standards and design improvements have reduced the volume of wood used per square foot of building space, and preservative treatments have substantially extended the service life of wood. These efficiency improvements help offset the rising demand for wood caused by population growth.

RECENT TRENDS

Global Population Growth

The scale of population growth in this century is unprecedented. If you were born in 1944, the population has more than doubled in your lifetime—rising from about 2.4 billion to about 5.6 billion people. And, before you die, the world population is likely to grow by an additional 2.5 billion, for a total of about 8 billion people or more.

Most industrialized countries have gone through a remarkable demographic change in this century. Thanks to improved health care and other factors, overall death rates, maternal death rates, and child and infant mortality rates have fallen dramatically. But birth rates have fallen as well, dropping close to or even below the "replacement" level (that is, an average of two children per family). The falling birth rates in industrialized countries are explained by a variety of factors, including the increasing share of the population living in urban areas, greater educational and employment opportunities for women, and greater access to reproductive health care. The result is that most industrialized countries are not expected to experience much increase in population over the next few decades. In fact, total population in all industrialized countries is expected to increase from today's 1.16 billion only to about 1.24 billion by the year 2025.

On the other hand, population in developing countries is expected to continue increasing at a rate of about 1.8 percent per year through the year 2025, rising from the 1995 total of about 4.5 billion to about 7 billion. Africa's population is growing at nearly 3 percent annu-

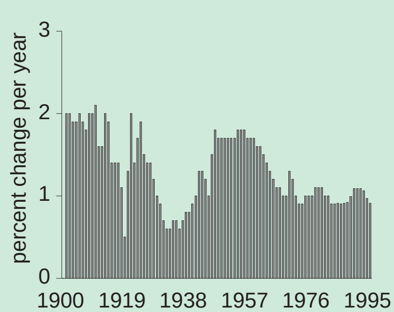
Photo Credit: Steve Delaney
U.S. Environmental Protection Agency

ally, while Asia's is growing at about 1.5 percent.

Over the past 30 years, many developing countries have made progress in primary health care, education, per capita income, and greater opportunities for women. As in industrialized countries, this has resulted in lower birth and death rates, increased life expectancy, and reduced infant mortality. But there is still a tremendous gap between the developed and developing worlds. For example, maternal death rates are 15 to 50 times higher in the developing world than in most developed countries.

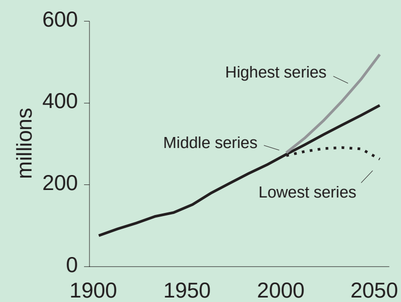
Growing global populations have important implications for worldwide energy consumption, resource use, and waste. For example, China and India may depend largely on coal to support the expansion of their energy sectors. Such a strategy could substantially increase total emissions of carbon dioxide, the principal "greenhouse" gas; this in turn could have significant implications for global climate.

Figure 4.4 U.S. Population Growth Rate, 1900-1995



Source: See Part III, Table 1.

Figure 4.5 U.S. Resident Population, 1900-2050



Source: Bureau of the Census, *Current Population Reports*, Series P-25, No. 311,519,917,1095, and 1127.
Note: Based on census data and projections.

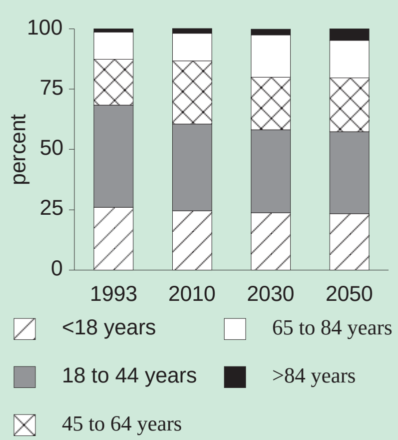
U.S. Population Growth and Demographics

At the turn of the century, U.S. population growth often hit 2 percent annually and did not dip below 1.5 percent until 1915. The Great Depression years decisively broke this strong growth pattern, with population growth rates falling to 0.6 percent in 1932 and 1933. Low rates prevailed until the "baby boom" years after World War II (1946 to 1964). By the mid-1960s, the rate was falling again; it began to level off at about 1 percent—an average annual rate of population growth retained over the past three decades (Figure 4.4).

Population projections by the U.S. Bureau of the Census and other institutions are based on assumptions about fertility, life expectancy, and net immigration. Most discussions refer to "middle series" projections, but the Census Bureau has developed nine other alternative projections series. The lowest projection, for example, assumes a 15 percent decrease in fertility rates by 2010 for all four non-Hispanic race groups and the Hispanic-origin population, a combined life expectancy of 74.8 years, and an annual net immigration of 300,000. The highest projection for that year assumes a 15 percent *increase* in fertility for these groups, a life expectancy of 89.4 years, and annual immigration of 1.37 million people. Thus, under the low series, population grows from the current 263 million to 282 million by 2050; under the high series, it increases to 519 million (Figure 4.5).

The rate of population growth is projected to decrease over the next six decades, from about 0.9 percent currently to about 0.63 percent by the 2040–50 period, according to the middle series projection of the U.S. Census Bureau (-0.18 percent by 2050 in the lowest series, 1.24 percent in the highest series).

Figure 4.6 U.S. Population Distribution by Age, 1993-2050



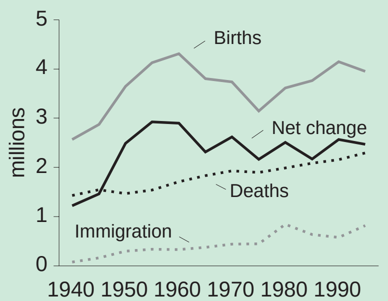
Source: See Part III, Table 3.
Note: Based on census data and projections.

The decrease is largely due to the aging of the U.S. population and, consequently, an increase in the annual number of deaths from 2.3 million per year in 1995 to an estimated 4 million per year in 2050.

Note that even with this decline in the population growth rate, the U.S. population as a whole is projected to grow substantially over the next few decades. Even as fertility declines, demographic "momentum" (each women is having fewer children, but many more women are giving birth) will continue to boost population totals. If fertility were currently at the replacement level, the U.S. population would still grow because of this built-in momentum. According to middle series population projections, the U.S. resident population should reach 274 million in the year 2000, 298 million in 2010, 347 million in 2030, and 394 million by 2050—or fully 50 percent more than today's total.

Age Composition. Population aging is a common feature of most industrialized countries, including the United States. And in fact, the future median age structure of the U.S. population will be older than it is now. As the baby boom population ages, the median age of the population will rise from the 1995 total of 34.3, peaking at a projected 38.7 years of age in the year 2035. After 2010, when the baby boom generation begins to reach 65, the United States will experience a strong surge in the proportion of the population that is 65 and over; the last of the "baby boomers" will reach age 65 in 2029 (Figure 4.6). Another important recent trend, which is expected to continue for several decades, is an increase in

Figure 4.7 Components of U.S. Population Change, 1940-1994



Source: See Part III, Table 2.

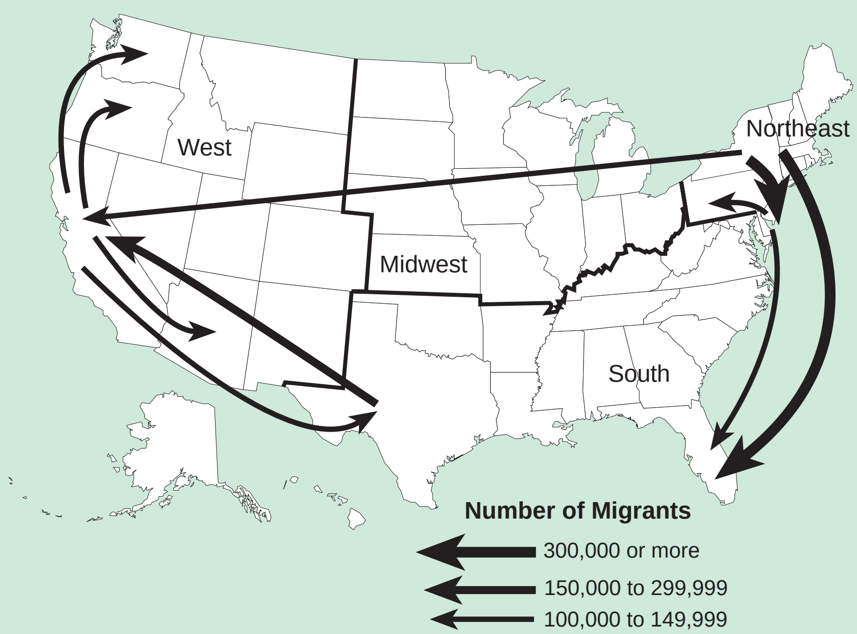
the proportion of the population that is 75 years or older.

Life expectancy is projected to increase from 76.0 years in 1995 (72.5 for males, 79.3 for females) to 82 years (79.7 for males, 84.3 for females) in 2050, under the Census Bureau's middle series projection.

The nation's changing age structure has a number of implications for environmental policy. For example, since the elderly are more susceptible to respiratory and other ailments, an aging population may increase the importance of air quality management. Growing numbers of relatively affluent retirees also may lead to an increase in second home ownership, some of which may occur in ecologically sensitive areas.

Migration. Net international migration for the United States—that is, the net difference between those emigrating

Figure 4.8 Ten Largest Interstate Migration Streams, 1985-1990



Source: U.S. Bureau of the Census, "1990 Selected Place of Birth and Migration Statistics for States," CPH-L-121 (1993) and Gober, 1993.

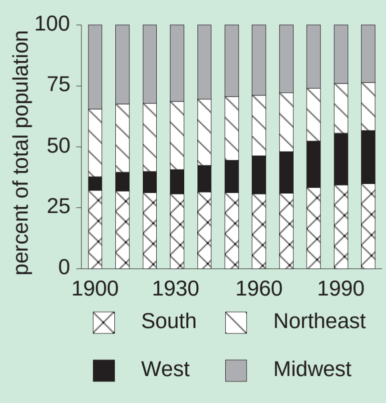
from and those immigrating to the country—was 731,000 in 1995. Net immigration is projected to remain constant at 820,000 annually over the 1995—2050 period, under the middle series projection. To put these totals in context, note that net migration has been averaging 757,000 per year during the 1990s, which is substantially higher than the average of 634,000 in the 1980s. This increase is due at least in part to the 1990 Immigration Act, which reduced the limiting effect of quotas on family reunifications (Figure 4.7).

Mobility. Americans are a nation of movers. Over the last 40 to 50 years, about one out of every five people changed residence every year. This figure has declined slightly in recent years, dropping from 20 percent to 17 percent. The average American currently makes 11.7 moves during a lifetime. About 42 million Americans moved between March 1992 and March 1993. About two thirds of these moves were "local" moves within the same county. Recent data show that Westerners are 80 percent more likely than Northeasterners to change their residence in any given year (Figure 4.8).

For the past several decades, the Northeast and Midwest have been losing population to the South and West. This shift was tied to faster job growth in the South and West in recent decades and the loss of manufacturing jobs in the Northeast and Midwest. The Midwest, however, rebounded somewhat in the late 1980s. Currently, the South is the nation's most populous region, with 91 million inhabitants, or about 3.7 times what it was in 1900. The population of the West has doubled since 1960, and 8 of the country's 10 fastest growing states are in the West. Additionally, the West has the lowest median age (32.7 years), while the Northeast has the highest (35.3 years) (Figure 4.9).

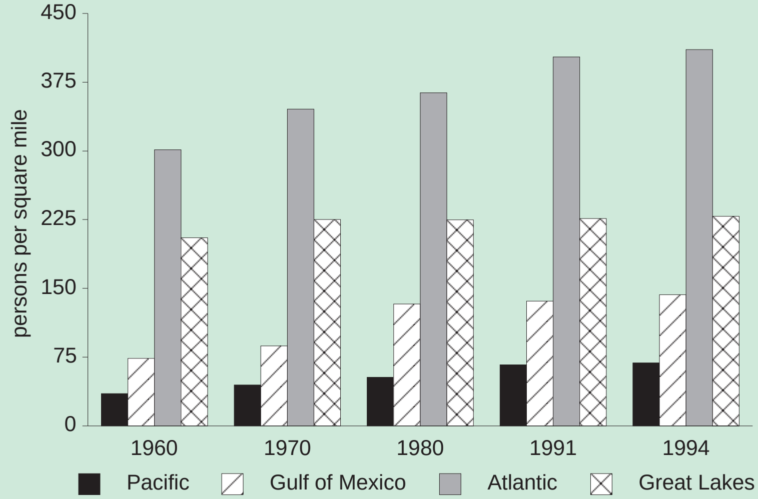
Coastal areas account for more than half of the nation's population and have grown faster than the interior since 1960. In the Pacific and Gulf of Mexico coastal regions, population per square mile nearly doubled between 1960 and 1994 (Figure 4.10). The National Oceanic and Atmospheric Administration notes that between 1970 and 1989, almost half of all building construction occurred in coastal regions, even though they represent only 11 percent of the nation's total land area. Over the next few decades, a significant amount of growth also is expected to occur in inland areas 20—70 miles from coastal areas.

Figure 4.9 U.S. Population by Region, 1900-1994



Source: See Part III, Table 5.

Figure 4.10 U.S. Coastal Population Density, 1960-1994



Source: See Part III, Table 6.

Urbanization. Like other industrialized countries, the proportion of the U.S. population living in urban areas has increased significantly in this century. Today, about three out of every four Americans lives in an urban area; during the 1980s, about 90 percent of U.S. population growth occurred in such areas. The nation now includes 39 metropolitan areas with more than 1 million people; all told, these account for fully half of the total U.S. population.

Urbanization is concentrated in the South and West and is dominated by Florida, which has 9 of the 11 fastest growing cities in the nation. Urban growth is spreading outward to suburban and "exurban" areas—these latter lie beyond the suburbs but are still within commuting distance. It is estimated that one-third of the nation's population growth between 1960 and 1985 took place in exurban counties. A variety of factors have contributed to this trend, including federal policies that stimulate development and home ownership; the desire to escape the negative aspects of urban life; the desire for space and access to environmental resources; and new developments in transportation, communications, and employment.

Urbanization and the redistribution of population can have a wide variety of environmental impacts, affecting the demand for energy to heat and cool homes, the demand placed on specific aquifers, the pace of land development, the number of vehicle-miles traveled per day, and the conversion of farmland and wetland habitats.

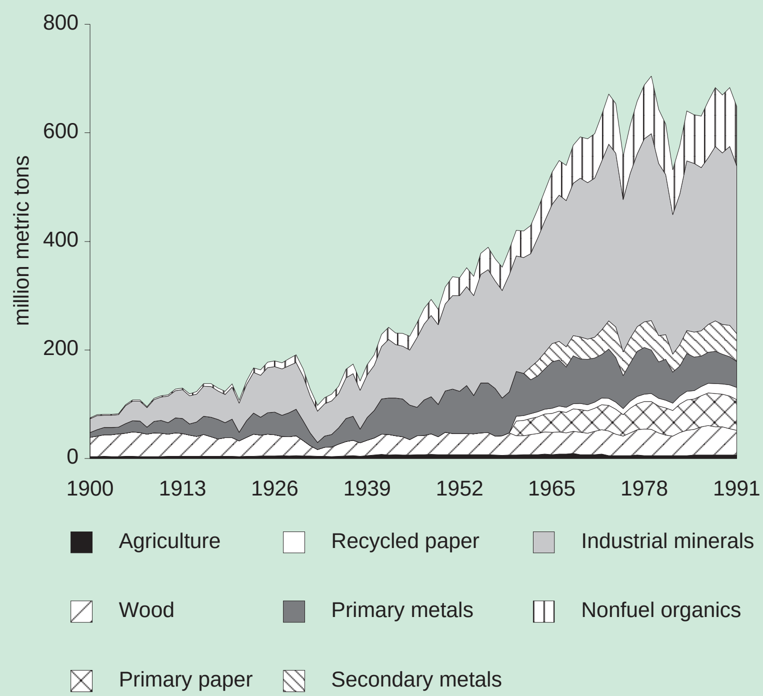
Trends in U.S. Consumption

According to *World Resources 1994—95*, the United States in 1989 consumed a total of about 4.5 billion metric tons of natural resources, or about 18 metric tons per person. Construction material (stone, sand, and gravel) accounted for 1.8 billion metric tons, energy fuel for 1.7 billion metric tons, food for 317 million metric tons, and industrial minerals for 317 million metric tons.

Historical consumption trends for some of those materials are shown in Figure 4.11. Among the notable trends are the following:

- Primary metal consumption has declined because of increased recycling and production from scrap.
- Nonfuel organic material consumption is rising because of increased use of plastic, synthetic fiber in carpets and textiles, synthetic rubber, and petrochemical products.
- There has been a growing use of more highly engineered and generally lighter material, packaging material, and paper. As a result, per capita consumption of forestry products, metal, and plastic measured by weight has been declining over the past 20 years,

Figure 4.11 U.S. Consumption of Raw Materials, 1900-1991



Source: Bureau of Mines, Branch of Materials.
Note: Does not include stone, sand, and gravel.

Photo Credit: Steve Delaney
U.S. Environmental Protection Agency

but per capita consumption measured by volume has been expanding slowly.

The top two income groups in the United States, representing 40 percent of the population, consume more than half of all resources, including utilities (51 percent), food (57 percent), housing (62 percent), transportation (62 percent), and clothing (64 percent). Spending on housing and transportation are significant across all income groups, varying from 23 to 25 percent for housing and between 16 and 19 percent for transportation.

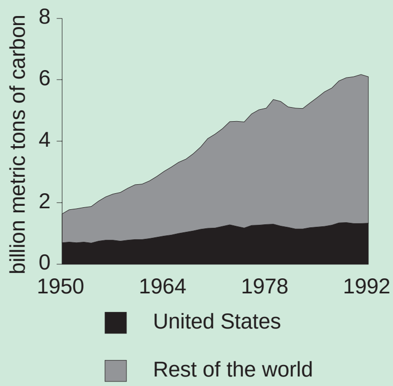
Not surprisingly, the per capita generation of municipal solid waste also has risen steadily, especially in the nonfood categories of paper products and plastics. Aside from population growth, other factors contribute to this, including socioeconomic status, household size, demands for convenience, and degree of urbanization. Note, however, that the amount of solid waste deposited in landfills has been substantially offset by recycling programs. (See Chapter 20, “Solid Waste.”)

The Global Dimension

As a group, Americans consume far more per person than people in developing countries, so the environmental impact of the average American is substantially greater than the impact of the average person in a developing country.

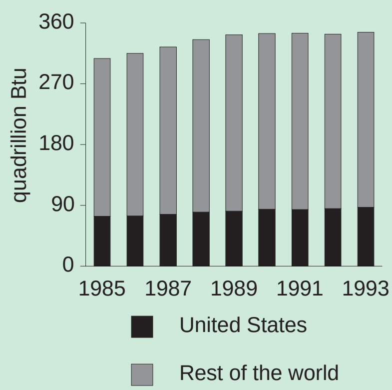
Resource consumption in the United States has an important global dimension. For example, primarily as a result of fossil fuel consumption and resulting carbon dioxide emissions, the United States

Figure 4.12 World CO_2 Emissions, 1950-1992



Source: Marland, G., Oak Ridge National Laboratory.

Figure 4.13 World Energy Consumption, 1985-1993



Source: DOE, Energy Information Administration.

is the world's leading producer of greenhouse gas emissions.

Private utilities account for about 40 percent of U.S. carbon dioxide emissions. Other significant contributions are made by petroleum refining, wholesale and retail trade, new construction, transportation, and coal mining. The fact that carbon dioxide emissions are spread across so many sectors of the economy suggests that significant changes in U.S. emissions could require complex policy adjustments (Figure 4.12).

In the area of energy use, the United States made great strides in energy efficiency in the last few decades even as its population continued to grow. Yet, with just 5 percent of the world's population, the United States still accounts for approximately 25 percent of global energy use on an annual basis (Figure 4.13). According to the report of the President's Council on Sustainable Development, U.S. energy use per unit of gross domestic product is about 36 percent greater than in Germany and 79 percent greater than in Japan. Use of petroleum feedstocks is seven times the global per capita average. U.S. oil consumption, at 19.9 million barrels per day in 1994, is nearly as great as the 23.8 million barrels per day collectively consumed by the remaining 24 members of the Organisation for Economic Co-operation and Development in Europe and Japan.

Clearly, there is a great opportunity for further improvements in energy efficiency in the United States; this challenge will become more evident and pressing as the U.S. population grows in the next century.

FUTURE CHALLENGES

What does a rise in population portend for resource use and the state of the environment? Clearly, population growth and rising per capita consumption will

The Cairo Action Plan

In 1994, the United States took part in forgoing an extraordinary consensus around the goals of human rights and health, equality and environmental protection, economic and social justice. The International Conference on Population and Development in Cairo embraced a comprehensive approach, recognizing that family planning and development each play a role in slowing population growth, but they work best when pursued together. The strategies for stabilizing population— quality health care, education, and opportunity— enhance the ability of individuals and societies to meet their needs and the needs of future generations.

As the first aspect of a comprehensive approach, Cairo participants committed their nations to high quality, voluntary family planning and reproductive health programs, with the aim of making them universally available early in the next century. A new sense of urgency emerged in support of making every effort to enable couples and individuals to fulfill the basic right to decide freely and responsibly the number and spacing of their children, and to have the information, education, and means to do so.

To complement, reinforce, and promote health, the Cairo conference agreed to make economic and environmental progress the second component of the effort. The integrated strategy would promote free trade, private investmen, and development assistance, and recognize the close relationships between population, sustained economic growth, and environmental integrity.

The Cairo Plan of Action underscores the importance of women's equal participation in the struggle to create a better future. Recognizing women's value to development, and empowering them to contribute their wisdom and talents to society, constitute the third component of the plan.

A fourth element is investing in education for all people, including women, because inadequate education is a powerful determinant of high fertility. A fifth aspect is ensuring that men fulfill their responsibilities, including preventing unintended pregnancies, helping to raise children, and stemming the spread of HIV/AIDS and sexually transmitted disease.

This comprehensive and integrated approach represents a powerful step to alleviate poverty, stabilize global population and promote sustainable development. The world took a major step forward at Cairo.

put more pressure on the environment. As noted earlier, the United States now consumes more than 4.5 billion metric tons of materials annually to produce the goods and services that make up its unparalleled economic activity. Based on current trends, efficiency in the use of all resources would have to increase by more than 50 percent over the next four or five decades just to keep pace with population growth.

The international Factor 10 Club, which consists of 16 distinguished scientists and economists from 10 countries, argues that over the next 30 to 50 years the industrialized countries "must work toward cutting in half present global nonrenewable material flows, including minerals, freshwater, and nonrenewable energy carriers. To achieve this, it is our view that a political commitment to a tenfold increase in the average resource productivity of the presently industrialized countries is a prerequisite for meeting the goal of long-term global sustainability." This conclusion was noted in the February 1996 communique of the OECD ministerial-level environmental policy committee.

Yet there are some grounds for optimism. In the area of solid waste, for example, recycling and reuse is now projected to absorb most additional waste in the next few years, so that net generation of waste (after recycling) is projected to go down slightly in this decade. This is a remarkable achievement, because it is built on innumerable local initiatives and on the willingness of many Americans to support community recycling programs. Because population growth and economic growth will continue to boost waste generation from 2000 to 2010, recovery rates will have to rise to 40 percent or more to absorb this growth. (See Chapter 20, "Solid Waste.")

According to the PCSD report,

> *continued population growth steadily makes more difficult the job of mitigating the environmental impact of American resource use and waste production patterns . . . Managing population growth, resources, and wastes is essential to ensuring that the total impact of these factors is within the bounds of sustainability. Stabilizing the population without changing consumption and waste production patterns would not be enough, but it would make an immensely challenging task more manageable. In the United States, each is necessary; neither alone is sufficient.*

If current population projections are correct, the U.S. population will grow substantially larger in the next few decades. This will pose difficult new challenges in many areas, including energy use, materials consumption, and waste disposal. Further progress in energy efficiency, pollution prevention, and reuse and recycling of materials will be essential to lessen the environmental impact of this larger population.

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CHAPTER FIVE

Environmental Aspects of Human Health

Environmental factors play a fundamental role in human health and disease. From polluted air and water to toxic substances in soil and food, environmental pollutants can pose both direct and indirect threats to human health. Their impact on health is often complex and may be influenced by a variety of factors, including exposure patterns, genetic makeup, nutritional habits, and psychological well-being. Correlations between an environmental hazard and an adverse health effect may not, standing alone, establish that the former is the cause of the latter. Nevertheless, reducing exposures to environmental hazards, where causal links are established or likely, is an important component in protecting public health.

Over the past 25 years, federal, state, and local government efforts to ensure safe supplies of food and water, to manage sewage and municipal waste, and to improve air quality have contributed substantially to human health improvements in the United States. The past 25 years also have seen an improvement in the dissemination of information about health risks from environmental degradation. Two primary challenges today are to continue making progress in reducing environmental risks, and to improve the existing regulatory system in order to achieve the greatest public health protection at the lowest cost. A further and related challenge is to improve scientific understanding about the links between environment and health, so that policy decisions can be made with the best information available.

Major new legislation, including the Safe Drinking Water Act Amendments of 1996 and the Food Quality Protection Act of 1996, will improve and streamline the regulatory process while keeping health concerns paramount. New regulations to protect air quality have shown that health standards can be met without sacrificing economic growth and that the health and economic benefits of reducing emissions can be substantial.

The Clinton Administration has been working toward greater transparency in how it evaluates health risks and formulates policy. The reevaluation of dioxin and its effects, for example, was a novel approach in how risk assessments are conducted—incorporating both scientific expertise and broad public input into the process. The Administration has also been actively involved in working toward a greater understanding of the health risks from emerging threats such as endocrine disruptors and global climate change.

This chapter highlights some of these efforts and provides an overview of environmental health hazards, particularly the contamination of drinking water, air, and food. Even so, it only touches on a few environmental risks to human health. Other risks, such as those associated with occupational hazards, accidents, noise, behavioral or lifestyle choices, and infectious diseases, are also important.

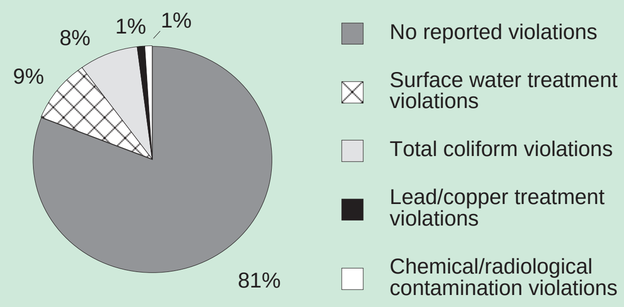
DRINKING WATER QUALITY

Current Trends

EPA and the states are responsible for regulating approximately 200,000 public water systems, including 58,000 community water systems that serve over 240 million people. The concentration of contaminants in drinking water supplies from these systems is controlled by standards established to minimize risk to human health. Contaminants found in drinking water can cause myriad health effects, ranging from stomach upset and diarrhea (as with *Cryptosporidium* or *Giardia*) to chronic health effects such as liver and kidney damage, neurological disorders, and cancer (i.e., from heavy metals and pesticides). When violations of health-based standards occur, water systems are required to take action to remove the contaminants from the drinking water supply and notify the public about the violation.

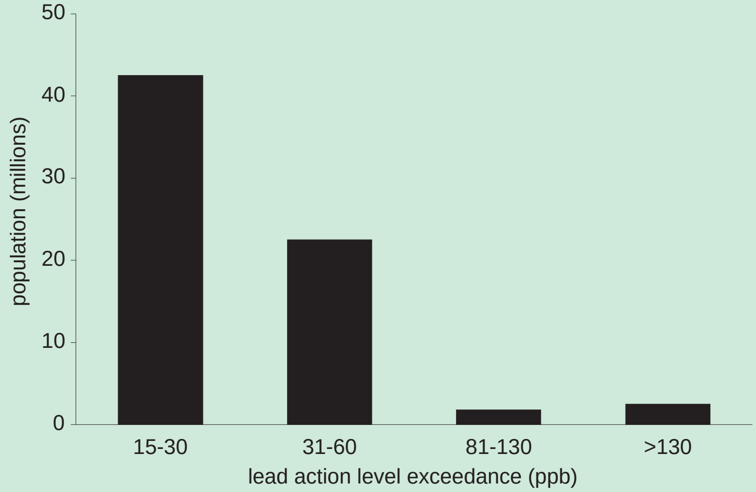
In 1994, more than 80 percent of community water systems serving 240 million people reported no violations of health-based standards. However, over 40 million people received their drinking water from a community water system that did report a violation of health-based standards. The majority of these violations involved microbiological contaminants: either surface water treatment violations (9 percent) or fecal coliform violations (8 percent) (Figure 5.1).

Figure 5.1 Population Served by Community Drinking Water Systems Violating Health-Based Requirements, 1994



Source: U.S. Environmental Protection Agency, Safe Drinking Water Information System, 1994.
Notes: As many as one-fourth of the water systems did not complete required monitoring; compliance status of some of these could not be assessed. 243 million people are served by community systems.

Figure 5.2 Population Served by Drinking Water Systems Exceeding Lead Action Levels, 1995



Source: U.S. Environmental Protection Agency, Safe Drinking Water Information System, 1995.
Note: Data are the results ot lead testing in high-risk households. A water system is found to exceed the action level if more than 10 percent of its high-risk households contain lead levels above 15 ppb.

About 69 million people are served by drinking water systems that have started to institute mitigation measures (such as corrosion control treatment) to reduce potential lead contamination at consumers' taps. These systems are required to act because initial monitoring, required under EPA's lead and copper rule, at high risk consumer taps found lead levels that exceeded the regulatory action level for lead (Figure 5.2). Although exposure to lead can come from many other sources (e.g., from paint, from contaminated soil, and though the air), lead in drinking water remains a significant risk to the public and a large problem for water systems.

In addition to improved regulations, technological innovation can reduce the amount of wastewater generated by developing new water conservation technologies and cleaner industrial technologies. For example, the Department of Energy is supporting research to improve the efficiency of water pipe galvanization. New "hot-dipped" galvanized water pipes emit four orders of magnitude less lead than the conventional technology, which leaves lead on the finished product.

Regulatory Background

The Clean Water Act of 1972 established a body of law and regulations backed by federal financial support to ensure that the nation's surface waters are safe for fishing and swimming and as sources of drinking water. In 1974, Congress enacted the Safe Drinking Water Act, further developing a legislative basis to protect water quality. The Safe Drinking Water Act is intended to ensure that every public water system consistently provides water that is safe to drink. The act, which was substantially amended in 1986, required EPA to establish national drinking water safety standards that incorporate enforceable maximum contaminant levels or treatment techniques, underground injection control regulations to protect underground sources of drinking water, and grant programs for the administration of state wellhead protection area programs. The states were to be delegated responsibility to ensure that safety standards were met.

Despite the progress made in improving drinking water quality in the United States, both natural processes and human activities continue to exert pressures on drinking water quality. For instance, population growth, newly identified and emerging microorganisms, changes in chemical usage, and outdated and deteriorating water systems present significant challenges to the long-term safety of the nation's drinking water supplies. These trends are further exacerbated by shrinking budgets and resources at all levels of government. In 1995, EPA's Science Advisory Board (SAB) released a report, *Safe Drinking Water: Future Trends and Challenges,* which identified significant trends affecting the nation's drinking water, including population growth impacts, public demand for better water, a changing contaminant profile, and changes in drinking water production and treatment. The report recommended improved management of water resources, consolidation of smaller systems, accelerated research in risk assessment methodologies, and establishment of an alert system for emerging pathogens.

Also in 1995, EPA Administrator Carol Browner launched a reassessment of EPA's drinking water program and released EPA's "white paper," *Strengthening the Safety of Our Drinking Water: A Report on Progress and Challenges and an Agenda for Action.* The white paper provided an overview of drinking water safety in the United States and identified five agenda items for improving drinking water protection:

- provide Americans with more information about the nation's drinking water;
- focus standards on the most serious health risks;
- provide technical assistance to protect source water and help small systems;
- reinvent federal/state partnerships to improve drinking water safety; and
- invest in community drinking water facilities to protect human health.

The white paper estimated that substantial health benefits could be achieved if existing standards were fully attained, including reduced exposure to lead for an estimated 50 million people (with protection for 200,000 children against unacceptable blood lead levels); prevention of more than 100,000 cases annually of gastrointestinal and other illnesses attributed to microorganisms; reduced exposure for millions of people to dozens of contaminants that may cause illness, including compromised reproductive capabilities, malfunction of vital organs, "blue baby" syndrome, and nervous system damage; and over 100 excess cancer cases avoided per year.

The Safe Drinking Water Act Amendments of 1996

On August 6, President Clinton signed the Safe Drinking Water Act (SDWA) amendments of 1996. The new law will help achieve many of the goals outlined in both the SAB and the EPA reports. It will: (1) establish a strong new emphasis on preventing contamination problems through source water protection and enhanced water system management; (2) move greater responsibility to the states and expand their role in creating and focusing prevention programs and helping water systems improve operations and avoid contamination problems; and (3) set up a state revolving fund (SRF) system to provide money to communities to improve their drinking water facilities.

The SRF is authorized at $1 billion for each of fiscal years 1995 to 2003. The states may use set-asides from the SRF to pay for programs such as source water assessments; voluntary source water quality protection partnerships with public water systems, local governments, and private companies; and capacity development and implementation efforts. States also will have more flexibility in establishing water quality monitoring requirements.

The 1996 amendments recognize the importance of community right-to-know about potential threats to drinking water quality. Within 2 years of enactment, the law requires EPA to issue regulations requiring all community water systems to prepare at least annually a report with information about the system's source water and the level of contaminants in the drinking water supply. In addition, public water systems must give notice of any violation of a national drinking water standard "that has the potential to have serious adverse effects on human health as a result of short-term exposure" within 24 hours after the violation.

The new law repeals the current requirement that EPA promulgate standards for 25 additional contaminants every 3 years. These requirements, instituted by Congress as part of the 1986 SDWA amendments, have diverted resources from science-based priorities, and have been impossible to meet within the mandated time frames. Efforts to meet all of the statute's remaining standard-setting requirements had detracted from the development of soundly analyzed, well-supported standards for the highest-risk drinking water contaminants, such as microbes. Under the 1996 amendments, the agency's decisions about new standards are informed by a cost-benefit analysis.

Other provisions of the 1996 amendments include the establishment of a priority list of unregulated contaminants and require that EPA promulgate rules on arsenic, enhanced surface water treatment incorporating standards for *Cryptosporidium,* and a new multimedia approach to reducing risks from radon. EPA is also directed to conduct research on sensitive subpopulations that may experience greater adverse health effects from drinking water contaminants than the general population (see also Chapter 6, "Environmental Justice").

Other Programs

In addition to the 1996 SDWA amendments, many other programs are under way to address drinking water quality. In 1993, the Surface Water Treatment Rule (SWTR) went into effect. The SWTR requires water systems using surface water sources to install filters for microbiological contaminants that cause disease, such as *Giardia lamblia*, *Legionella*, and viruses. Compliance with the rule will dramatically reduce the probability of human exposure to harmful levels of microbiological contaminants from surface water sources.

To protect sources of drinking water even before water is withdrawn by a drinking water supplier, EPA has established the Source Water Protection and Wellhead Protection Programs under the SDWA. The Source Water Protection Program emphasizes preventing contamination of drinking water resources and includes wellhead protection and "sole source aquifer" designations. The Wellhead Protection Program protects supplies of groundwater that will provide drinking water in the future from contamination by chemicals and other hazards, including pesticides, nutrients, and other agricultural chemicals. The program is based on the concept that local or state governments that adopt land use plans and other preventive measures can protect groundwater. Currently, 39 states have an EPA-approved wellhead protection program.

The Comprehensive State Ground Water Protection Program (CSGWPP), established by EPA in 1991, coordinates all federal, state, and tribal and local programs that address groundwater quality. States have the primary role in designing and implementing CSGWPPs in accordance with local needs and conditions. EPA has approved programs in 6 states, and plans from an additional 13 states are under review.

The Administration is also working to develop a comprehensive approach to water resource management to address the myriad water quality problems that exist today from nonpoint and point sources as well as from habitat degradation. The Watershed Protection Approach is a management approach for more effectively protecting and restoring aquatic ecosystems and protecting human health. The watershed protection approach recognizes that water quality management must embrace human and ecosystem health and that managing for one without considering the other can be detrimental to both. It has four major features: targeting priority problems, stakeholder involvement, integrated solutions, and measuring success. The watershed protection approach is not a new program that competes with or replaces existing water quality programs; rather, it is a framework within which ongoing programs can be integrated effectively.

AIR QUALITY

Ambient Air Quality

Over the past three or four decades, there have been important advances in the understanding of how air pollutants affect human health. Air pollutants may cause lung cell damage, inflammation, acute changes in lung function and respiratory symptoms, as well as more long-term lung cell changes. Acute and chronic exposure to air pollutants is also associated with increased mortality and morbidity. Yet much remains to be understood, including, for instance, the role of air pollution in observed increases in asthma cases and deaths from lung disease. Table 5.1 summarizes the major health effects of the six pollutants monitored by EPA.

In 1963, the United States took the first step toward healthier air by passing the Clean Air Act. Amended in 1970 and again in 1990, the Clean Air Act requires EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment and to ensure that these air quality standards are met through strategies to control air emissions from sources such as automobiles, power plants, and factories. As a result of these measures, air quality in the United States improved significantly (see Chapter 10, "Air Quality").

Despite these improvements, in 1994 approximately 62 million people still lived in counties where air quality levels exceeded the national air quality standards for at least one of the six principal pollutants. Ozone is the most commonly violated NAAQS, affecting 50 million people in 1994. According to the current ozone standards established by EPA, ozone levels exceeding 0.12 parts per million can be detrimental to public health. During the high smog season extending from June to early September, those levels are regularly exceeded in major cities across the United States, including New York and Los Angeles. Scientific evidence indicates that ozone affects not only people with impaired respiratory systems, such as asthmatics, but also healthy adults and children. Even exposures to relatively low concentrations of ozone have been found to temporarily reduce lung function and induce respiratory inflammation in normal, healthy people, especially during exercise. EPA is currently reviewing the NAAQS and has agreed to complete its review and issue revised standards by June 28, 1997. EPA may propose more stringent ambient air quality standards for ozone if the data support those changes.

In addition, more than 13 million people live in counties where the current EPA standard for particulate levels is exceeded. On the basis of studies of human populations exposed to high concentrations of particulates and laboratory studies of animals and humans, it has been determined that particulates pose major concerns for human health. These include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis, and premature death. Two recent epidemiological studies (Douglas Dockery, et.al., and C.

Table 5.1
Air Pollutants and their Impacts on Health

Carbon Monoxide

Sources: Carbon monoxide is a colorless, odorless, poisonous gas formed when carbon in fuels is not burned completely. It is a byproduct of motor vehicle exhaust, which contributes more than two-thirds of all CO emissions nationwide.

NAAQS: 9 ppm (measured over 8 hours)

Health Effects: Carbon monoxide enters the bloodstream and reduces oxygen delivery to the body's organs and tissues. Exposure to elevated CO levels is associated with visual impairment, reduced work capacity, reduced manual dexterity, poor learning ability, and difficulty in performing complex tasks.

Lead

Sources: Smelters and battery plants are the major sources of lead in air. Indoors, lead can be found in old buildings from paint on walls.

NAAQS: 1.5 ug/m3 (measured as a quarterly average)

Health Effects: Lead accumulates in the body in blood, bone and soft tissue. Because it is not readily excreted, lead can also affect the kidneys, liver, nervous system, and other organs. Excessive exposure to lead may cause anemia, kidney disease, reproductive disorders, and neurological impairments such as seizures, mental retardation, and/or behavorial disorders.

Nitrogen Dioxide

Sources: Nitrogen oxides form when fuel is burned at high temperatures, and come principally from motor vehicle exhaust and stationary sources such as electric utilities and industrial boilers.

NAAQS: 0.053 ppm (measured as an annual average)

Health Effects: Nitrogen dioxide can irritate the lungs and lower resistence to respiratory infections such as influenza. The effect of short-term exposure are still unclear, but continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children.

Ozone

Sources: Unlike other pollutants, ozone is not emitted directly into the air but is created by sunlight acting on NOx and VOC emissions in the air. There are literally thousands of sources of these gases, from gasoline vapors to chemical solvents.

NAAQS: 0.12 ppm (measured at the highest hour during the day)

Health Effects: Exposure to ozone significantly reduces lung function and induces respiratory inflammation in normal, healthly people during periods of moderate exercise. It can be accompanied by symptoms such as chest pain, coughing, nausea, and pulmonary congestion.

Sulfur Dioxide (SO2)

Sources: Formed when fuel containing sulfur (mainly coal and oil) is burned, and during metal smelting and other industrial processes.

NAAQS: 0.03 ppm (annual average) .14 ppm (over 24 hours)

Health Effects: SO2 can affect breathing, respiratory illness, alterations in pulmonary defenses, and aggravation of existing cardiovascular disease.

Particulate Matter (PM-10) **(PM-10 refers to particles with a diameter of 10 micrometers or less)**

Sources: Particulate matter is the term for solid or lliquid particles found in the air. Particles originate from a variety of mobile, stationary, and natural sources (diesel trucks, wood stoves, power plants, dust, etc.), and their chemical and physical compositions vary widely.

NAAQS: 50 ug/m3 (annual average) 150 ug/m3 (daily average)

Health Effects: Major concerns for human health from exposures to PM-10 are: effects on breathing and respiratory systems, damage to lung tissue, cancer, and premature death. The elderly, children, and people with chronic lung disease, influenza, or asthma tend to be especially sensitive to particulate matter.

Source: U.S. Environmental Protection Agency (EPA), *Air Quality Trends* (EPA, Office of Air Quality, Planning & Standards, Research Triangle Park, N.C., September 1995)

Arden Pope III, *et. al.*) have linked particulate pollution to excess morbidity and mortality in U.S. cities, providing striking evidence of the impact of energy-related transportation and industrial emissions upon human health and longevity.

As with ozone, EPA is considering the revision of its particulate standards. Ambient air standards for total suspended particulate matter were first set in 1971. Since 1987, however, EPA has used the indicator PM-10, which includes only those particles with aerodynamic diameter of 10 micrometers or less. These smaller particles are likely responsible for most of the adverse health effects of particulate matter because of their ability to reach the thoracic or lower regions of the respiratory tract. Further investigations by EPA may develop standards down to the PM-2.5 scale.

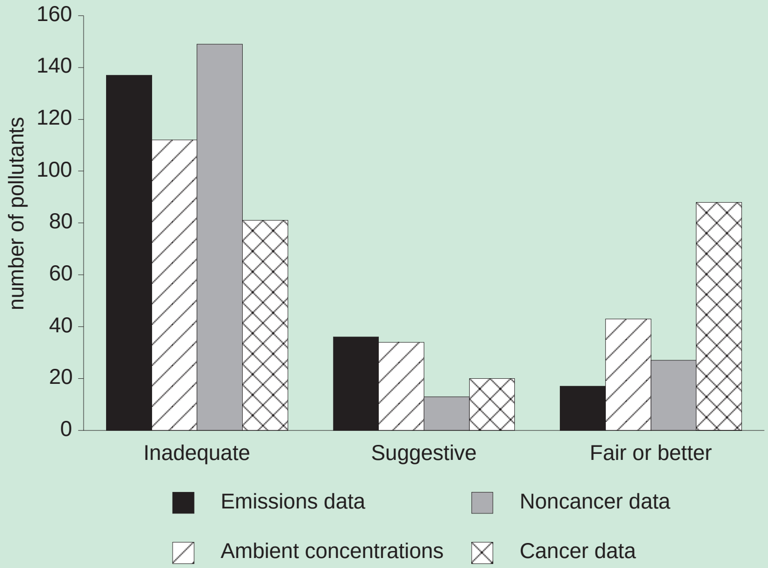
Most of the smaller particles under 2.5 microns in diameter are from fossil-fuel based energy-related emissions such as those from power plants, vehicles (especially diesel), and industry. Fortunately, initiatives intended to address other energy-related air pollution problems, such as ozone, acid rain, air toxics, and global climate change, can also yield substantial reductions in fine particle pollution while increasing energy efficiency and decreasing costs.

In addition to evaluating standards, the Administration has been working with federal agencies, the states, and industry to develop innovative and cost-effective programs to reduce emissions under the Clean Air Act. Market-based programs such as emissions trading provide incentives for industry to develop new pollution control technologies or pollution prevention approaches. In May 1996, EPA completed a draft study on benefits and costs of the Clean Air Act during the 1970–90 period. The analysis, which must still undergo review and possible revision by the EPA Science Advisory Board, found that spending for Clean Air Act programs had yielded benefits that far outweigh the costs due to the impact of lead and particulate matter controls (see Chapter 1, “America and the Environment: A 25-Year Retrospective” and Chapter 10, “Air Quality”).

There have also been government-wide efforts to find innovative solutions to air pollution problems. For example, the Department of Energy (DOE) has made much progress both in research and in deployment of technologies to mitigate the urban heat islands that can negatively affect air quality. DOE is working to help develop and identify the best roofing and paving materials, to use computer models to determine the optimal approach to cooling a city, and to disseminate information around the nation. DOE estimates that over a 20-year period, trees can be planted cheaply and roads, roofs, and parking lots replaced with cooler surfaces, with considerable savings in energy and environmental costs.

In many cities and regions, local efforts to reduce air pollution are also bearing fruit. In Los Angeles, the combination of cars, industries, weather, and natural topography contributes to the worst air pollution problems in the United States. To meet federal health standards by 2010, a regional air pollution control board has devised an elaborate

Figure 5.3 Adequacy of Available U.S. Data on 189 Hazardous Air Pollutants



Source: K. Sexton, "Science and Policy in Regulatory Decision Making: Getting the Facts Right about Hazardous Air Pollutants," *Environmental Health Perspectives*, Vol. 103, Supplement 6 (1995), pp. 213-222.

local air quality management plan that targets industry, transportation, and consumers and relies on both current technologies and some that are just now being developed. The estimated health benefits would be substantial. In Chattanooga, Tennessee, a collaborative effort among the city's political, business, and environmental leaders managed to end the severe air pollution problems that plagued the city only two decades ago. When confronted with federal standards in the Clean Air Act requiring local industries to install air pollution equipment, the city translated these requirements into economic growth, generating nearly $40 million in locally manufactured air pollution control equipment.

Hazardous Air Pollutants

In addition to the six criteria pollutants monitored under NAAQS, EPA also monitors hazardous air pollutants such as benzene, chlorine, and heavy metals, from stationary and urban area sources. Hazardous air pollutants are believed to pose a significant threat to human health. Estimates by EPA suggest that as many as 2,500 cancer cases per year may result from outdoor exposure to 45 of the 189 hazardous air pollutants listed under the Clean Air Act Amendments of 1990. However, the scientific basis for estimating risks from outdoor exposure to hazardous air pollutants is currently fragmented and sparse (Figure 5.3). EPA is in the process of using its research capabilities and testing authorities to respond to this gap in scientific knowledge. In June 1996, EPA proposed a test rule under the Toxic Substances Control Act to acquire needed inhalation toxicity data on 21 hazardous air pollutants.

The Administration has also taken a steady and aggressive stance on increasing the amount of information available to the public about toxics in their communities, their homes and their workplaces. The Federal Right-to-Know Program, for example, assures that communities have easy access to critical environmental information about the releases of toxic chemicals within their communities. In 1995, the number of chemicals covered by the Right-to-Know Program of Toxics Release Inventory increased from 300 to over 600. In 1996, EPA proposed to require the mining industry, utilities, hazardous waste handlers and other industrial sectors to also disclose basic toxic emissions data. Reporting from these industries would begin in 1997.

In addition, the 1990 Clean Air Act amendments introduced important innovations for controlling air toxics. Prior to passage of the 1990 amendments, EPA had regulated directly only seven of the hundreds of toxic air pollutants emitted from industries. Under the 1990 amendments, EPA must identify categories of "major" sources that emit any of the 189 hazardous air pollutants listed specifically under the act. This modification will allow EPA to better protect human health from hazardous air pollutants. These major sources of toxic air pollutants also will provide a roadmap for DOE pollution prevention efforts, which are targeted at the responsible industrial sectors.

Indoor Air Quality

Modern indoor environments contain an array of chemical and biological sources of air pollution, including synthetic building materials, consumer products, and dust. Common indoor pollutants include lead, radon, tobacco smoke, volatile organic compounds, combustion gases, particles, and mold. This section highlights three indoor air problems: lead, radon, and environmental tobacco smoke.

Lead. In the United States, children's mean blood lead levels have decreased more than 75 percent since the 1970s. This reduction is primarily the result of the phaseout of lead in gasoline and reductions in other sources and pathways of exposure, such as lead in soldered cans and paint (see Chapter 6, "Environmental Justice"). With the reduction of lead in gasoline and foods, the remaining major sources of lead are lead-based paint, dust and soil, drinking water, and occupational exposures.

While lead is not solely an "indoor air" issue, lead-based paint is currently the largest source of high-dose lead exposure for children. Approximately 1.7 million children still have blood lead levels above 10 micrograms per deciliter, the accepted level set by the Centers for Disease Control and Prevention, with the highest rates of blood lead levels found among poor, urban, African American, and Hispanic children. Although lead was banned from residential paint in 1978, it is estimated that 83 percent of all housing units built before 1980 contain some lead-based paint. Older, deteriorating buildings with peeling paint pose the greatest lead risk. The Department of Housing and Urban Development (HUD) estimates that about two out of three homes occupied by young children have lead paint and dust hazards, potentially affecting their mental and neural development. In adults, lead in the blood can interfere with hearing, increase blood pressure, and, at high levels, cause kidney damage and anemia.

In response to this environmental health threat, several U.S. agencies have made reducing lead exposure to children a top priority. Under the Toxic Substances Control Act and the Residential Lead-Based Paint Hazard Reduction Act of 1992, many new rules have been or will be developed to help reduce lead exposures. These rules incorporate lead hazard identification programs, lead disclosure and consumer education, and renovation and remodeling procedures to reduce lead hazards. Since 1992, HUD has awarded a total of $279 million in grants to reduce lead hazards in low-income housing. The grant program supports activities such as public education (using local media and community-based organizations to ensure widespread dissemination in the neighborhoods where lead poisoning is most prevalent), paint inspection and risk assessments, low-cost interim controls, and lead abatement. EPA and the National Institute of Environmental Health Sciences (NIEHS) also have programs researching the health risks from lead exposures as well as reducing lead exposures.

Radon. Radon is a cancer-causing, radioactive gas that comes from the natural breakdown of uranium in soil, rock, and water. Odorless and colorless, radon is believed to be a leading cause of lung cancer in the United States today. Radon is estimated to cause about 14,000 deaths per year. However, this number could range from 7,000 to 30,000 deaths per year. The links between radon and cancer are based largely on high-level dose-risk relationships developed from early studies of uranium miners, but the degree to which residential exposure to radon represents an actual risk of lung cancer is not known. Despite the uncertainty about the exact toll on human health, all major health organizations (e.g., the Centers for Disease Control and Prevention, the American Lung Association, and the American Medical Association) agree with estimates that radon causes thousands of preventable lung cancer deaths every year.

Radon gets into buildings from the soil, moving up through the ground into buildings through cracks in floors and walls, construction joints, gaps around service pipes, and well water. Nearly 1 out of every 15 homes in the United States is estimated to have indoor radon levels at or above EPA's current action level of 4 picocuries per liter. Typically, mitigation systems to lower radon levels cost less than $2,000. With these systems, radon levels can be lowered in virtually all homes to below 4 picocuries per liter, and in 70 percent of those homes the levels will be below 2 picocuries per liter.

EPA has taken action on many fronts to address this hazard to human health. For example, EPA has developed a program that evaluates the proficiency of contractors who conduct radon testing and those who install mitigation systems for homes and buildings. The names of proficient contractors are available through states, and 20 states have added their own certification programs for these contractors. EPA's Office of Air and Radiation has been educating the public about the dangers of radon and about ways to address it. This outreach program informs communities about how simple measures such as sealing cracks in floors and walls can help to reduce radon. With the assistance of EPA and other collaborative groups, state agencies are also coming up with innovative outreach programs. For example, in Kentucky, the state's medical history forms were amended to include a question about whether patients had tested their homes for radon. If not, a public health nurse would then explain radon risks and present a brochure on how to test a home cheaply and quickly for radon. With one simple change in a form, some 70,000 Kentucky citizens are now being reached every year.

In the 6 years of the program, EPA estimates that more than 9 million homes have been tested for radon and mitigation systems have been installed in 300,000 homes. In addition, on the basis of EPA's national school survey and discussions with states, it is estimated that about 20 percent of U.S. schools have been tested for radon.

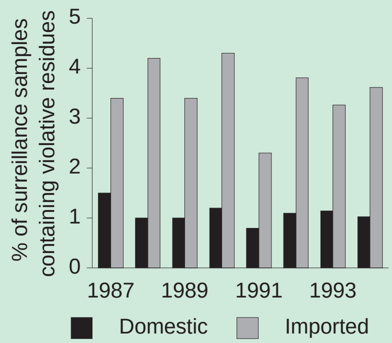
On the research front, DOE is sponsoring research at the Lawrence Berkeley Laboratory's Center for Building Science that has found ways to prevent radon from entering homes. In addition, Lawrence Berkeley Laboratory is working with the U.S. Geological Survey to develop radon concentration maps.

Environmental Tobacco Smoke. Smoking is the number one cause of lung cancer in the United States, and one of the greatest public health threats. Many government agencies are actively pursuing policies, from education campaigns to regulatory instruments, to educate the public about the health hazards of smoking and to get people to put down their cigarettes.

Tobacco smoke can also be hazardous to the health of the nonsmoker. Environmental tobacco smoke, also known as secondhand smoke, includes mainstream smoke, which is exhaled by the smoker, and sidestream smoke, which is the smoke that comes from the end of a burning cigarette, pipe, or cigar.

EPA estimates that environmental tobacco smoke is responsible for approximately 3,000 lung cancer deaths each year. EPA warns that environmental tobacco smoke can be especially harmful to children and estimates that on an annual basis it is responsible for 150,000 to 300,000 cases of lower respiratory tract infection, such as pneumonia and bronchitis, in infants and children under 18 months of age and a worsening of the condition of 200,000 to 1 million asthmatic children.

Figure 5.4 Pesticide Violations in Food Samples, 1987-1994



Source: See Part III, Table 76.

Many new laws, regulations, and ordinances restrict or ban public smoking. On the federal level, the General Services Administration imposed regulations restricting smoking to designated areas in federal office buildings. By law, smoking is prohibited on almost all domestic airline flights and, by regulation, on all interstate bus travel. In 1995, the United States entered into an international agreement banning smoking on all nonstop flights between the United States, Canada, and Australia. Currently, nearly every state has some form of legislation to protect nonsmokers; some states require private employers to enact policies that protect employees who do not smoke. In addition to state legislation, more than 560 local jurisdictions have enacted ordinances addressing nonsmokers' rights, and most are more restrictive than their state counterparts.

On August 23, 1996, President Clinton established the nation's first-ever comprehensive program to protect children from the dangers of tobacco and a lifetime of nicotine addiction with the publication of the Food and Drug Administration's final rule on tobacco and children, and with FDA's initiation of a process to require tobacco companies to educate children and adolescents — using a national multimedia campaign — about the dangers of cigarettes and smokeless tobacco.

The plan is intended to reduce tobacco use by children and adolescents by 50 percent in seven years. It builds on previous actions taken by Congress and others such as the ban on television advertising and state laws to prohibit the sale or use of tobacco by children. It follows recommendations by the American Medical Association and the National Academy of Science's Institute of Medicine. Experts have consistently recommended that the keys to achieving the goal are reducing access and limiting the appeal to children. This initiative accomplishes that objective while preserving the availability of tobacco products for adults.

CONTAMINATED FOOD AND FISH

Pesticide Residues in Food

Pesticides are used widely in agriculture in the United States. The use of pesticides has contributed to dramatic increases in yields for most major fruit and vegetable crops by controlling harmful pests. Their use has led to substantial improvements over the past 40 years in the quantity and variety of the U.S. diet and thus in the health of the public. The use of pesticides can also reduce spoilage and health risks from biological contaminants. In general, pesticide residues in food have remained at low levels for many years. In 1994, only about 1 percent of domestic food samples (55 out of 5,366 samples) contained illegal pesticide residues that exceeded established tolerance levels. In imported food samples, the frequency was 3.6 percent (197 out of 5,488 samples). In 1987, 1.5 percent of domestic samples and 3.4 percent of imported samples exceeded tolerance levels (Figure 5.4).

However, many pesticides are harmful to the environment and may negatively affect human health. Historically, EPA has regulated pesticides under two major federal statutes: the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA). FIFRA prohibits the sale or use of pesticides not registered by EPA for use in the United States and prescribes labeling and other regulatory requirements to prevent unreasonable adverse effects on health or the environment. Under FFDCA, EPA establishes tolerances (maximum legally permissible levels) for pesticide residues in food. Tolerances are enforced by the Department of Health and Human Services' Food and Drug Administration for most foods and by the U.S. Department of Agriculture's Food Safety and Inspection Service for meat, poultry, and some egg products.

For over two decades, there have been efforts to update and resolve inconsistencies in the two major pesticide statutes, but consensus on necessary reforms has been elusive. In 1993, the Administration published a "Pesticide Reform Agenda" with proposals for reform. In August 1996, Congress unanimously passed and President Clinton signed a landmark pesticide food safety bill, the Food Quality Protection Act of 1996, which incorporated these proposals, to better protect people from food contamination. The act represents a major breakthrough, amending both FIFRA and FFDCA to establish a more consistent, protective regulatory scheme, grounded in sound science. It mandates a single, health-based standard for all pesticides in all foods; provides special protection for infants and children; expedites approval of safer pesticides; creates incentives for the development and maintenance of effective crop protection tools for American farmers; and requires periodic reevaluation of pesticide registrations and tolerances to ensure that the scientific data supporting pesticide registrations will remain up to date.

A significant provision of the Food Quality Protection Act is that it substitutes a single strong health-based limitation on risks presented by pesticides in food for the inconsistent standards in the Delaney clause. The Delaney clause, contained in the section on food additives of the FFDCA, states that no additive will "be deemed safe if it is found to induce cancer when ingested by man or animal" and directs EPA not to approve such food additives. Its language was interpreted to mean a "zero risk" standard for any cancer-causing food additive, including residues from pesticides found in processed foods. However, on raw foods the law requires that EPA use a negligible risk standard, in the belief that if the cancer risk is outweighed by several factors such as the ability of the pesticide to help in the production of an adequate, wholesome, and economical food supply, the safe use of the pesticide is warranted. Thus, the Delaney clause presented regulators with the problem of conflicting standards for pesticides in raw versus processed foods. The application of the Delaney clause criteria limited the introduction of lower-risk pesticides that could replace older and potentially more hazardous compounds. Furthermore, the Delaney clause approach was unduly narrow, because it singled out one health endpoint—cancer—and did not cover substances causing birth defects, nerve damage, or immune system failures.

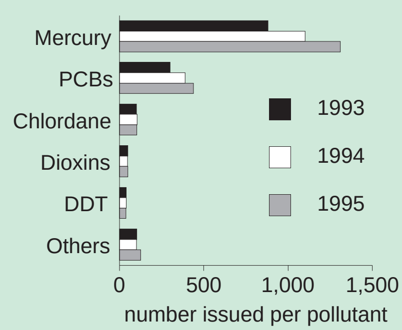
These “paradoxes” now no longer exist for pesticides in food. A new standard that requires that all tolerances be safe, in both raw and processed foods, is now used. Safety is defined as “a reasonable certainty that no harm will result from aggregate exposure,” and the requirement applies to both raw and processed food, not just for cancer risks, but for all risks. This revision will allow EPA and others to address any risks presented by food as it is consumed as well as to devote resources that had been consumed by Delaney-related activities to higher- priority public health and environmental protection activities, including mandates secured in the Food Quality Protection Act of 1996: protecting children and other sensitive subpopulations, implementing Consumer Right-to-Know provisions regarding pesticide risks, and evaluating and reducing risks from pesticides that may be endocrine disruptors.

Contaminated Fish

Last year, 46 contaminants, from dioxin to chlordane, were found in fish. The number of lakes, rivers, and other U.S. waterways where consumers have been advised to avoid or limit consumption of trout, salmon, or other species because of chemical contamination rose from 1,278 in 1993 to 1,740 in 1995 (Figure 5.5).

While EPA provides guidance on levels of contamination, primary responsibility for protecting residents from the health risks of consuming noncommercial contaminated fish and wildlife lies with the states, the District of Columbia, and the four U.S. territories. They issue consumption advisories to the public when high concentrations of chemical contaminants have been found in local wildlife and freshwater fish. A complete database of these advisories—the Nation-

Figure 5.5 Contaminated Fish Advisories, 1993-1995



Source: U.S. Environmental Protection Agency (EPA), *Update: National Listing of Fish and Wildlife Consumption Advisories* (EPA, Office of Water, 1996).

al Listing of Fish and Wildlife Consumption Advisories—is maintained by EPA's Office of Water to help water quality officials and the public identify where fish contamination is a concern. The database contains information on the types of advisories and bans in effect (e.g., whether the advisory applies to the population in general or only to sensitive subpopulations such as pregnant women and children), the species and size range of piscivorous (fish-eating) fish in the wild, the chemical contaminant identified in the advisory (e.g., mercury, PCBs, chlordane, dioxins, or DDT), the geographic location and area covered by each advisory, and the date the advisory was issued.

The database is designed primarily to help federal, state, and local government agencies and Native American tribes assess the potential for human health risks associated with the consumption of chemical contaminants in noncommercial fish and wildlife. The increase in advisories issued between 1993 and 1995 reflects an increase in the number of assessments of the levels of chemical contaminants in fish and wildlife tissues. These additional assessments were conducted as a result of increased awareness of health risks associated with the consumption of chemically contaminated wildlife and freshwater fish. The number of advisories decreases if states determine that the monitored concentrations of chemical contaminants in wildlife or freshwater fish tissues have decreased and no longer pose a risk to human health.

Mercury, PCBs, chlordane, dioxins, and DDT were responsible for almost 95 percent of all fish consumption advisories in effect in 1995. In 463 cases, the advisories recommended that everyone avoid eating a certain species of fish; in 1,393 instances, children, pregnant women, or other vulnerable groups were warned to restrict or eliminate their freshwater fish consumption.

For commercial fish, EPA and FDA also set limits for levels of chemical contamination to protect human health.

Case Study: The Dioxin Reassessment

Since the early 1970s, dioxins have often been referred to as one of the most toxic groups of chemical compounds known. Dioxins are inadvertently created through a number of activities, including combustion, certain types of chemical manufacture, chlorine bleaching of pulp and paper, and other industrial processes. The main pathway for exposure to humans is via airborne emissions of dioxin that settle on plants and are passed on and accumulated through the food chain. While dioxin is produced in very small quantities in comparison with other pollutants (equivalent to around 30 pounds of the most toxic member of the class annually), its high toxicity and properties of bioaccumulation and persistence in the environment have led EPA to treat dioxin as a major public health threat. EPA first took action against dioxin regarding the herbicide 2,4,5-T in 1979 and since then has expanded its dioxin control efforts to each of its major programs.

In 1985, EPA published a scientific review of the health effects of 2,3,7,8-

TCDD, the most toxic of the dioxin family of compounds. In the 1985 assessment, EPA concluded that dioxin is a proven animal carcinogen and a probable human carcinogen and began using that assessment as the scientific basis for dioxin risk estimates for all EPA programs. In 1988, EPA prepared a draft reassessment, as well as a draft exposure document that presented procedures for conducting site-specific exposure assessments. However, questions about the scientific methodology, dioxin's toxicity, and possible health effects remained.

In 1991, EPA announced that it would conduct a scientific reassessment of the health risks of exposure to dioxin and dioxinlike compounds, drawing on significant advances in the scientific understanding of mechanisms of dioxin toxicity, new studies of dioxin's carcinogenic potential in humans, and increased evidence of other adverse health effects. In September 1994, EPA released its final "public review draft" of the dioxin reassessment. The dioxin reassessment breaks new ground—not only by providing policymakers with the most comprehensive assessment of dioxin to date, but also by establishing a new, participatory model of how a risk assessment should be conducted.

The dioxin reassessment process is noteworthy for several reasons. First, EPA has worked to make each phase of the dioxin reassessment an open and participatory process. More than 100 scientists from academia, government, and industry have collaborated throughout the reassessment process by providing data, writing chapters, and reviewing drafts. In addition, EPA has held several public meetings to gather comments on progress, and it published earlier drafts for public comment and review. Second, unlike the 1985 report, which considered only the compound 2,3,7,8-TCDD, the 1994 draft report also investigates the health impacts of dioxin-related compounds. Thus, other chemicals that behave like dioxins (i.e., chemicals that have a similar structure to dioxin and bind to a cellular protein called the "Ah receptor") were also considered in the 1994 report.

Third, the 1994 draft report is also unique in that it attempted to provide a comprehensive inventory of emission sources. It found that waste combustion accounts for a large percentage of all known emissions, yet acknowledged the likelihood that there are a number of unidentified sources of dioxin in the United States. The sources of dioxin are still under review, and EPA is still in the process of collecting additional information and data about sources and emission levels.

Finally, unlike the 1985 report, which focused exclusively on cancer risks, the 1994 draft report evaluates dioxin's noncancer effects as well. These effects may include developmental and reproductive effects, immune suppression, and disruption of hormones that regulate normal biological functions. In addition, the reassessment reaffirmed with greater confidence that dioxin is a proven animal carcinogen and a probable human carcinogen.

Until the final report is released in 1997, EPA's efforts to control dioxin risks will not change. Indeed, during the reassessment process, efforts to implement dioxin control programs have continued. In December 1995, EPA Administrator Carol Browner announced promulgation of air standards for new and existing municipal waste combustors. The rule specifies technology-based performance standards, which would reduce dioxin and other organic chemical emissions by 95 to 99 percent from a number of existing municipal waste combustors and all new plants. In addition, EPA has proposed similar regulations for medical waste incinerators. EPA has continued to administer programs to limit dioxin contamination of U.S. waters by developing technology-based effluent limitation guidelines for pulp and paper mills, by developing ambient water quality criteria guidance, and by prohibiting the discharge of dredged material that is contaminated with dioxin in violation of state water quality standards. The Safe Drinking Water Program, the Superfund Program, and the Pesticides and Toxic Chemicals Program also all have active pollution prevention and control programs for dioxins and furans. Once the final report is released, EPA will begin an extensive review of policies developed to manage dioxin risks, again relying heavily on early public input into the policy evaluation process.

EMERGING CHALLENGES

The Endocrine Disruptor Debate

There have been many reports that domestic animals and wildlife have suffered adverse reproductive and other health effects from exposure to environmental chemicals that interact with the endocrine system, often called endocrine disruptors or environmental hormones. These problems have primarily been identified in animals and humans exposed to relatively high levels of certain organic chemicals. Whether similar effects are occurring in the general human or wildlife populations from ambient environmental levels is currently unknown.

While many uncertainties exist regarding the effects that environmental hormones have on humans and animals, the issue must be taken seriously. Hormones play a major role in the functioning of all organ systems, and small disturbances in endocrine function in laboratory animals, at critical stages of development, have been shown to produce profound and lasting effects. In addition, people are exposed to a complex mixture of many natural and synthetic compounds, which may have synergistic effects. Further, some chemicals that have been identified as endocrine disruptors, such as PCBs, persist in the environment for a long time.

Most of the effects associated with exposure to endocrine-disrupting chemicals, such as reproductive dysfunction and sexual abnormalities, have been observed in wildlife populations receiving relatively high levels of exposure consisting mainly of persistent chlorinated compounds, such as DDT. Examples include reproductive problems in wood ducks from Bayou Meto, Arkansas; embryonic deformities in Great Lakes fish-eating birds; feminization and demasculinization in gulls; developmental effects in Great Lakes snapping turtles; and developmental dysfunction in lake trout in the Great Lakes. In each case, detectable concentrations of chemicals with known endocrine-disrupting effects have been reported in the animals or their environment, but a cause-and-effect link has been established for only a few of these observations.

For human populations, some studies have suggested that endocrine-disrupting chemicals may be responsible for reported increases in certain cancers and adverse reproductive effects. The hypothesis that endocrine disruptors can cause cancer in humans is based largely on the clear association between exposure of pregnant women to diethylstilbestrol (DES), a drug taken to avoid miscarriage, and reproductive organ cancers in their daughters. In addition, cancer trend data for the 1973–91 period show increases in the incidence of some cancers associated with hormones (female breast, 24 percent; testicular, 41 percent; prostate, 126 percent). So far, because there are insufficient supporting data, the linkage between the incidence of human cancers and an endocrine (hormonal) disruption mechanism remains a working hypothesis. Most of these increases in incidence may be attributed to improvements in detection and early diagnosis, or other factors. In the case of breast cancer, for example, epidemiological studies have determined a variety of risk factors, such as oral contraceptives, estrogen replacement therapy, family history, smoking, and alcohol use.

There have been documented cases of reproductive problems in humans exposed accidentally to high doses of endocrine-disrupting chemicals as well as reports of declines in the quality and quantity of sperm production in humans over the last four decades. Several studies, such as a 1992 study by Carlsen *et al.* and a 1995 study by Auger *et al.*, have provided evidence that there have been declines in sperm count in their selected populations. However, other studies, such Suominen and Vierula's review of several studies published between 1958 and 1992, and clinical studies by Fisch *et al.* and Paulsen *et al.*, have concluded that there were no decreases in sperm count or semen volume. Thus, while there may be reductions in some specific locations, more research is needed concerning potential reductions in sperm production in the general population.

While there is much scientific uncertainty and debate about this issue, there is resounding agreement that additional data and research are needed. The public and private sectors have recognized this need and have established research programs. Several federal agencies are currently engaged in a wide range of research activities relating to endocrine disruptors, which include studies of exposure and effects, as well as the mechanisms of endocrine-disrupting chemicals. The National Science and Technology Council's Committee on Environmental and Natural Resources identified this issue as an initiative in November 1995, and has established an interagency working group of scientists to identify research needs related to the health and ecological effects of endocrine-disrupting chemicals and to develop an interagency research plan. The National Academy of Sciences is also conducting an assessment. The Environmental Protection Agency has recently completed an agencywide draft on the state of the science entitled "Environmental Endocrine Disruption: An Effects Assessment and Analysis Document," which has been submitted to the Risk Assessment Forum and the Science Policy Council for approval. EPA is also forming a committee (the Endocrine Disruptor Screening and Testing Advisory Committee) to advise the agency on the development of a strategy for screening and testing chemicals and pesticides for their potential to disrupt the endocrine system. These efforts, and others, will lead the way to a better understanding of endocrine disruptors and their potential impacts and ultimately will provide the tools needed to make informed policy decisions about this issue.

Ozone and Climate Change

Ozone. In 1994, the World Meteorological Organization (WMO) in collaboration with the National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), and the United Nations Environment Programme (UNEP) released its scientific assessment of ozone depletion. The report, *Scientific Assessment of Ozone Depletion: 1994*, includes a review of potential health impacts from stratospheric ozone depletion.

The assessment reports that the accumulation of certain human-made gases in the upper atmosphere or stratosphere—from the widespread use of various halocarbons for refrigeration, insulated packaging, and in industry and agriculture—has resulted in a sustained decline in stratospheric ozone concentrations. The major consequence of this stratospheric ozone depletion is reduced shielding of Earth's surface against incoming solar ultraviolet radiation; thus, a continuing depletion of stratospheric ozone would increase the amount of ultraviolet radiation that reaches Earth's surface. These increases would be experienced, mostly, in the middle and high latitudes, where the majority of the global population is concentrated. Indeed, United Nations projections indicate that as ozone depletion reaches its peak before the year 2000, mid-latitudes in the Northern Hemisphere may experience a 15 percent increase in UV-B exposure during winter and spring. The assessment found that UV-B radiation increased by 2 percent for every 1 percent decrease in the ozone layer.

Although the amount of UV-B striking Earth's surface can vary routinely by as much as 20 percent, scientists have warned that if the current trend were to continue, radiation would reach levels high enough to increase the incidence of skin cancer and cataracts in humans. The assessment, assuming no change in exposure patterns in the general population, projected that a sustained 10 to 15 percent depletion of stratospheric ozone over several decades could result in an estimated 15 to 20 percent increase in the incidence of skin cancer in fair-skinned populations. Solar ultraviolet light is an important cause of squamous-cell carcinoma of the eye. Increased UV-B radiation can also interfere with the body's immune system; this constitutes one of the most potentially dangerous effects of UV-B because of the possibility that immunity to infectious diseases may be compromised.

Climate Change. As discussed in Chapter 12, "Climate Change," the international scientific community, represented by the 2,500 scientists of the Intergovernmental Panel on Climate Change (IPCC), reported in its latest assessment in 1995 that human activities are having a discernible influence on global climate. The models used by the IPCC predict an increase in average global temperature of about 1^{o} to 3.5^{o} C (1.4^{o} to 6.3^{o} F) by 2100. A change of this magnitude will likely produce alterations both in physical systems (e.g., higher temperatures, heavier rainfall, and rising sea level) and in ecosystems (e.g., forests, agriculture, marine ecologies, and the habitats of various insects and animals), with profound implications for human health.

In its chapter on human health, the IPCC reports that climate change, by altering local weather patterns and by disturbing life-supporting natural systems and processes, may affect the health of human populations and that adverse effects are likely to outweigh beneficial effects. The range of health effects would be diverse, often unpredictable in magnitude, and sometimes slow to emerge. Researchers believe that both direct risks (e.g., death in heat waves or floods) and indirect risks (e.g., changes in food production or the distribution and incidence of vector-borne diseases) to human health will emerge.

Estimating health impacts of climate change is still a relatively new field of scientific study, and it remains controversial. There are inevitable, multiple uncertainties involved in trying to project potential health impacts in relation to future scenarios of climate change. In addition, actual health impacts will vary dramatically by region depending on environmental circumstances, the existing health infrastructure, social and economic resources, and the baseline health status of the population. Many of the anticipated adverse health impacts of climate change are expected in the world's less-developed regions; in many of those countries, there already exists a high prevalence of undernutrition, chronic exposure to infectious disease agents, and inadequate access to social and physical infrastructure. Nevertheless, human health in the United States may be adversely affected in several ways: by an increase in heat-related mortality, especially in urban areas; by an increase in the frequency and severity of extreme weather events such as flooding; and by an increase in the potential for the spread of diseases such as malaria, dengue, cholera, and salmonellosis. In addition, demographic trends including population aging and increasing levels of disability, chronic illness, and coastal retirement may increase the vulnerability of the U.S. population to adverse health impacts related to climate change.

Table 5.2

Total Summer Heat-related Deaths in Selected Cities: Current Mortality and Estimates of Future Mortality Under the GFDL89 Climate Change Scenario

		GFDL89 climate change scenario			
		Year 2020		Year 2050	
City	Present mortality[1]	No acclimatization	Acclimatized population	No acclimatization	Acclimatized population
	average number of summer-season heat-related deaths				
United States					
Atlanta	78	191	96	293	147
Dallas	19	35	28	782	618
Detroit	118	264	131	419	209
Los Angeles	84	205	102	350	174
New York	320	356	190	879	494
Philadelphia	145	190	142	474	354
San Francisco	27	49	40	104	85
Canada					
Montreal	69	121	61	245	124
Toronto	19	36	0	86	1
China					
Shanghai	418	1,104	833	2,950	1,033
Egypt					
Cairo	281	476	na	830	na

Source: A.H. McMichael, A.Haines, R.Sloof and S, Kovats, eds. *Climate Change and Human Health*, p. 57 (World Health Organization and United Nations Environment Program, Geneva, 1996).

Notes: [1]raw mortality data. na=not applicable.

Cases of heat-stress mortality, particularly in vulnerable individuals such as the very young and the very old, could increase because of climate change. Recent analyses of concurrent meteorological and mortality data in cities in the United States, Canada, the Netherlands, China, and the Middle East show that overall death rates rise during heat waves, particularly when the temperature and humidity rise above the local population's threshold value. One model suggests that the annual number of heat-related deaths would approximately double by 2020 and would increase severalfold by 2050. For a city like Atlanta, Georgia, that could increase the number of heat-related deaths from the current average of about 80 each summer to nearly 200 in 2020 and closer to 300 in 2050 (see Table 5.2). These estimates are based on myriad assumptions and involve a large amount of uncertainty. Nevertheless, in very large cities with populations sensitive to heat stress, climate change could cause significant increases in extra heat-related deaths annually.

Climate change will also likely increase the frequency and severity of some extreme weather events such as flooding. Flash flooding is currently a leading cause of weather-related mortality in the United States. In addition to direct deaths from drowning and other accidents, flooding could also facilitate the spread of infectious diseases by damaging homes and displacing residents, as well as contaminating water sources with fecal material or toxic chemicals. Weather-related disasters often overwhelm local public health facilities and water and sanitation infrastructure, further affecting human health.

A third area in which climate change can affect human health in the United States is by changing the distribution of disease vectors. Infectious agents and their vector organisms are sensitive to factors such as temperature, surface water, humidity, wind, soil moisture, and changes in forest distribution. Net climate-change-related increases in the geographic distribution (altitude and latitude) of the vector organisms of infectious diseases (e.g., malarial mosquitos, schistosome-spreading snails) and changes in the life-cycle dynamics of both vector and infective parasites would, in aggregate, increase the potential transmission of many vector-borne diseases. Malaria, a mosquito-borne disease that currently afflicts an estimated 1 in 20 people in the world, provides an apt example. Models reported on by the IPCC suggest that with the predicted climate change, the proportion of the world's population living within the potential malaria transmission zone could increase from around 45 to around 60 percent by the latter half of the next century. Although this predicted increase in potential transmission encroaches mostly into temperate regions, actual climate-related increases in malaria incidence would occur primarily in tropical, subtropical, and less well protected temperate zone populations currently at the margins of endemically infected areas.

Addressing the Issues. The United States has been an active participant in both the Montreal Protocol and the Climate Convention. On December 31, 1995, the industrialized nations of the world officially ended their production of ozone-depleting chlorofluorocarbons (CFCs), except for a few essential uses. The U.S. role in this effort and the Administration's continued work toward reducing greenhouse gas emissions are discussed in detail in Chapter 11, "Stratospheric Ozone" and Chapter 12, "Climate Change."

On the health side, the Administration is working closely with the scientific community to further investigate the links between ozone depletion and climate change and human health. The development of advanced remote sensing and GIS technologies will help in facilitating large-scale data collection and analysis.

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CHAPTER SIX

Environmental Justice

On February 11, 1994, President Clinton issued Executive Order 12898, placing environmental justice firmly on the nation's political agenda. The order directs federal agencies to incorporate environmental justice principles into their day-to-day operations. In addition, the order promotes nondiscrimination in federal programs involving human health and the environment, and ensures that minority and low-income communities are given the opportunity to participate in decisionmaking.

Concerns about environmental "injustices" are not a new phenomenon. In fact, the first mention of inequities in the distribution of environmental hazards was published 25 years ago, in the first annual report of the Council on Environmental Quality (see Box 6.1). While progress has been made in addressing environmental justice issues, much still remains to be done before, as President Clinton stated as he issued the Executive Order, "all communities and persons across this nation live in a safe and healthful environment."

BACKGROUND

Historically, federal and state agencies have set pollution standards to protect all citizens equally from environmental pollution. Air and water quality standards, for example, are set to protect the nation as a whole. The environmental justice movement, however, has brought national attention to the fact that environmental hazards are not shared equally and that minority and low-income communities bear a disproportionate share of the nation's air, water, and waste problems. Several studies have found that the geographic distribution of municipal and hazardous landfills, incinerators, and abandoned toxic waste dumps are located primarily in minority and low-income neighborhoods. Minority and low-income communities may face a number of other environmental risks as well; for instance:

- African Americans and Hispanic-origin populations are more likely than whites to live in areas with reduced air quality (Figure 6.1).
- Low-income residents living in older, poorly maintained buildings are more likely to be exposed to dangerous levels of lead.
- Migrant farm workers are more likely to be exposed to hazardous levels of pesticides and less likely to have access to adequate protective clothing.
- In some areas, Navajo land and water supplies are contaminated with uranium, which may be contributing to the high incidence of organ cancer among Navajo teenagers.

Box 6.1
Milestones in the Environmental Justice Movement

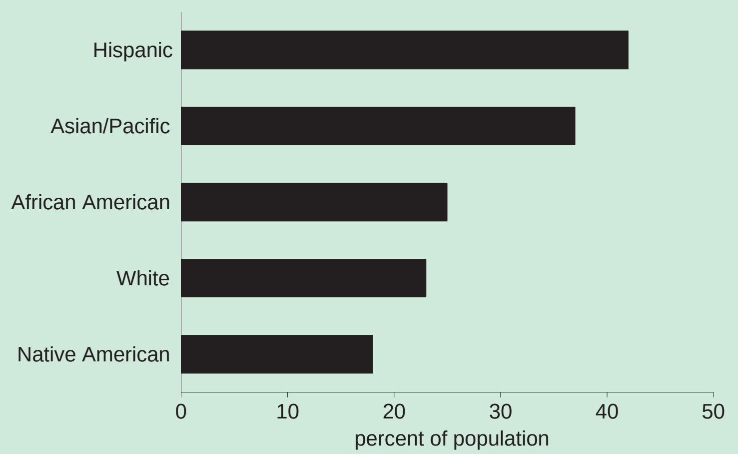
1971	Council on Environmental Quality annual report notes inequities in distribution of environmental hazards.
1982	500 citizens are arrested for demonstrating in opposition to the siting of a PCB disposal landfill in the predominantly black and poor Warren County, North Carolina.
1983	The General Accounting Office investigates relationship between race and the siting of four commercial hazardous waste landfills in the Southeast. At three of the four landfills, African Americans made up the majority of the population living nearby. At least 26 percent of the population in all four communities was below the poverty level.
1987	United Church of Christ's *Toxic Wastes and Race in the United States* is released and concludes that race, not income, was the factor more strongly correlated to residence near a hazardous waste site. It found that the proportion of minorities in communities with a hazardous waste facility is nearly double that in communities without one. Where two or more such facilities are located, the proportion of minorities is more than triple.
1990	Michigan Conference on Race and the Incidence of Environmental Hazards is held, bringing together academics, activists, and policymakers around the issue of environmental justice.
1992	The Environmental Protection Agency's (EPA's) Environmental Equity Working Group, established in 1990, releases *Environmental Equity: Reducing Risk for All Communities*, which concludes that racial minorities and low-income people are disproportionately exposed to lead, selected air pollutants, hazardous waste facilities, contaminated fish, and agricultural pesticides in the workplace. EPA establishes the Office of Environmental Equity (renamed the Office of Environmental Justice in 1994).
1994	President Clinton issues Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requiring federal agencies to develop a comprehensive strategy for making environmental justice part of their daily operations. The Interagency Working Group on Environmental Justice is established, chaired by EPA Administrator Carol M. Browner and comprised of the heads of 11 agencies and several White House offices. Update of United Church of Christ report finds that minority populations in 1993 are more likely to live in ZIP codes where hazardous waste facilities are located than they were in 1980; race/ethnicity remains a stronger indicator of proximity to a facility than income.

As discussed later in this chapter, other studies have presented conflicting evidence as to whether a disproportionate burden exists, especially in the area of waste facility siting. Setting aside these controversies, however, environmental justice has to do with more than documented disproportionate exposure to environmental hazards. It is primarily about raising awareness of and sensitivity to the issues, and about trying to achieve fairness in U.S. environmental policy and in how environmental policy decisions are made. Examples of environmental "injustices" could include a permitting office that authorizes a hazardous waste landfill in a predominantly minority area without considering other sites or without consulting community residents; a state agency that publishes environmental hearing notices only in English, even though the affected community is largely Spanish-speaking; or a federal water pollution study that does not take into account the fact that members of a nearby Native American tribe consumes fish from a waterbody in greater quantities than the national average, possibly exposing them to higher doses of toxins.

Thus, environmental justice has to do with equal protection from environmental hazards and the ability of all communities to have a voice in decisions that affect their health, environment, and quality of life. Communities where residents are unaware of environmental laws and regulations may not be able to make informed decisions about, for example, a proposal to build an incoming hazardous waste facility. In addition, minority and low-income residents may lack the time, money, contacts, information, and other resources needed to take political action. Minorities often face further barriers because of housing discrimination, language differences, and underrepresentation in government offices.

Within the environmental justice movement, debate continues on whether race or income is a stronger influence on exposure to environmental hazards. The landmark 1987 study by the United Church of Christ, *Toxic Wastes and Race in the United States*, found that race was a stronger determinant of proximity to a hazardous waste facility than income.

Figure 6.1 U.S. Populations Exposed to Poor Air Quality, 1993



Source: Fred Seitz and Christine Plepys, *Monitoring Air Quality in Healthy People 2000*, Statistical Notes No. 9 (National Center for Health Statistics, Hyattsville, MD, 1995).
Note: Data refer to proportion of population living in counties with air quality above the primary national air quality standard. Persons of Hispanic origin may be of any race.

Indeed, a review of studies by Paul Mohai and Bunyan Bryant found that race has an effect, independent of income, on the distribution of environmental hazards. Other researchers argue that minorities are disproportionately affected because they are disproportionately poor. Regardless of whether race or income has a more important effect on the distribution of environmental hazards, the environmental justice movement contends that as minority and low-income families become increasingly concentrated in inner cities and other isolated pockets, their communities become the dumping grounds for the waste of the wealthy. To paraphrase Mohai and Bryant, perhaps knowing whether race or income has a more important effect on the distribution of environmental hazards is less relevant than understanding how the conditions that lead to environmental inequity can be addressed and remedied.

RECENT ACTIONS

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, is the first presidential effort to direct all federal agencies with a public health or environmental mission to make environmental justice an integral part of their policies and activities. The order focuses federal attention on the environmental and human health conditions of minority and low-income populations with the goal of achieving environmental protection for all communities. Among other things, the executive order creates an Interagency Working Group on Environmental Justice; requires each federal agency to develop an agencywide environmental justice strategy; and directs agencies to include information about minority and low-income communities in their research, data collection, and analysis on human health and environmental issues (see Box 6.2).

President Clinton issued an accompanying memorandum to the executive order for the heads of all departments and agencies, directing them to take appropriate and necessary steps to ensure that:

- in accordance with Title VI of the Civil Rights Act of 1964, each federal agency shall ensure that all programs or activities receiving federal financial assistance that affect human health or the environment do not directly, or through contractual or other arrangements, use criteria, methods, or practices that discriminate on the basis of race, color, or national origin;
- each federal agency shall analyze the environmental effects, including human health, economic, and social effects, of federal actions, including effects on minority and low-income communities, when such analysis is required by the National Environmental Policy Act of 1969 (NEPA); and
- each federal agency shall provide opportunities for community input in the NEPA process including identifying potential effects and mitigation measures in consultation with affected communities and improving the accessibility of meetings, crucial documents, and notices.

Box 6.2
Highlights of Executive Order 12898

Executive Order 12898 directs each federal agency to make environmental justice part of its mission by identifying and addressing disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.

One significant provision of the order is the establishment of an Interagency Working Group (IWG) on Environmental Justice. IWG is chaired by Environmental Protection Agency Administrator Carol M. Browner and is comprised of the heads of 11 agencies and several White House offices, including the Departments of Agriculture, Commerce, Defense, Energy, Housing and Urban Development, Health and Human Services, Interior, Justice, Labor, and Transportation; the Council of Economic Advisors; Council on Environmental Quality; Domestic Policy Council; Office of Management and Budget; and Office of Science and Technology Policy. The Nuclear Regulatory Commission and National Aeronautics and Space Administration also have participated in IWG.

IWG provides guidance to federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority and low-income populations; it also coordinates, provides guidance, and serves as a clearinghouse for each agency as it develops an environmental justice strategy to ensure consistent administration, interpretation, and enforcement of programs, activities, and policies. IWG is also responsible for coordinating and stimulating cooperation among agencies in their research efforts.

The executive order also directs each federal agency to do the following:

- Develop an agencywide environmental justice strategy, to be completed within 12 months of the date of the order. As part of this strategy, each agency was required to identify and begin work on several specific environmental justice projects. The agencies are required to report on their progress to IWG, which compiles this information and submits it to the President on an annual basis.
- Include diverse segments of the population in epidemiological and clinical studies, including segments at high risk from environmental hazards, such as minority populations, low-income populations, and workers. It emphasizes the need for environmental human health analyses to consider multiple and cumulative exposures.
- Provide minority and low-income populations with the opportunity to participate in the development and design of research strategies.
- Collect, maintain, and analyze information on the consumption patterns of populations that principally rely on fish and/or wildlife for subsistence.

The executive order explicitly encourages public participation by stating that the public may submit recommendations to federal agencies relating to the incorporation of environmental justice principles into federal agency programs or policies. It allows each federal agency to translate crucial public documents, notices, and hearings relating to human health or the environment for limited-English-speaking populations; and requires that each agency ensure that these documents, notices, and hearings be concise, understandable, and readily accessible to the public.

Box 6.3
Historical Measures to Reduce Lead Exposure

Since the late 1970s, the U.S. government has taken specific actions to reduce lead exposures in the national population, largely by mandating that manufacturers eliminate lead from their products.

- In 1976, a total of 186.47 million kg of lead was used in gasoline in the United States. By 1983, this amount had dropped to 51.59 million kg; and by 1990, lead used in gasoline had been reduced to 0.47 million kg.
- The amount of lead used in soldered cans decreased markedly throughout the 1980s. In 1980, 47 percent of food and soft drink cans were lead soldered. By 1985, this figure had dropped to 14 percent; by 1990, only 0.85 percent of food and soft drink cans were lead soldered. As of November 1991, lead-soldered food or soft drink cans were no longer manufactured in the United States.
- In 1978, the amount of lead in lead-based paint was limited to less than 0.06 percent by weight.

These measures have been effective in reducing overall exposures to lead hazards. Still, lead-based paint remains a problem, predominantly in older, deteriorating housing stock. Eliminating the hazards of lead-based paint will require more than just removing lead from manufactured products; instead, it must be addressed as a holistic environmental justice concern, not simply a housing health or environmental issue. A new strategy that considers the economic and racial parameters of lead exposures and how to address them is needed to reduce lead hazards for all populations.

The executive order and its accompanying memorandum reinforce the need to look at how environmental hazards, and the government policies intended to address them, affect different groups within society. The purpose of the executive order is to heighten sensitivity to possible environmental inequities and to avert disproportionately high and adverse human health or environmental effects of government programs, policies, and activities on minority and low-income populations.

The executive order has made environmental justice a governmentwide initiative, implemented through a wide range of programs, including reducing lead exposures in minority children and preventing asthma deaths, initiating research about the cumulative effects of environmental exposures in minority and low-income populations, and conducting community outreach and education. A key component of all these programs is giving affected communities the information and voice they need to contribute effectively to the environmental decision-making process. Furthermore, the order acknowledges that developing solutions to local human health and environmental problems requires the combined efforts of federal, state, local, and tribal officials in collaboration with local communities, universities, and private enterprises.

Below are descriptions of some of the Administration's more recent accomplishments in response to the executive order; these provide a sample of some successful projects in which federal agencies are demonstrating progress toward environmental justice through new partnerships.

Reducing Lead Poisoning among Children

Largely as the result of federal efforts to remove lead from gasoline and soldered cans, blood lead levels in children have decreased significantly since the late 1970s (see Box 6.3). Between 1976 and 1991, the percentage of U.S. children aged 1 to 5 years with blood lead levels above 10 micrograms per dry liter (μg/dl) decreased from 88.2 percent to 8.9 percent. Despite these national efforts, however, lead poisoning remains one of the major health hazards to America's children under the age of 6. Approximately 1.7 million children still have blood lead levels exceeding the 10 μg/dl level designated as acceptable by the Centers for Disease Control and Prevention (CDC). The highest average blood lead levels are found among poor, urban, African American and Hispanic children (see Table 6.1). Often, these children live in older, deteriorating buildings and are exposed to lead in peeling paint and dust.

In response to this public health threat, several U.S. agencies have made reducing lead a top priority. Since 1992, the Department of Housing and Urban Development (HUD) has awarded a total of $279 million in grants to reduce lead hazards in low-income housing. The grant program supports activities such as public education (using local media and

Table 6.1

Percentage of U.S. Children Aged 1 to 5 Years with Blood Lead Levels 10 μg/dl or Greater by Race/Ethnicity, Income Level, and Urban Status: 1988-1991

Income/ Urban Status	Total	Non-Hispanic White	Non-Hispanic Black	Mexican American
Low income	16.3	9.8	28.4	8.8
Mid income	5.4	4.8	8.9	5.6
High income	4.0	4.3	5.8	0*
Central city ≥ 1 million	21.0	6.1*	36.7	17.0
Central city ≤ 1 million	16.4	8.1	22.5	9.5
Non-central city	5.8	5.2	11.2	7.0

*Estimate may be unstable due to small sample size.
Source: See References, Brody et al.

community-based organizations to ensure widespread dissemination in the neighborhoods where lead poisoning is most prevalent), paint inspection and risk assessments, low-cost interim controls, and lead abatement. In several innovative public housing projects, unemployed residents are being trained to become lead testing and abatement workers, thus incorporating economic development through job creation into the program.

In 1994, HUD and CDC jointly funded competitive grants to Chicago and Providence, Rhode Island, to develop comprehensive, innovative lead poisoning prevention programs in targeted low-income neighborhoods. Local residents are involved in the planning and implementation of these local strategies. The Environmental Protection Agency (EPA) has also established community-based partnerships with other federal agencies and cities, such as Boston and Washington, D.C., to develop lead abatement projects which involve training, inspections, and remediation of lead-contaminated housing. In Boston, the state, city, Roxbury Community College, and local community groups are training unemployed workers in a minority community in how to remove harmful lead paint from homes and bridges. Not only does this program encourage members in these communities to become involved in the restoration of their environment, it also gives minority contractors an opportunity to bid for state and city lead paint abatement contracts, providing much-needed jobs and income.

Seeking Equity in Siting Hazardous and Nonhazardous Facilities

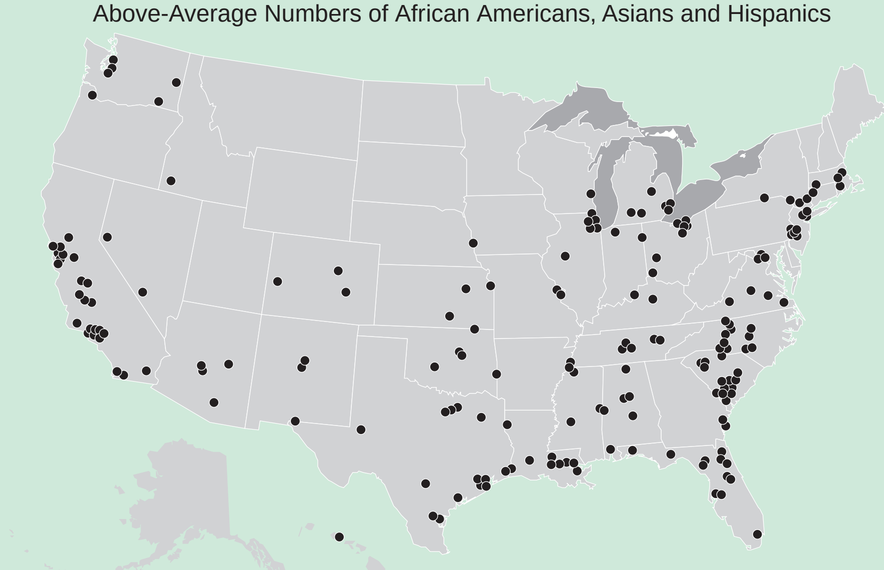
The environmental justice movement was catapulted to national attention because of public concern regarding the siting of hazardous waste facilities. In 1987, the United Church of Christ study, *Toxic Wastes and Race in the United States*, found that in 1980 the proportion of minorities in communities with a hazardous waste facility was nearly double that in communities without one. Where two or more such facilities were located, the proportion of minorities was more than triple. In 1994, the Center for Policy Alternatives, the National Association for the Advancement of Colored People, and the United Church of Christ released a second study, *Toxic Wastes and Race Revisited*, which found that in 1993 minorities were even more likely than whites to live in communities with commercial hazardous waste facilities than they were in 1980 (Figure 6.2).

However, other studies, such as one conducted by the Social and Demographic Research Institute of the University of Massachusetts-Amherst, found no consistent national level of association between the location of commercial hazardous waste facilities and the percentage of blacks and Hispanics residing nearby. Indeed, a June 1995 report issued by the General Accounting Office (GAO) reviews 10 separate studies addressing the demographics of people living near hazardous waste facilities and found that only 3 of these 10 studies concluded that minorities and low-income people were disproportionately represented in these areas. Two studies concluded that there was no significant association between the location of the sites and minority populations; three studies were split as to whether minorities were disproportionately affected by the location of waste facilities; two drew no conclusions from the data. The GAO report notes, however, that all of the studies were limited by study design and underlying assumptions, data availability, lack of time-series analysis, and insufficient information on actual human exposures to harmful materials.

Despite the current lack of consensus among studies, the Administration has made it clear that it is important to be aware of the possibility that some communities may be faced with the siting of multiple waste facilities, and that these facilities are a concern for community residents. Thus, addressing community concerns and reevaluating procedures by which industries and waste facilities are sited should be among the nation's top environmental justice priorities.

For example, EPA has been working with the city of Chester, Pennsylvania, to address concerns about waste facility siting. The city has one of the highest concentrations of industrial facilities in the state and hosts a number of waste processing plants and two oil refineries. All solid waste from Delaware County is incinerated in Chester, and at least 85 percent of the county's raw sewage and associated sludge is treated there as well. Plans to build a large infectious medical

Figure 6.2 Hazardous Waste Facilities
Areas Containing Commercial Hazardous Waste Facilities and
Above-Average Numbers of African Americans, Asians and Hispanics



Source: Center for Policy Alternatives, NAACP, and United Church of Christ Commission for Racial Justice.

waste facility were also recently approved. Many of these sites are located close to residential neighborhoods. In fact, a cluster of waste treatment facilities has been permitted within 100 feet of approximately 200 Chester residences.

Residents in Chester have long argued that they house a disproportionate share of the area's wastes and complain of frequent illnesses. Among all Pennsylvania cities, Chester has the highest infant mortality rate, the lowest birth rate, and one of the highest death rates due to certain malignant tumors. In response to community concerns, EPA's regional office initiated two studies to assess environmental regulatory and pollution issues in the city of Chester. The first 30-day study focused on enforcement actions; it just recently issued field citations to a number of underground storage tanks in the neighborhood. In addition, a 180-day study, conducted by a team of toxicologists working with state and local officials, is assessing all available environmental data and human exposure pathways using geographical information systems mapping.

In Brooklyn's Greenpoint and Williamsburg communities, minority and low-income residents have long complained that their neighborhoods appear to be the city's dumping grounds. These two communities have a significant concentration of factories, solid waste transfer stations, hazardous waste storage facilities, sewage treatment plants, and incinerators. The New York Department of Environmental Protection, in conjunction with several EPA headquarters offices and local community groups, formed a partnership for environmental protection. The partnership identified the community's top priority as being able to monitor the waste facilities to ensure that industries meet environmental standards. To this end, "environmental scorecards" were developed for community members to prepare compliance profiles of local industrial and municipal facilities. Using the data from the scorecards, the city has developed new enforcement strategies which are important steps toward environmental cleanup.

Reducing Risks from Contaminated Fish Consumption

Some minorities are more likely to be exposed to certain chemical contaminants in the food supply due to dietary differences. For example, Native Americans, Chinese, Vietnamese, and Laotian populations may consume, on average, greater quantities of fish as part of their daily diet. EPA has historically set standards based on national averages of fish consumption, not accounting for the fact that certain cultures may rely on fish for a greater share of their protein. But this orientation is changing. A draft EPA notice for a water permit to discharge effluent containing dioxin from a paper and pulp facility into the Penobscot River noted that the Penobscot Indian Nation had a fish consumption rate nearly twice the national average. These populations thus may be at a much greater health risk from dioxin in fish.

The Administration is taking action to provide greater public health protection for those populations that, for cultural or economic reasons, consume greater quantities of fish. As part of regular procedures to protect human health, states issue consumption advisories that inform the public that high concentrations of chemical contaminants have been found in local fish and wildlife. A complete database of these advisories, the National Listing of Fish and Wildlife Consumption Advisories, is maintained by EPA's Office of Water to help water quality officials and the public identify where fish contamination is an issue of concern. (See Chapter 5, “Environmental Aspects of Human Health.”)

More recently, as required by the executive order, federal agencies have begun to collect information on food consumption patterns among those populations that rely on fish and/or wildlife for subsistence. EPA and the Departments of Agriculture, Defense (DOD), Energy (DOE), and the Interior (DOI) have all launched efforts to study this issue and improve communication with populations at risk. For instance, in the Columbia River Basin—an area with known dioxin contamination—a fish consumption study is under way of the Umatilla, Nez Perce, Yakama, and Warm Spring Tribes. Other programs include research on the effects of Native American cooking practices on mercury concentrations in various fish species prepared for consumption. These studies and the data and information gathered through them could greatly improve the development of more relevant and protective water quality criteria for all populations, regardless of income or race/ethnicity.

Revitalizing "Brownfields"

Throughout the United States, communities are faced with increasing numbers of "brownfields"—empty buildings on contaminated lots that no one wants to develop. While the exact scale of the brownfield problem is unknown, EPA estimates that the number of contaminated sites ranges from 100,000 to 500,000, of which 27 percent are located in urban areas. In addition to posing potential health hazards, brownfields contribute to the poverty in these communities by impeding economic revitalization.

On March 11, 1996, the President announced a brownfield tax incentive that would encourage the cleanup and redevelopment of abandoned or underused contaminated properties in cities and rural areas across the country. Under the President’s proposal, environmental cleanup costs would be fully deducted in the year in which they were incurred. The $2 billion incentive—fully paid for in the President's seven-year balanced budget—is expected to leverage $10 billion in private investment, returning potentially 30,000 brownfields to productive use. The tax incentive would be available in existing EPA brownfield pilot areas, in areas with a poverty rate of 20 percent or more, in adjacent industrial or commercial areas, and in Empowerment Zones and Enterprise Communities.

The President's announcement builds on the momentum of EPA's Brownfields Action Agenda unveiled in January 1995. EPA has launched a major initiative to encourage cleanup and revitalization of idle, abandoned, or underused industrial or commercial facilities where opportunities for redevelopment are complicated by existing or potential environmental contamination. The Brownfields Economic Redevelopment Initiative is designed to help states, communities, and private enterprises work together to prevent, assess, safely clean up, and sustainably reuse brownfields. In 1995--96, EPA aimed to fund at least 50 brownfield pilots to support creative two-year explorations and demonstrations of brownfield solutions. In addition, the agency's Sustainable Industries Initiative supports environmentally safe and economically sustainable industries wanting to develop in these areas.

Other agencies are also taking an active role in addressing the brownfield problem. The Department of Commerce, through its Economic Development Administration, is working to ensure that sound environmental and economic development principles are followed and that assessment and cleanup activities are linked with economic redevelopment opportunities. The Department of Labor is providing important resources to leverage job training activities in brownfield pilot cities. EPA and HUD are working together on brownfield redevelopment opportunities on pilots in Empowerment Zones and Enterprise Communities. In addition, an Interagency Task Force on Brownfields was established to stimulate the creation of additional partnerships to provide communities with assistance on key issues such as community involvement, workforce development, and health risks.

Some efforts are already demonstrating some measure of success. In Cleveland, the percentage of land made up of vacant parcels increased from 9 percent in 1977 to 12.5 percent in 1987. Responding to this challenge, a coalition of businesses, community development corporations, Cuyahoga County officials, neighborhood groups, and other citizens began to work together to tackle the brownfield problem. In 1992, the Cuyahoga County Planning Commission convened a symposium to discuss brownfield redevelopment strategies. The following year, a multistakeholder Brownfield Working Group analyzed the problem of brownfields and made recommendations to the planning commission. Since then, Cleveland has received funding from EPA for two demonstration projects. The planning commission is using an EPA grant to streamline the remediation and redevelopment process of at least three brownfield sites. As part of the project, the commission is to identify financial and regulatory barriers and recommend ways to remedy them. So far, the project has already produced $3.2 million in new private investment, including the establishment of a new distribution center that has generated more than 170 new jobs in the area.

Improving Information

The Administration has also stressed the need to gather data on exposure and risk levels so as to be able to determine whether there are disproportionately high and adverse human health effects in different population subgroups. To date, information about the cause-and-effect relationships of many pollutants are still unclear. Furthermore, questions about multiple exposures and how different chemicals may be working synergistically to affect human health have not been answered. For example, do current health and environmental standards protect populations exposed to multiple hazards? What new approaches, criteria, and programs are needed to ensure that they do?

New technologies and advancements in science are helping answer some of these questions. For example, geographical information systems are being used to combine land use, population characteristics, and the location of environmental hazards in one map. The Census Bureau, EPA, Nuclear Regulatory Commission, and other agencies have worked together to develop LandView II, a computerized spatial display of information that will help federal agencies analyze data about the demographic composition of areas surrounding federal facilities. DOE has drafted a tutorial for users of LandView II in characterizing populations surrounding the facilities.

In 1994, President Clinton issued Executive Order 12906, Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure (NSDI). The order outlines a number of federal agency actions to foster development of NSDI, which is designed to provide a foundation for more efficient collection, management, and use of data. The order also reinforces the Federal Geographic Data Committee's leadership role in directing federal coordination and federal-state-local cooperation in sharing spatial data. The goal of the executive order is to achieve better access to higher quality geospatial data at lower costs and to make those data available to all interested parties.

The Administration is also encouraging interagency projects that will help identify and reduce the impacts of environmental hazards on human health. One of these projects, the Mississippi Delta Project, is the largest geographic-specific public health initiative ever mounted to study the association between hazardous environmental exposure and health effects in minority and low-income communities. Government agencies participating include the Agency for Toxic Substances and Disease Registry, CDC, EPA, and the National Institutes of Health. In addition, the project will rely on workgroups that include representatives from government, state health and environmental agencies, local universities, and community-based organizations. The project covers 219 counties in seven states (Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee), and more than 8.3 million people. The Mississippi Delta area has a high concentration of transportation routes, heavy and petrochemical industries, waste sites, and other facilities; yet the health impacts of these facilities—especially on minority and low-income communities—are not well-known. In Phase 1 of this three-phased project, the study will attempt to identify the key environmental hazards that might affect high-risk communities as well as evaluate the public health impact on high-exposure populations. Phases 2 and 3 will focus on identifying needs and developing and implementing successful interventions to protect human health.

As in all its activities, the Administration is making sure to include communities in the design and implementation of studies to gather information about health impacts. In 1994, an agencywide symposium was held on Health Research and Needs to Ensure Environmental Justice. The symposium was a collaborative project involving the public in identifying research programs needed to fill data gaps in critical areas of health, exposure, prevention, and intervention. The cosponsors of the conference included DOE and the Department of Health and Human Services' National Institute of Environmental Health Sciences, the National Institute of Occupational Health and Safety, the Agency for Toxic Substances and Disease Registry, the National Center for Health, and EPA. Over 1,300 people—many from local communities around the country—attended a series of sessions dealing with respiratory diseases, lead poisoning, hazardous waste problems, pesticides exposure, workplace hazards, and Superfund-related problems.

Empowering Communities

Historically, minority and low-income groups have not been involved in environmental decisionmaking, and few programs have been designed to reach out to these populations. One of the major accomplishments, and continuing goals, of the Administration is to level the playing field and provide communities with the information they need in order to be active participants in environmental decisionmaking processes. Involving stakeholders and developing partnerships with local groups is critical to achieving environmental protection for all communities.

Public meetings have proven to be an effective forum for increasing community participation in environmental decisionmaking. Executive Order 12898 explicitly states that the Interagency Working Group should hold public meetings to receive comments, questions, and recommendations regarding environmental justice issues. On January 20, 1995, a public meeting on environmental justice was conducted at Clark Atlanta University in Atlanta, Georgia. Over 350 people, including representatives from 10 federal agencies, attended the day-long meeting. In addition, an estimated 1,000 people watched the evening session, which was televised via satellite to approximately 40 locations across the nation including Puerto Rico. The purpose of the meeting was to provide an opportunity for the public to share concerns and recommend changes in the agencies' environmental justice strategies.

In addition to public meetings, the Administration has made a wide variety of information available electronically. For example, through the Internet, the public can now directly access databases including the Toxics Release Inventory, scientific reports, and information regarding current major announcements. EPA's Office of Pollution Prevention and Toxics is developing a set of user-friendly computerized spatial analysis tools so that communities can analyze their proximity to possible environmental hazards. The Administration has begun to address language differences as well, and publishes many environmental and other policy documents in multiple languages. EPA's Office of Radiation and Indoor Air, for example, published meeting and hearing notices in Spanish-language newspapers and has provided Spanish-language materials and a translator at all public meetings and hearings. The National Estuary Program has produced multilingual signs and brochures alerting non-English-speaking groups, such as Chinese, Vietnamese, and Laotian populations, of the dangers of eating contaminated fish. The Department of Transportation is taking greater care to involve communities in decisions about highway and other road sitings.

The case of McFarland, California, shows that communities can often find innovative ways to use existing legislation when provided with information about policies relevant to environment and health. A small, low-income, mostly Hispanic, agricultural town, McFarland's residents have been concerned about increased incidences of cancers; fetal deaths; low birth weights; and a number of health effects perhaps attributable to unprotected exposure to pesticides, arsenic, lead, and other heavy metals. A health assessment conducted by the California Department of Health and Human Services from 1984 to 1991 indicated no significant increased levels of cancer but recommended that additional studies were needed to evaluate air and dust pathway exposures to pesticides.

In 1996, the citizens of McFarland petitioned EPA under Superfund and Executive Order 12898 to reinvestigate the continued health problems. Although pesticide concerns have not generally been addressed under Superfund legislation, residents contended that the pesticide dust drift has created a hazardous waste site. EPA Region 9 is recommending that the agency grant the petitioners' request for preliminary assessment and investigation under Superfund and that a multimedia approach be used to investigate all exposure pathways, including drinking water, soil, and indoor and outdoor air exposures. EPA is also developing community involvement plans which include interviews with residents to record concerns; community input to EPA sampling plans; local information repository, fact sheets, and community meetings; and identification of potential funding sources for community groups to organize outreach efforts.

Enforcing Environmental and Civil Rights Laws

The memorandum that accompanied Executive Order 12898 states that "application of existing statutory provisions is an important part of this Administration's efforts to prevent those minority communities and low-income communities from being subject to disproportionately high and adverse environmental effects." Since the issuance of the executive order, the Department of Justice (DOJ) has worked with EPA and other federal agencies to fulfill this mandate by enforcing environmental and civil rights laws in a manner that helps ensure that all people live in a safe and healthy environment.

For example, as part of an effort to address recurring environmental problems such as illegal dumping, the U.S. Attorney's Office for the District of Columbia and DOJ's Environment and Natural Resources Division brought criminal action against a company president and employee for illegally disposing of waste chemicals in a residential dumpster of a minority, low-income public housing complex in the District of Columbia. Both defendants pleaded guilty to one felony count under the Resource Conservation and Recovery Act. In the U.S. Attorney's Office in Philadelphia, a local subsidiary of a St. Louis corporation pleaded guilty to violating the Clean Air Act by illegally dumping debris contaminated with asbestos onto a private lot located in a low-income neighborhood in southwest Philadelphia. The respondent agreed to a $1 million remediation plan.

Where possible, DOJ has undertaken efforts to consult with and inform communities of environmental enforcement-related matters.

FUTURE CHALLENGES

Throughout the federal government, efforts to integrate environmental justice considerations into federally conducted and supported programs continue, and many new projects are only just beginning. One of the goals for the future is to increase the understanding of how environmental exposures affect human health, especially among minority and low-income communities. In particular, understanding the risks posed by multiple industrial facilities, cumulative and synergistic effects, and multiple and different pathways of exposure will be critical in quantifying the disproportionate burden of environmental hazards on the health and well-being of minority and low-income populations. EPA's Office of Policy, Planning and Evaluation has begun work on a cumulative exposure project which will assess cumulative exposure from air toxics; pollutants in drinking water; and pollutants in food across populations, communities, and geographic areas. The project's goal is to help focus environmental policies on those communities and populations with the greatest cumulative exposures and help aim resources at the most important sources and pollutants.

A second goal will be for all federal agencies to work toward integrating environmental justice concerns into the NEPA process, as directed by the President's accompanying memorandum to Executive Order 12898. The Council on Environmental Quality is currently drafting guidance for agencies on how to incorporate environmental justice concerns into the NEPA process. DOD, DOE, DOI, and EPA have also been taking steps toward this goal. For example, DOI issued the Environmental Compliance Memoranda on Environmental Justice and Trust Resources, which revises NEPA guidelines to require environmental justice consideration within the program offices. Accordingly, in Olympic National Park, Washington, DOI incorporated environmental considerations in its NEPA process and developed the Elwha River ecosystem restoration project. The National Park Service worked closely with the Lower Elwha S'Klallam Tribe in developing two environmental impact statements and by creating jobs for tribal members. Restoration of the Elwha River ecosystem improved the native fisheries, primarily for salmon fisheries, and improved recreational use of the park. The Air Force developed a model for environmental justice analysis and used it as part of the development of their base closure process. This model has been inserted into the environmental impact statements for two base disposal actions.

CONCLUSION

While much work remains to be done, the Administration has made important first steps toward raising awareness about environmental justice issues and taking appropriate actions so that no one—regardless of race, color, national origin, or income—suffers disproportionately from adverse human health or environmental effects; and that all people live in clean, healthy, and sustainable communities. Furthermore, the Administration is committed to ensuring that those who must live with environmental decisions—community residents; environmental groups; state, tribal, and local governments; businesses—are given every opportunity to participate in the making of those decisions.

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CHAPTER SEVEN

Ecosystems

Ecosystems may be thought of in structural terms—as a systematic collection of species and processes that have a recognizable form, such as tallgrass prairies, coastal salt marshes, redwood forests, or high desert. Ecosystems sometimes are described as geographically defined ecological units, consisting of groupings of plants and animals and their surrounding environment, with characteristics shared in common. Watersheds, for example, are useful representations of ecosystems.

In a 1995 report, Defenders of Wildlife describes ecosystems as "a characteristic community of interdependent plants, animals and microorganisms associated with particular kinds of soil, temperature, rainfall and disturbance patterns." To identify at-risk ecosystems (see Figure 7.1), Defenders of Wildlife categorizes plant-animal communities in an easily recognizable manner, e.g., grasslands, forests, and wetlands.

The Interagency Ecosystem Management Task Force defined an ecosystem as "an interconnected community of living things, including humans, and the physical environment within which they interact." The task force did not, however, identify specific types of ecosystems, nor did it delineate ecosystem boundaries on a map. Instead, it acknowledged that geographic boundaries appropriate for addressing one issue may not work for another. It concluded that, in most ecosystem protection efforts, a practical definition of the ecosystem can be determined by the participants themselves. The boundaries should have an ecological basis, and should encompass the problem for which a solution is being sought.

Ecosystems and ecological communities are the underpinning for the health, vitality, and diversity of all of the individual species that inhabit the ecosystems. Conservation efforts must be applied with broader scope than traditional species-by-species focus allows.

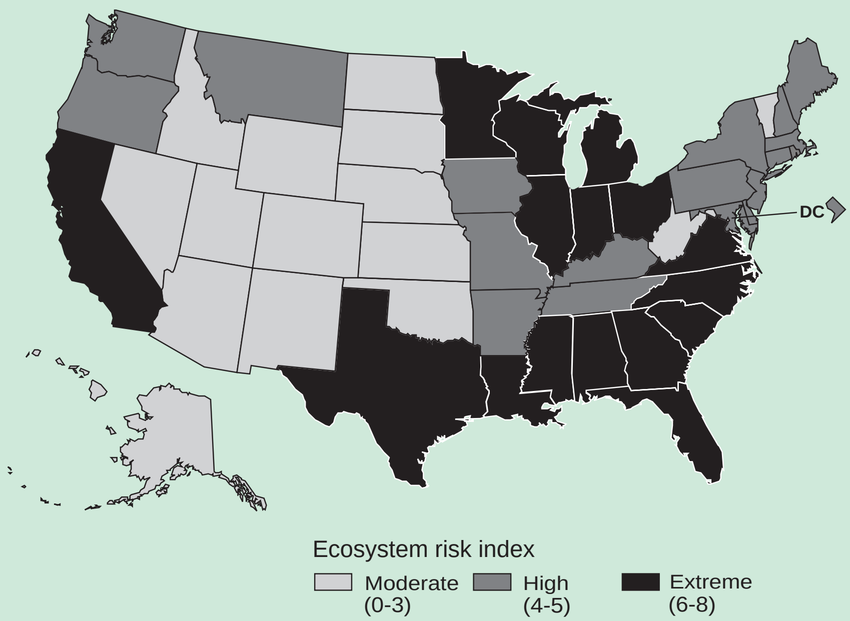
BACKGROUND

Categories and Current Status of Ecosystems

The National Biological Service of the Interior Department organizes ecosystems into four broad categories: terrestrial, aquatic, coastal and marine, and riparian. The following paragraphs summarize the current status of these ecosystems.

- Terrestrial Ecosystems. Change has been a natural part of terrestrial ecosystems throughout history; in recent

Figure 7.1 Endangered Ecosystems



Source: R.E. Noss and R.L. Peters, *Endangered Ecosystems: A Status Report on America's Vanishing Habitat and Wildlife* (Defenders of Wildlife, Washington, DC, 1995).

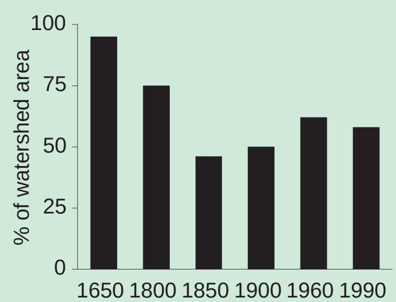
Note: The ecosystem risk index is a scaled score reflecting how many of the 21 most-endangered ecosystems occur in each state. Values range from 0 to 8, with 8 signifying the greatest risk.

years, human intervention has been the principal agent of change. Disease, fire suppression, pollution, conversions to other uses, exotic species, noxious weeds, harvesting activities such as logging, and global climate change are among the numerous variables that can affect terrestrial ecosystems.

• Aquatic Ecosystems. Aquatic ecosystems have been severely degraded in the last century in the United States. Natural aquatic systems have been altered for transportation, diverted for agricultural and municipal needs, straightened, dammed, and polluted.

• Coastal and Marine Ecosystems. The quantity and health of the nation's coastal and marine resources have declined over time at the species,

Figure 7.2 Chesapeake Bay Watershed Forests, 1650-1990



Source: Chesapeake Bay Program.

community, and ecosystem levels. Urbanization, shoreline modification, overfishing, high-density recreational use, and other human activities have been the major factors contributing to this decline. (See Figure 7.2 for an example of this phenomenon.)

- Riparian Ecosystems. Stream bank and floodplain ecosystems, particularly in the West, have been greatly altered over the last 200 years, largely as a result of water development projects, clearing of trees, overgrazing by livestock, agricultural conversion, urban growth, and invasions of non-native plants. (See Figure 7.3 for an example of alteration in this ecosystem category over time.)

Assessing Ecosystems

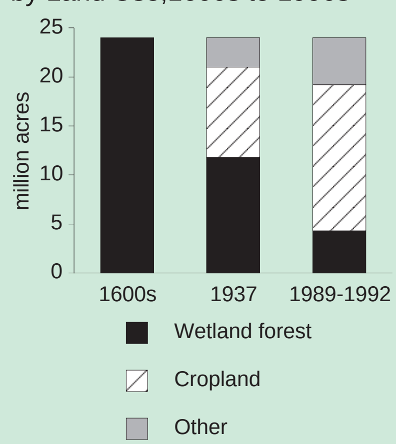
Within these four broad categories are many smaller ecological units. The relative condition of these units has been examined recently by Defenders of Wildlife, the World Wildlife Fund, and The Nature Conservancy.

In its 1995 report, Defenders of Wildlife listed the 21 "most-endangered" ecosystems in the United States (see Figure 7.1). The three highest ranking ecosystems were the South Florida landscape, Southern Appalachian spruce-fir forest, and longleaf pine forest and savanna. The sources of threat to these ecosystem types vary, ranging from human population growth in Florida to acid fog and an insect pest in the Southern Appalachians; the longleaf pine and savanna communities have been replaced by agriculture, tree farms, and by the invasion of hardwood forests (Table 7.1).

The ranking used by Defenders of Wildlife was based on four criteria: decline in original area since European settlement, present area (rarity), imminence of threat, and number of federally listed threatened and endangered species. But the report acknowledges that there may be a need to supplement risk with other criteria, including ecological value, scientific value, and the economic and political feasibility of conservation (Figure 7.4).

The World Wildlife Fund is also working to identify high-priority ecoregions in the United States; it is doing so as part of a North American conservation assessment. This project seeks to set priorities on national, continental, and global scales. It considers not only the conservation status but also the biological distinc-

Figure 7.3 LMRAP Bottomlands, by Land Use,1600s to 1990s



Source: U.S. Fish and Wildlife Service.
Note: LMRAP = Lower Mississippi River Alluvial Plain.

Table 7.1

The 21 Most Endangered Ecosystems of the United States

South Florida Landscape
Southern Appalachian Spruce-Fir Forest
Longleaf Pine Forest and Savanna
Eastern Grasslands, Savannas, and Barrens
Northwestern Grasslands and Savannas
California Native Grasslands
Coastal Communities in the Lower 48 States and Hawaii
Southwestern Riparian Forests
Southern California Coastal Sage Shrub
Hawaiian Dry Forest
Large Streams and RIvers in the Lower 48 States and Hawaii
Cave and Karst Systems
Tallgrass Prairie
California Riparian Forests and Wetlands
Florida Scrub
Ancient Eastern Deciduous Forest
Ancient Forest of Pacific Northwest
Ancient Red and White Pine Forest, Great Lakes States
Ancient Ponderosa Pine Forest
Midwestern Wetlands
Southern Forested Wetlands

Source: Reed F Noss and Robert L. Peters, *Endangered Ecosystems: A Status Report on Americas Vanishing Habitat and Wildlife* (Defenders of Wildlife, Washington, DC, 1995).

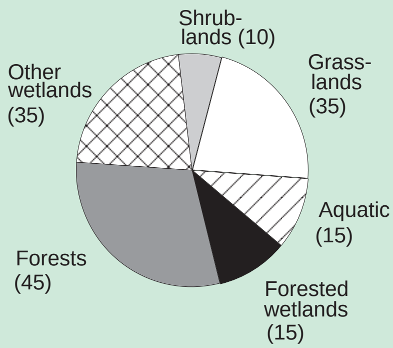
tiveness of ecoregions. The World Wildlife Fund's biological distinctiveness criteria include species richness, endemism, presence of rare ecological and evolutionary phenomena, and rarity of habitat type. Conservation status criteria include the percentage of native original habitat lost, presence of large blocks of original habitat, degree of habitat fragmentation and degradation, and degree of protection. The World Wildlife Fund has preliminarily identified 19 high-priority ecoregions for terrestrial biodiversity conservation and 7 areas for freshwater biodiversity conservation.

Vegetation structure and plant species composition are being used by The Nature Conservancy and Network of

South Florida Landscape. This vanishing habitat is one of America's 21 most-endangered ecosystems.

Photo Credit: National Park Service

Figure 7.4 Ecosystems With Losses of 70% of Original Area



Source: Noss, et al. *Endangered Ecosystems of the United States: A Preliminary Assessment of Loss and Degradation* (NBS, Washington, DC, 1995).

Note: Number of ecosystems are in parenthesis.

Natural Heritage Programs in collaboration with the Federal Geographic Data Committee to develop a framework for the classification of ecological communities in the United States. Approximately 4,000 ecological communities have been identified using this framework. The conservation status of each is being assessed based on rarity and threat.

More specifically, within the lower 48 states, 371 globally rare terrestrial vegetated communities have been identified and described. An additional 300 such rare communities are anticipated to be documented through this process. More than half of these rare or threatened types occur in the West (Figure 7.5). Most are in the forest class, followed by the woodland, shrubland, and herbaceous classes. The Nature Conservancy cites fire suppression as having pushed many forest types to this level of rarity; flood-control and water diversion projects have similarly affected many of the forest and woodland riparian types. Herbaceous communities have been adversely affected by overgrazing and—to a lesser degree—direct agricultural conversion.

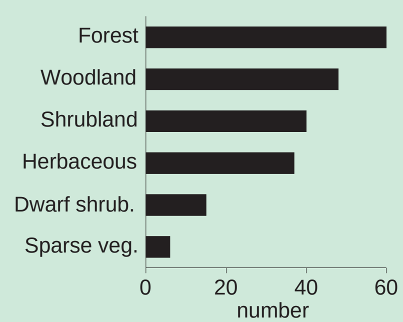
WHAT CAN BE DONE?

Collaboration Is Key

Protecting ecosystems and ecoregions is not something any single landowner can accomplish alone, since in most cases these areas may encompass many different political jurisdictions and patterns of land ownership. An important part of any ecosystem protection strategy, therefore, is to bring together all affected parties to build new cooperative agreements. We already can point to a few models, such as the cooperative effort to improve conditions in the Chesapeake Bay.

Cooperative ecosystem efforts are supported and enhanced by advances in

Figure 7.5 Rare Terrestrial Communities, Western Region, 1994



Source: Grossman, et al., *Rare Plant Communities of the Conterminous United States: An Initial Survey* (The Nature Conservancy, Arlington, VA, 1995).

technology. When the National Environmental Policy Act was passed in 1969, only a few rudimentary maps were available to facilitate broad-scale analysis of large expanses of land. Most map overlays were done manually with transparent sheets. There were no easy ways to integrate, analyze, and compare the enormous volumes of data needed for large-scale analysis. With the advent of modern computers, data systems, geographic information systems, and networks, the technological means are now widely available to support the partnerships that are required for evaluation and cooperative management of large land areas. Science and management, so often strangers, can now be effective partners.

The Ecosystem Approach

The Clinton Administration has taken a strong stand in favor of an *ecosystem approach* to resource management in concert with sustainable development. This stance has its roots in the Vice President's National Performance Review, which called for federal government agencies to adopt "a proactive approach to ensuring a sustainable economy and a sustainable environment through ecosystem management."

An Interagency Ecosystem Management Task Force was established in August 1993. One of its first accomplishments was to establish a goal for the ecosystem approach:

> *To restore and sustain the health, productivity, and biological diversity of ecosystems and the overall quality of life through a natural resource management approach that is fully integrated with social and economic goals.*

As articulated by the task force, the ecosystem approach emphasizes the following:

- Ensure that all relevant and identifiable ecological and economic consequences (long term as well as short term) are considered.
- Improve coordination among federal agencies.
- Form partnerships among federal, state, and local governments; Indian tribes; landowners; and other stakeholders.
- Improve communication with the general public.
- Carry out federal responsibilities more efficiently and cost effectively.
- Use the best science.
- Improve information and data management.
- Adjust management direction as new information becomes available.

The task force conducted case studies to learn about ecosystem efforts, identify barriers to implementing the ecosystem approach, and identify ways the federal government could help overcome barriers. Seven areas were used as case studies: Anacostia River watershed, Coastal Louisiana, Great Lakes Basin, Pacific Northwest forests, Prince William Sound, South Florida, and the Southern Appalachians. The results of these case studies have been published in three volumes.

To support the science underpinnings of the ecosystem approach, the federal interagency Committee on Environment and Natural Resources is developing science-based principles for ecosystem management and a predicting ecological impacts of environmental change. This will require that federal research and development programs take a broader, ecosystem approach, that the approach be multidisciplinary, and that research increase our understanding of the structure, function, and dynamics of ecological processes, as well as the consequences of societal action or inaction.

Barriers to the Ecosystem Approach

The Interagency Ecosystem Management Task Force identified several persistent barriers that federal agencies face in implementing the ecosystem approach and in participating in ecosystem partnership efforts initiated by others.

1. **Federal Agency Coordination.** A coordinated and comprehensive framework is essential to implementing the ecosystem approach. Federal resource management has traditionally been characterized by specific missions, rigidly stratified and specialized organizational structures, and the subdivision of problems into narrowly defined tasks.

2. **Partnerships with Nonfederal Stakeholders.** The ecosystem approach requires active partnerships and collaboration with nonfederal parties, particularly state, local, and tribal governments; neighboring landowners; nongovernmental organizations; and universities. Although partnerships between the federal government and nonfederal entities are not uncommon, agencies need to strengthen their own outreach programs and improve the ability of nonfederal entities to participate. Together, they must also project and articulate a desired ecosystem outcome with a shared vision for the future.

3. **Communication between Federal Agencies and the Public.** Current outreach activities must be strengthened. Coordination with the public is generally perceived to be secondary to the "normal" work of the agencies. Regional offices typically lack specialized staff with experience in working with the public. Most federal employees who should be interacting with the public are not trained in the skills needed for the public participation aspects of the ecosystem approach—educating the public, motivating people to become involved, facilitating public discussion, building consensus, and resolving conflict.

4. **Resource Allocation and Management.** Agency coordination in ecosystem efforts can be improved by recognizing the interdependency of agency budgets. The ability of each agency to take an ecosystem approach is affected by its ability to budget for long-term goals, organize around and fund interdisciplinary activities, and quickly modify programs in response to new information. Agency budget priorities and structures, however, often reflect

narrow, program-specific perspectives; are driven by immediate concerns; and are sometimes linked primarily to the production of tangible outputs such as commodities. Furthermore, Congress makes funding decisions on an agency-by-agency basis, making it difficult to coordinate the funding of interagency programs.

5. Knowledge Base and the Role of Science. The existing *information* base—what we know about what exists in a place—and the existing *knowledge* base—how well we understand how ecological and economic components function—are both inadequate for many systemwide ecosystem analyses. The linkage between scientists and managers, and between natural resource agencies and other agencies and entities, is essential in establishing a shared vision of desired ecosystem conditions, specifying how the vision can be achieved, and monitoring and measuring progress toward goals.

6. Information and Data Management. No single entity has the resources or mandate to develop all relevant information on any ecosystem—or even the capability for locating and accessing information pertinent to an ecosystem that is available from other sources. Some agencies are sources for ecological data, others for social and economic data. Managers must have coherent and complete information from all sources in order to make reasonable decisions on actions that affect the ecosystem.

7. Flexibility for Adaptive Management. Adaptive management requires a willingness to undertake prudent experimentation consistent with sound scientific and economic principles, and to accept occasional failures. This contrasts with the strongly risk-averse nature of most agencies and managers. Agencies are hampered in their efforts to adapt management practices to new circumstances. As a result, innovation is discouraged, new knowledge is applied too slowly, and inefficiencies persist to the detriment of both resources and communities.

The Federal Advisory Committee Act. In addition, the Federal Advisory Committee Act (FACA) has caused some problems in implementing the ecosystem approach. FACA was passed by Congress in 1972 to control the growth and operation of what was perceived to be a proliferation of advisory groups of all kinds. The act was designed to eliminate unnecessary advisory committees, limit the establishment of new ones, and hold existing committees to uniform standards and procedures.

In most of the seven ecosystem case studies, FACA was identified as an impediment to adopting an ecosystem approach. Interviewees reported, for example, that citizen groups—even those already established—do not meet because of confusion over FACA requirements. Furthermore, agencies resist forming groups that are necessary for planning, especially in the scientific area, because the burden of FACA compliance is greater than the benefit gained. In general, there was a great deal of confusion over what kinds of communication were allowed with whom, and the extent to which these communications were regulated by FACA.

Because stakeholder participation in government decisionmaking and improved coordination among federal, state, and local decisionmakers are so crucial to the ecosystem approach, the issue of FACA compliance is likely to arise with increasing frequency as federal managers adopt an ecosystem approach.

Breaking Down and Getting Around the Barriers. In most cases, the Interagency Ecosystem Management Task Force did not choose to recommend changes to laws. It does, however, present a series of recommendations in its report to resolve many of problems identified. Task force member agencies also have signed a memorandum of understanding committing their agencies to work toward implementing the recommendations.

Regarding FACA, the task force recommended that the Administration revise its policies to ensure that federal land managers have adequate latitude to form advisory committees in certain situations. It also noted that FACA has been amended to create exemptions for state and tribal consultations (Unfunded Mandates Reform Act, Title II, Section 204, signed by the President on March 22, 1995). Additionally, in its three-volume report, the task force recommended that interagency training programs be established that help government employees understand how to maximize communication and consultation with stakeholders and the public within the context of FACA; and discusses some “do’s and don’ts” regarding FACA.

WHAT IS BEING DONE?

The Ecosystem Approach in Action

One of the real values of the ecosystem approach is that it brings together the parties that have an interest in a particular region, regardless of what side they are on. All too often, people who care about the region’s destiny have simply never sat together and talked about where the region was going, what changes they would like to see, or what tools were available to shape the future. Yet, people often live in particular areas precisely because its ecological amenities provide a special quality of life. The ecosystem approach provides a forum for working with others in the region to ensure the conservation of important ecological values.

Different groups bring varying resources to the table. Land managers have the ability to manipulate habitat and land resources. Regulatory agencies have authorities derived from their statutory mandates. Local governments have zoning authority to influence development patterns and practices. Private landowners have their own set of incentives and opportunities. Other groups rely on the power of public opinion to influence a result. The ecosystem approach requires advocates of many positions to seek common ground and work together on areas of common agreement. The

Riparian Zone Restoration. An ecosystem approach to regional resource management can bring about powerful results when all stakeholders seek common ground and work together on areas of common agreement.

Photo Credit:
U.S. Department of the Interior

Box 7.1
The Ecosystem Approach in the Pacific Northwest

In the Pacific Northwest, we have, over the past century, acted as though cutting some of the oldest trees on earth and suppressing fires would not have a long-term effect on the ability of forests to continue to produce large amounts of harvestable timber—-or that activities associated with timber harvests would not compound the problem for salmon and other anadromous fish. The economic consequences of our actions have been profound. A number of salmon stocks are now on the endangered species list. Forests have fire, insect, and disease problems and cannot sustain historical levels of timber harvest. Individuals, companies, and local economies have suffered the effects of boom-and-bust cycles, with no long-term stability.

The Clinton Administration has established an ecosystem effort in the Pacific Northwest forests based on five principles: (1) protecting the long-term sustainability of forests, wildlife, and waterways; (2) never forgetting the human and economic dimensions of the problems; (3) making efforts that are scientifically sound, ecologically credible, and legally responsible; (4) producing a predictable and sustainable level of timber sales and nontimber resources that will not degrade or destroy the environment; and (5) making the federal government work together with and for the people.

The Administration's Forest Plan represents an entirely new way of doing business. It features an ecosystem-based management plan for 25 million acres of federal land in the region, an economic assistance plan, and a blueprint for improved agency coordination. Such a comprehensive approach was probably the only viable alternative for breaking the impasse caused by years of competition and conflict in the region. In response to legal challenges, Judge Dwyer pointed out the unprecedented nature of the Administration's effort and noted: "Given the current condition of the forests, there is no way the agencies could comply with the environmental laws without planning on an ecosystem basis."

results of their efforts can be simple and powerful (see Box 7.1).

Habitat Conservation Plans

The Administration has also used flexibilities written into the Endangered Species Act to promote conservation in the context of broader ecosystems. This has been accomplished by using habitat conservation plans (HCPs) instead of taking the traditional species-by-species approach. Increasingly, HCPs originally intended to deal with a single listed species are being expanded to include other rare or declining species and the habitat that supports them all.

The issues involved in HCPs can be technical and legally complex. State and local governments are often involved in HCP planning and implementation. HCPs provide a way of allowing economic use of private lands while conserving endangered species. Under the "no surprises" policy of the Secretary of the Interior, landowners who develop HCPs will not be subject to later demands for more money or land to conserve those species, even if circumstances change. "A deal is a deal," and development can proceed without the prospect of additional mitigation requirements for covered species. Thus, the use of HCPs helps minimize socioeconomic effects, ensures fair treatment for landowners, and strengthens partnerships between federal and nonfederal entities.

A highly visible and widely publicized example of an HCP is under way in Orange County, California. The coastal sage scrub vegetation of the area is habitat for the endangered California gnatcatcher, as well as many other species. However, development pressures in the area are intense, and land values are high. A significant amount of this land is owned by the Irvine Corporation, which has acted as the major partner with the Fish and Wildlife Service and the California Department of Fish and Game in developing a regional land-use and conservation plan. This plan provides for subregional planning by landowners and local governments, with guidance from an independent state scientific review panel and approval by state and federal agencies.

Another HCP example comes from the Southeastern states, where private timber firms were becoming increasingly frustrated by harvest limitations resulting from the need to protect habitat for the red-cockaded woodpecker. The companies felt that they often would not know in advance what the restrictions would be, and could not take the constraints into account in their planning. Led by firms such as Georgia-Pacific Corporation and International Paper, plans are being developed that provide much greater certainty for timber managers as to what they can and cannot do, and where this applies.

Partnerships

In many cases, the ecosystem approach has emerged spontaneously as landowners and other interested parties attempt to deal with local resource issues. For example:

- On the Henry's Fork of the Snake River in Idaho, ranchers sat down with fishermen and environmentalists to determine how their apparently conflicting needs could be resolved while mutually held goals could be achieved.
- In the Anacostia River watershed in the Washington, D.C., area, a group of state and local governments established a six-point action plan for watershed restoration.
- In southeast Arizona and southwest New Mexico, ranchers worked with The Nature Conservancy to form an unofficial million acre planning area to coordinate fire and ecosystem management across political boundaries. The Forest Service and Natural Resources Conservation Service are providing technical assistance to support these efforts; the Bureau of Land Management is also participating.
- In 1994, a unique partnership was created to manage 21,000 acres of diverse bottomland hardwoods and cypress gum swamp wetlands along North Carolina's Lower Roanoke River. Georgia-Pacific Corporation owns the land, but a joint commit-

tee—including representatives from The Nature Conservancy and Georgia-Pacific—establish criteria for where and under what conditions timber harvesting can occur.

- Efforts are currently under way to protect the San Francisco Bay/Delta Estuary. This 1,620 square mile area spans 12 counties, is a source of freshwater for 20 million people, and irrigates 4.5 million acres of farmland. In recent years, however, the estuary's ability to support a diverse ecosystem has declined because of near-total destruction of wetlands, altered hydrologic and salinity conditions, and urban and agricultural runoff. After 12 months of intense negotiations, a historic agreement on Bay/Delta environmental protection was signed in December 1994. The agreement, endorsed by a wide range of stakeholders, contains water quality standards for the Bay/Delta as well as measures to protect the habitats of currently listed endangered or threatened species.

- Within the San Francisco Bay estuary region, the North Bay contains the largest area of historic baylands and associated wetlands. Much of the area has been diked and is now used mostly for agriculture. The North Bay Initiative is a joint effort involving 13 local, state, and federal agencies working to restore the area. For example, the Sonoma County Resource Conservation District is contacting landowners in an effort to integrate agricultural and environmental goals into the long-term development of the reclaimed wetlands in San Pablo Bay. The Napa County Resource Conservation District coordinated development of the *Napa River Watershed Owner's Manual*, which addresses agricultural activities, urban storm runoff, residential land management, nonpoint source pollution, wildlife habitat, and ways to increase watershed biodiversity.

- In South Florida, a number of federal, state, tribal, and local agencies have coordinated efforts to restore the Everglades ecosystem, stretching from north of Lake Okeechobee to the Florida Keys. The Governor's Commission for a Sustainable South Florida recently brought together representatives of agricultural, environmental, urban water user, and other interests, to develop a consensus plan for managing water resources. That plan will expedite efforts by the Army Corps of Engineers to redesign the Central and Southern Florida Project so that waters flowing through this unique ecosystem are managed in a more sustainable manner. The South Florida Ecosystem Restoration Task Force will continue to coordinate the many restoration efforts at various levels of government.

Management Strategies

Using the ecosystem approach presents a host of management challenges. It requires a high degree of interagency cooperation, a multidisciplinary approach, and sophisticated information and technology systems. Three current

Protecting the Upper Mississippi Flyway. Ecosystem management strategies at work.

Photo Credit: J.G Wiener.
National Biological Service

examples include large marine ecosystems, National Estuary Programs, and habitat management in the Upper Mississippi River.

The National Oceanic and Atmospheric Administration has recognized that ecosystem-level programs are required for many coastal and marine areas. The agency is implementing a broad-based, multidisciplinary approach to marine monitoring, modeling, and management, which it calls the Large Marine Ecosystem Initiative. Large marine ecosystems are characterized by unique bathymetry, hydrography, and productivity, within which marine populations have adapted reproductive, growth, and feeding strategies. The initiative is designed to reflect the complexities of these marine systems.

The National Biological Service, Fish and Wildlife Service, Army Corps of Engineers, and five affected states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) are working cooperatively to develop an ecosystem approach to managing the upper Mississippi River. As wildlife habitat continues to decline in both abundance and quality in the upper Midwest, the upper Mississippi River and its adjacent habitats have assumed even greater significance for many migrating bird species. With its north-south orientation, the Great River Flyway functions as a pathway between breeding and wintering areas for some 292 bird species.

Their approach exploits the latest advances in technology and information, including aerial and satellite images which can then be digitized and stored in a geographic information system database. Detailed land cover maps can depict areas of specific vegetation types or communities. Using these maps to describe migratory bird habitats provides a link to relate the migratory bird corridor to other natural resource priorities and to look at threats to bird habitat from a broader perspective. The approach can be used at any scale, allowing development and evaluation of models for individual species, groups, communities, and entire ecosystems. The approach also uses maps of changes in habitat and vegetation over the past century, and maps of areas that can potentially support many species.

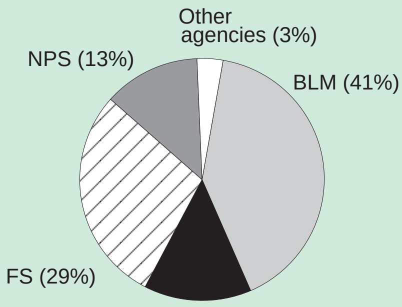
By tracking and predicting habitat changes and the causes of those changes, this approach can determine where habitats should be protected, created, or restored to meet the needs of migratory birds. The management strategy will serve as a vehicle to coordinate and consolidate river-based management plans for migratory birds and to develop specific management objectives. As a process, the Upper Mississippi River management strategy can be a valuable prototype for managing other ecological systems.

The U.S. Environmental Protection Agency (EPA) is actively using the ecosystem approach in protecting the environment. For example, EPA's National Estu-

A Conservation Reserve Program (CRP) Success. Pothole conservation in the upper midwest.

Photo Credit: Tim McCabe/SCS
U.S. Fish and Wildlife

Figure 7.6 Federal Land, by Agency, 1995



Source: See Part III, Table 14.

ary Program (NEP) promotes an ecosystem approach to protecting and restoring the health of estuaries while supporting economic and recreational activities. To date, the program encompasses 28 local NEPs including Casco Bay in Maine, Galveston Bay in Texas, and Tillamook Bay in Oregon. EPA helps each local NEP develop partnerships between government agencies that oversee estuarine resources and the people who depend upon the estuaries for their livelihood and quality of life. Together, these participants identify an estuary's problems, recommend solutions, and make financial commitments in a Comprehensive Conservation and Management Plan. EPA provides each NEP with grants and technical assistance. In implementing solutions, these local NEPs are demonstrating practical and innovative ways to rejuvenate and protect their estuaries (see also Chapter 14, "Coastal and Marine Resources").

Private Lands

Many opportunities exist to increase incentives for biodiversity and habitat conservation on private lands. In July 1995, a diverse group of 30 experts met at The Keystone Center in Colorado to compile a list of such opportunities. The group developed 18 proposals on which there was general consensus.

The Keystone Group noted a current lack of voluntary, incentive-based programs for restoring or conserving endangered species habitat. The participants suggested that the existing Conservation Reserve Program (CRP) could provide a model for developing a private-land endangered species conservation program. CRP pays farmers to retire highly erodible croplands and other environmentally sensitive lands from commodity production for 10 years and establish a protective vegetative cover. About two thirds of CRP lands are in the Great Plains. Though not intended as an endangered species protection program, the large new areas of grassland habitat created by CRP have contributed to the recovery of several state-listed endangered species and helped reverse declining populations of numerous endemic grassland birds.

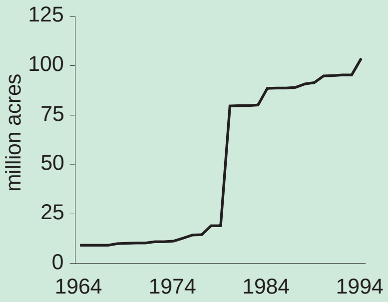
The Keystone Group proposed an endangered species protection program modeled after CRP that would be voluntary, of limited duration (5 to 10 years, with a right to renew), provide assurance to landowners that the land could be placed in another use after the program's end, provide assured funding for annual contract payments, and use a competitive bid system to maintain cost effectiveness.

Federal Protected Areas

The federal government has designated large blocks of lands for special protection, thereby contributing to a broad conservation effort. Four federal agencies administer about 95 percent of these federal lands. (See Figure 7.6.) In the Department of Agriculture, the Forest Service manages 187.3 million acres. In the Department of Interior, the Bureau of Land Management manages 264.7 million acres, the Fish and Wildlife Service 92.3 million acres, and the National Park Service 83.2 million acres.

Protection is also provided for the national wilderness system and the national wild and scenic rivers system. Since passage of the Wilderness Act in 1964, the national wilderness system has grown from about 9 million acres to about 103.7 million acres—or about 4.5 percent of the nation's land (Figure 7.7).

Figure 7.7 National Wilderness Preservation System, 1964-1994



Source: See Part III, Table 15.
Note: Data reflect year-end cumulative totals.

Red-cockaded Woodpecker. Resident of the endangered Longleaf Pine Forest and Savanna ecosystem.

Photo Credit: J.Hanula and K. Franzreb
U.S. Forest Service

The wild and scenic rivers system, which preserves rivers or stretches of rivers in a free-flowing condition, now protects about 10,734 river miles (Figure 7.8). Wild and scenic rivers are administered by federal or state agencies; if a protected river runs through privately owned land, it is maintained by the private landowner.

Congress established a National Trails system in 1968; in 1991, it established the National Recreational Trails Fund and the National Recreational Trails Trust Fund. Congress appropriated $7.5 million for the program in fiscal year 1993. The National Highway System Designation Act of 1995 authorized $15

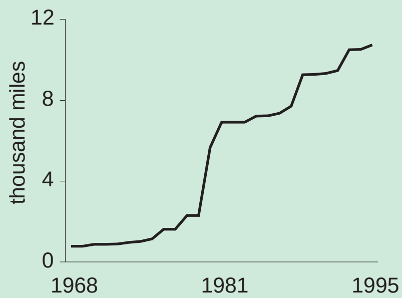


Figure 7.8 National Wild and Scenic Rivers, 1968-1995

Source: See Part III, Table 15.
Note: Data reflect year-end cumulative totals.

million for fiscal years 1996 and 1997 for the national recreational trails program.

The Department of Energy has established seven national environmental research parks, located within six major ecoregions of the United States. The program was begun in the 1970s, and the Savannah River Site in South Carolina was designated the first research park in 1972. Over the years, these large protected land holdings became, in some cases, the last remaining refuges of what had once been extensive naturally balanced ecosystems. Most of the land in the research parks is undeveloped, with minimal cultivation and almost no human residents. Environmental research projects are carried out with little interference, and a long history of environmental research and monitoring data are consequently available for these areas.

The Department of Defense (DOD) is steward to approximately 25 million acres of public lands. While these lands support military training and readiness capabilities, they also offer pristine habitats for a wide variety of unique species, as

Box 7.2
Protecting the California Desert

In December 1994 Congress passed the California Desert Protection Act, climaxing a decade-long struggle among environmentalists, ranchers, landowners, and others over land protections in the Southern California Desert. The law transferred about 3 million acres from the Bureau of Land Management to the National Park Service, upgraded Death Valley and Joshua Tree National Monuments to national park status, and established the 1.4 million acre Mojave National Preserve. In addition, the law provided wilderness status for 69 Bureau of Land Management areas totaling 3.6 million acres and 4 million acres in the two parks and the preserve.

In a single stroke, the act provided protection for almost one third of the land stretching across the Sonoran, Mojave, and Great Basin Desert systems of the Southwest. The area includes some of the oldest trees in the world, the hottest place on the entire planet, and California's only known dinosaur tracks.

The act was a difficult compromise among competing interests. Hunting, which is prohibited in most units of the National Park system, will be allowed in the Mojave National Preserve. Grazing of domestic cattle, now permitted on a limited basis in only one small park in Nevada, will be permitted throughout much of the protected desert area. A small number of working mines will also continue operations.

well as a wealth of opportunities for recreational and other renewable uses. DOD strives to apply wise conservation practices to ensure that natural resources are not degraded from overuse. In 1996, the department issued a directive on environmental conservation that provides—among other things—for managing natural resources consistent with the military mission while protecting and enhancing resources for multiple use, sustainable yield, and biological integrity. Special provisions are made for biologically or geographically significant or sensitive natural resources, such as wetlands or coastal barrier islands, and for threatened and endangered species.

For example, at 11 installations in the Southeast, DOD is protecting and enhancing populations of the endangered red-cockaded woodpecker. Resource managers are maintaining the mature longleaf pine forest upon which the woodpecker depends by simulating natural fires that control invasive hardwood trees and by controlling timber harvests. Troops that train in the forests treat nesting trees as biologically contaminated sites or mines to avoid disturbance to woodpecker colonies.

DOD also manages about 10 percent of the lands of the Mojave Desert. It has teamed up with the Department of the Interior to manage these lands so that biological integrity can be addressed across their jurisdictional boundaries. (See Box 7.2 for information on other efforts to protect federally owned desert land.)

FUTURE CHALLENGES

While there is increasing recognition of the value of ecosystems and the need to preserve biodiversity, achieving these ends presents many difficult challenges. Our knowledge of how ecosystems function is still limited, making comprehensive analyses difficult. Furthermore, the ecosystem approach requires interdisciplinary, cooperative, holistic, and adaptive efforts that are new to our resource management and political institutions.

Concerted efforts are being made to overcome these problems. What is most promising is that conservation efforts are increasingly based on cooperation, negotiation, and partnerships among landowners—both governmental and nongovernmental. Also, a growing number of efforts are aimed at improving incentives to private landowners to conserve ecosystems. In the face of increasing population growth and development, we must seize these new opportunities quickly, try to minimize conflicts with development interests, and generate creative new approaches to protect and restore ecosystems.

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CHAPTER EIGHT

Biodiversity

Biodiversity is the sum of all the biological differences among living things, whether at the species level, genetic level, or ecosystem/community level. As expressed by The Keystone Center in a 1991 report, biodiversity is "the variety of life, and its processes; including the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur." Implicit in this definition are the interacting, interdependent structures and functions among the genetic, species, and ecosystem levels of biota and their physical, chemical, and biological environment.

From an ecological-economic standpoint, biodiversity is important for the "goods and services" provided to living systems, including human systems. Some of those services are the capture of solar energy (plants); conversion of that energy into food, fiber, fuel, and pharmaceuticals (plants); pollination of fruit-providing plants (bees, butterflies, and hummingbirds); dispersal of seeds (animals); decomposition of waste (microbes); filtration of water (plants); and purification of air (plants). Conversely, biota require goods and services provided by their habitats, and the condition of habitat-specific biota reflects the condition of that environment. As the integrity of a habitat is destroyed through degradation, fragmentation, or contamination, the species living there are affected.

The United Nations Environment Programme cites 13.6 million as a reasonable estimate of the total number of species on Earth. Of this total, nearly 60 percent are insects; another 21 percent are bacteria, fungi, or viruses. Fewer than one eighth of all species have been scientifically described.

Species richness generally increases moving from colder polar regions to hotter tropical regions. This distribution is exemplified by the tally of species abundance in North American countries (Table 8.1).

RECENT TRENDS

The Nature Conservancy and state agency-based Natural Heritage Network maintain databases with information on more than 28,000 U.S. species and an additional 11,000 subspecies and varieties. In 1996, The Nature Conservancy reported on the conservation status of 20,481 native U.S. species, representing 13 major groups of plants and animals that have been classified and studied in sufficient

Table 8.1 Abundance of Species in North American Countries

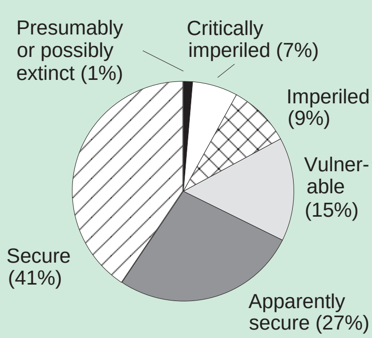
	Mammals	Birds	Reptiles	Plants
Canada	197	462	42	3,220
United States	466	1,090	368	20,000
Mexico	439	961	717	20,000

Source: World Resources Institute, *World Resources 1992-93* (Oxford University Press, New York, 1992).

detail to allow status assessment for each of their species.

The Nature Conservancy analysis revealed that, based on their global rarity, almost one third (32 percent) of the species surveyed were in some danger (Figure 8.1). About 1.3 percent were presumed or possibly extinct, 6.5 percent were classified as critically imperiled, another 8.9 percent were imperiled, and 15 percent were classified as vulnerable. States in the Southwest and Southeast harbor the greatest number of imperiled species (Figure 8.2). Hawaii and California both have more than 600 imperiled species and subspecies.

Figure 8.1 Status of U.S. Plant and Animal Species, 1995



Source: The Nature Conservancy, *Priorities for Conservation: 1996 Annual Report Card for U.S. Plant and Animal Species* (TNC, Arlington, VA, 1996).

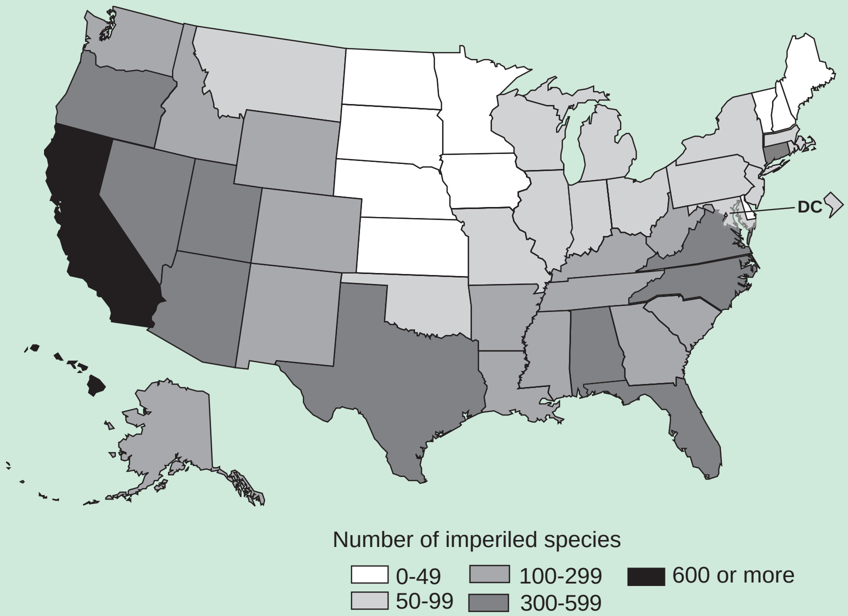
Note: Total=20,481 species; does not include 346 species not yet ranked.

The work done by.The Nature Conservancy and Heritage Network complements that done by the Defenders of Wildlife, which identified the 21 most-endangered ecosystems of the United States (see also Chapter 7, "Ecosystems," Figure 7.1). These reports corroborate studies done by federal and state agencies and by academia identifying correlations between ecosystem degradation, fragmentation, or contamination and species found at risk. A compilation of many of those studies—especially those addressing species status and trends—was prepared by the Department of the Interior's National Biological Service as *Our Living Resources*; this publication is the basis for much of the following discussion.

Species Dependent on Aquatic Systems

Records of species at risk indicate that those dependent on aquatic systems for all or part of their life cycle are in the most dire condition. The four groups

Figure 8.2 Biodiversity Hotspots by State, 1995

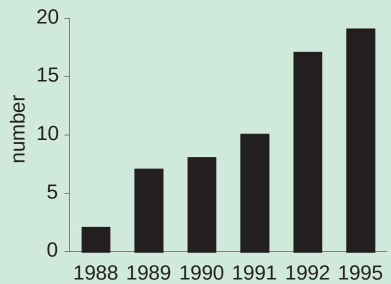


Source: B.A. Stein, "Putting Nature on the Map," *Nature Conservancy* (TNC, Arlington, VA, January/February 1996).

most at risk—freshwater mussels, freshwater fishes, crayfish, and amphibians—all depend on rivers, streams, or lakes; they generally spend their life cycle confined to a single watershed or reach of the waterway.

Mussels. In many national waterways, mussel populations have suffered badly from habitat loss as a result of dam construction, channelization, dredging operations, and water pollution. Dam construction alone has wiped out 30 to 60 percent of native mussel populations in some rivers. Competition from nonnative mollusks, notably the Asian clam and the recently introduced zebra mussel, also contributes to the decline. During the next 10 to 20 years, zebra mussels will most likely spread throughout most of the United States and southern Canada (Fig-

Figure 8.3 U.S. States Affected by Zebra Mussels, 1988-1995



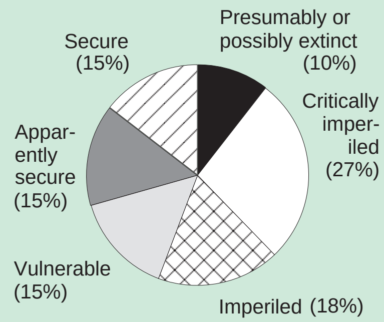
Source: A.J. Benson and C.P. Boydstun, "Invasion of the Zebra Mussel in the United States," In: *Our Living Resources,* LaRoe et al, eds., U.S. Department of the Interior, National Biological Service (GPO, Washington, DC, 1995).

ure 8.3). This exotic species attaches to the surface of native mussels in such high numbers that the native species are unable to breathe or eat.

Both the National Biological Service and The Nature Conservancy report that about two thirds of all native mussel species are in danger (Figure 8.4). According to Interior Department figures, only 70 of 297 native mussel species appear to have stable populations, and many of these species have declined in abundance and distribution since the late 1800s (Figure 8.5).

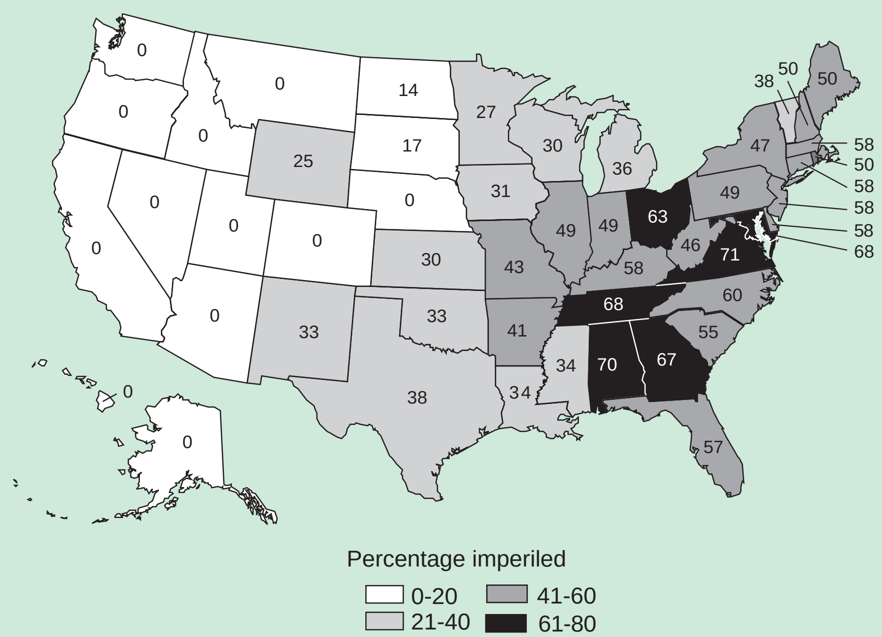
Freshwater Fishes. Freshwater fishes also are experiencing relatively rapid changes in their habitats, often causing

Figure 8.4 Status of U.S. Freshwater Mussel Species, 1995



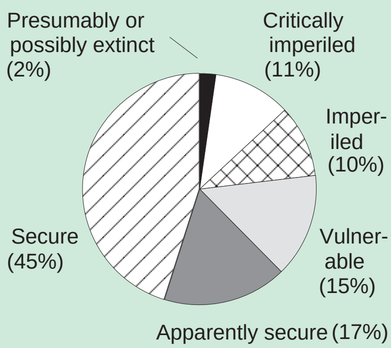
Source: The Nature Conservancy, *Priorities for Conservation: 1996 Annual Report Card for U.S. Plant and Animal Species* (TNC, Arlington, VA, 1996).
Note: Total=311 species; does not include 15 species not yet ranked.

Figure 8.5 Imperiled Freshwater Mussels by State, 1993



Source: J.D. Williams and R.J. Neves, "Freshwater Mussels: A Neglected and Declining Aquatic Resource," In: *Our Living Resources,* E.T. LaRoe, G.S Farris, C.E. Puckett, P.D. Doran and M.J. Mac, eds., U.S. Department of the Interior, National Biological Service (GPO, Washington, DC, 1995), p. 178.

Figure 8.6 Status of U.S. Freshwater Fish Species, 1995



Source: The Nature Conservancy, *Priorities for Conservation: 1996 Annual Report Card for U.S. Plant and Animal Species* (TNC, Arlington, VA, 1996).
Note: Total=815 species; does not include 10 species not yet ranked.

tion of nonnative fish and other species, and disease seem to be less significant threats to fish populations.

Many imperiled species have local distributions—some are restricted to particular reaches of a single watershed; others, such as the Devils Hole pupfish, are limited to a single spring. These species could be lost by a single, isolated, debilitating event. Other species, such as paddlefish and sturgeons, depend on large rivers. Their imperiled status indicates widespread threats to these extensive habitats.

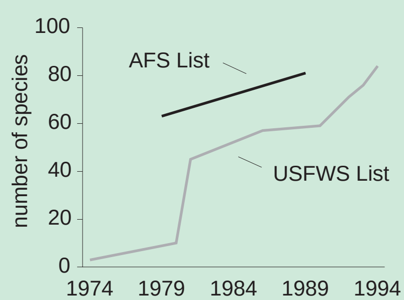
According to the AFS list, the Southwest and Southeast have the highest average number of fish species listed per state (Figure 8.7). In the Southeast, a relatively high proportion of minnows, darters, and madtom catfishes are imperiled. In many cases, sedimentation and siltation resulting from poor land-use practices are

risks to their survival. Fish species have adapted to a variety of conditions in the United States. Some of the species found in the country are old, primitive forms such as the sturgeon, gar, paddlefish, and bowfin; as well as younger and more genetically advanced species such as sunfishes, minnows, and darters.

Of the roughly 800 native freshwater fish species in the United States, The Nature Conservancy estimates that about 35 percent are imperiled or vulnerable (Figure 8.6). The American Fisheries Society (AFS) in 1979 developed a list of 198 native fish species judged in danger of disappearing; in 1989, the AFS list had grown by 25 percent to 254 species.

The vast majority of imperiled species are threatened by the deteriorating quality of their aquatic habitats, either through habitat destruction or contamination. Factors such as overharvesting, introduc-

Figure 8.7 Imperiled Fishes in the U.S. Southeast, 1974-1994



Source: Walsh et al., "Southeastern Freshwater Fishes," In: *Our Living Resources,* LaRoe et al, eds., U.S. Department of the Interior, National Biological Service (GPO, Washington, DC, 1995).
Note: USFWS=U.S. Fish and Wildlife Service. AFS= American Fisheries Society.

White sturgeon, the largest freshwater fish in North America, has been negatively affected by overexploitation, poaching, and habitat alteration due to hydropower dams.

Photo Credit:
Courtesy of Oregon Historical Society

eliminating habitat for these bottom-dwelling species.

The cumulative effect of habitat degradation also has caused widespread fragmentation (that is, more populations living in smaller, unconnected habitats) of many species, which adds to the challenge of trying to reverse and restore any diminished genetic reserves of fish populations. Introduction programs can also cause the loss of genetic diversity; for example, the introduction of the Florida largemouth bass has compromised the genetic integrity of all populations of northern largemouth bass into which the species has been introduced in the Southeast.

In the Pacific Northwest, stocks of salmon and steelhead in the Columbia River basin are down by more than 80 percent from historic levels. Similarly, in California, salmon stocks are down 65 percent, and winter-run chinook salmon in the Sacramento River have been reduced by more than 97 percent in the last 20 years.

White sturgeon—the largest freshwater fish in North America, found in the Sacramento-San Joaquin, Columbia, Snake, and Fraser Rivers—has been negatively affected by overexploitation, poaching, and habitat alteration due to hydropower dams. Of the 11 fish communities isolated upstream between dams on the Columbia River, white sturgeon are known to be relatively abundant in only three. In the lower reaches of the Columbia, the recent adoption of more restrictive harvest regulations may have allowed populations to stabilize.

Reptiles and Amphibians. Because reptiles and amphibians are critical to the natural functioning of many ecological processes, the species in these groups are key components of important ecosystems. Furthermore, the benefits to human medical practices in understanding basic biological processes from study of amphibian metamorphosis and development are significant.

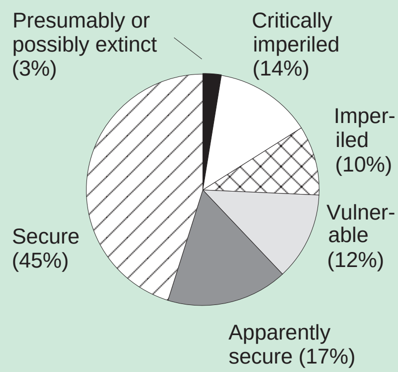
The native herptofauna of the continental United States comprise about 230 species of amphibians (about 62 percent of which are salamanders and 38 percent frogs) and about 277 species of reptiles (about 19 percent turtles, 35 percent lizards, 45 percent snakes, and fewer than 1 percent crocodilians). Another 2 species of turtles, 17 lizards, 2 snakes, and 1 crocodilian have been introduced.

The Nature Conservancy provides information on the status of amphibians (Figure 8.8). For example, the coastal plain of the southeastern United States, which is identified as an endangered ecosystem (see also Chapter 7, "Ecosystems"), contains a rich diversity of reptiles and amphibians. Of the 290 species native to the Southeast, 170 (74 amphibians, 96 reptiles) are found within the range of the remnant longleaf pine ecosystem. Many of these species are not found elsewhere, particularly those amphibians that require temporary ponds for reproduction. Many coastal plain species are listed federally or by states as endangered or threatened or are candidates for listing. Examples include the flatwoods salamander, striped newt, Carolina and dusky gopher frogs, eastern indigo snake, gopher tortoise, eastern diamondback rattlesnake, and Florida pine snake.

Habitat degradation and loss seem to be the most important factors adversely affecting amphibian and reptile populations. The drainage and loss of small aquatic habitats and their associated wetlands have had a major adverse affect on many amphibian species and some reptiles.

Many other factors have been involved in the decline of amphibian and reptile populations; most—perhaps all—of these are human-caused. For example, nonnative species of gamefish introduced for sport are thought to be one reason for the declines of frog populations in mountainous areas of some western states.

Figure 8.8 Status of U.S. Amphibian Species, 1995

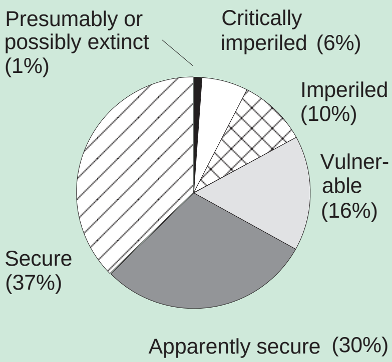


Source: The Nature Conservancy, *Priorities for Conservation: 1996 Annual Report Card for U.S. Plant and Animal Species* (TNC, Arlington, VA, 1996).
Note: Total=237 species.

Plants and Fungi

This section describes trends in two of the major groups of life on earth: green plants and fungi, including mushrooms, lichens, and molds. Members of the plant and fungal groups have both economic and ecological importance. Plants transform solar energy into usable economic products essential to society and provide the basis for most life on earth by generating oxygen as a product of photosynthesis. Fungi not only mediate critical biological and ecological processes, including the breakdown of organic matter and recycling of nutrients, but also play important roles in symbiotic association with plants and animals. Some fungi also produce commercially valuable substances including antibiotics and ethanol; others are pathogenic and cause damage to crops and forest trees.

Figure 8.9 Status of U.S. Vascular Plant Species, 1995



Source: The Nature Conservancy, *Priorities for Conservation: 1996 Annual Report Card for U.S. Plant and Animal Species* (TNC, Arlington, VA, 1996).
Note: Total=18,156 species; does not include 262 species not yet ranked.

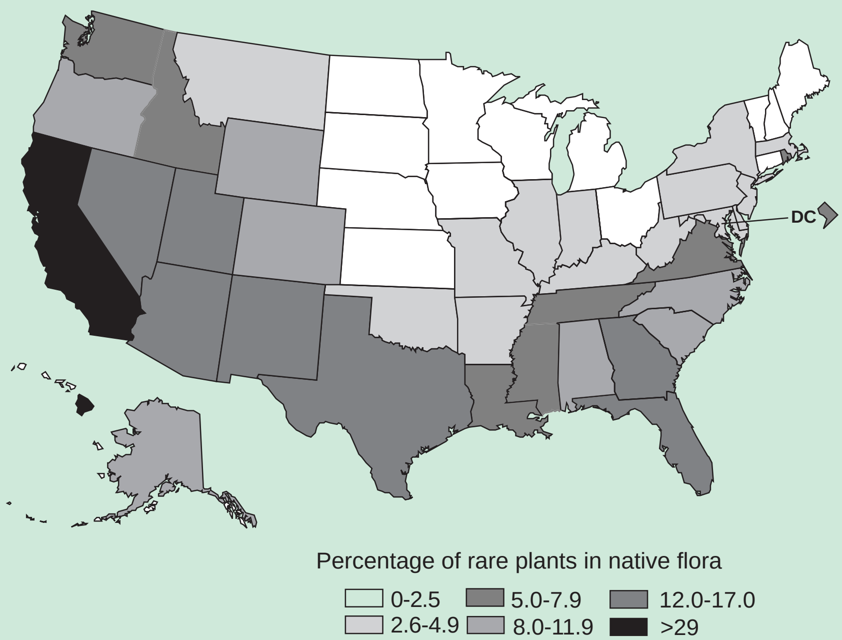
Plant estimates range upward from 17,000 species; only 5 to 10 percent of the estimated 1.5 million fungal species worldwide have been described. California, with 5,000 species, and southern states such as Texas (4,500 species) have the largest number of native vascular plant species in the United States (Figure 8.9). Arizona, Florida, Georgia, New Mexico, and Oregon each have over 3,000 native species.

Habitat loss and incompatible land use are the major threats to most rare U.S. plant species. Species at higher risk of extinction usually include those having small geographic ranges, narrow habitat requirements, unusual life histories, or vulnerability to exotic pests or diseases.

Of the 16,000 vascular plants in The Nature Conservancy survey, about 2,500 are considered imperiled. Globally rare native species are concentrated in the southern and western states (Figure 8.10). Even globally common species may not be altogether secure in the U.S., however; 110 globally common species have been lost from three or more states, and more than 35 have been lost from four or more states.

Opportunistic nonindigenous plant species often displace native plants, particularly those whose habitats have been disturbed. Hundreds of invasive nonnative species have become management problems in many natural areas. Although importation bans and other measures have been imposed by the federal government for a number of species, strict compliance is difficult to implement. Since about 1970, the rate of

Figure 8.10 Proportion of Globally Rare Vascular Plant Species by State, 1994



Source: L.E. Morse, J.T. Kartesz and L.S. Kutner, "Native Vascular Plants," In: *Our Living Resources,* E.T. LaRoe, G.S Farris, C.E. Puckett, P.D. Doran and M.J. Mac, eds., U.S. Department of the Interior, National Biological Service (GPO, Washington, DC, 1995), p. 207.

increase of exotic introductions appears to have moderated, however.

Plant surveys have shown that a significant number of plants are more common than previously believed. For example, Merriam's bearpaw poppy, a native of southern Nevada and neighboring parts of California, has been considered rare and possibly endangered. During an inventory of Nellis Range Air Force Base carried out as part of the Defense Department's Legacy Resource Management Program, many previously unknown populations of the poppy were discovered.

Even a few species that were thought to be extinct have been recently rediscovered. The running buffalo clover was rediscovered in West Virginia in 1983 and subsequently in four other states. During the 1991 field season, the yellow passionflower was found at two sites in Delaware for the first time since the early 1800s. Such examples underscore the value of ongoing inventories and the dynamic nature of local and regional flora.

Loss of biodiversity increases the significance of germ plasm management and conservation. Preservation of the tissues and seeds that comprise the nation's plant germ plasm is the responsibility of the National Plant Germplasm System (NPGS), a diffuse network of cooperative federal and state laboratories and research stations. Many NPGS collections are considered to be valuable national and global resources for use by agricultural scientists and plant breeders in research to improve crops.

Mammals

Many mammalian population studies have been initiated to determine a species' biological or ecological status because of its perceived economic importance, abundance, threatened or endangered status—or because it is viewed as our competitor for specific resources or habitat. As a result, data on mammalian populations in the United States have been amassed by researchers, naturalists, trappers, farmers, and land managers for years.

The inventory and monitoring programs that produce data about the status and trends of mammalian populations are significant for many reasons. For one thing, mammalian species are significant biological indicators for assessing the overall health of advanced organisms—such as humans—in an ecosystem.

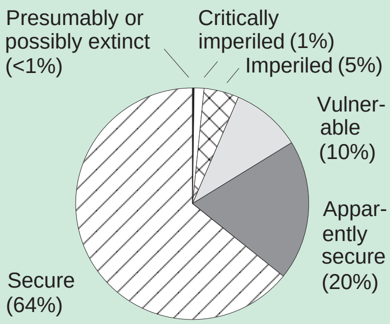
As a group, mammals are relatively secure. Of the 433 mammals listed in The Nature Conservancy's report, 6 are imperiled and 21 are vulnerable (Figure 8.11).

Rapid and sustained habitat and landscape changes, unregulated hunting and trapping, indiscriminate predator and pest control, and urbanization are among

Recolonization of the gray wolf has been successful at Yellowstone National Park.

Photo Credit: L.D. Mech
National Biological Service

Figure 8.11 Status of U.S. Mammal Species, 1995



Source: The Nature Conservancy, *Priorities for Conservation: 1996 Annual Report Card for U.S. Plant and Animal Species* (TNC, Arlington, VA, 1996).
Note: Total=433 species.

the factors that have contributed to the decline of some mammalian populations in North America.

For example, by 1960, the gray wolf was exterminated from all of the United States except for Alaska and northern Minnesota. Following the 1994 Environmental Impact Statement and recovery plan, 34 wolves were reintroduced into Yellowstone National Park and central Idaho during two periods, January 1995 and January 1996. The program is considered successful; the population has expanded to 50 wolves to date. Wolf populations have recovered somewhat since the mid-1970s; the Minnesota population is now estimated at about 2,000. Recolonization also has been successful at Glacier National Park and the surrounding area in Montana, which now has a population of 8 to 10 packs.

Despite being listed as a threatened species in 1975, five of the seven remaining grizzly bear populations in the United States do not have optimistic prospects.

Photo Credit:
National Biological Service

Triplet bald eagles born at George Washington's Birthplace National Monument, Popes Creek, Virginia.

Photo Credit: National Park Service

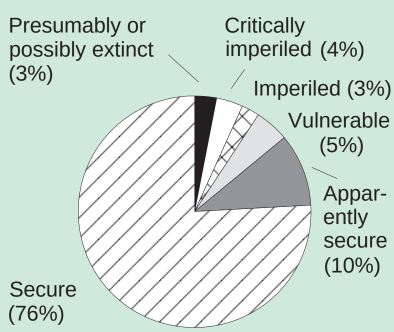
Grizzly bears once roamed over most of the West. In the Great Plains, they favored areas near rivers and streams, where conflict with humans was likely. For this and other reasons, grizzly bears in the United States were vigorously sought out and killed by European settlers in the 1800s and early 1900s. Since listing of the grizzly bear as threatened in 1975, populations have probably stabilized in the Yellowstone and northern Continental Divide ecosystems. But five of seven potential or existing populations do not have optimistic prospects, and even the two largest populations remain at risk.

One of the first species recognized as imperiled was the black-footed ferret. This member of the weasel family is closely associated with prairie dogs, which provide ferrets with both food (they comprise 90 percent of the ferret diet) and shelter (ferrets live in prairie dog burrows). As prairie dog colonies were eradicated by prairie dog control campaigns, ferret populations also declined. Black-footed ferrets, almost extinct by 1985, are being reintroduced from captive breeding. Because of inbreeding, however, their population lacks genetic diversity.

Birds

Birds are valued and highly visible components of natural ecosystems; they are also regarded as good indicators of environmental quality. Moreover, migratory bird populations are an international resource for which there is special federal

Figure 8.12 Status of U.S. Bird Species, 1995



Source: The Nature Conservancy, *Priorities for Conservation: 1996 Annual Report Card for U.S. Plant and Animal Species* (TNC, Arlington, VA, 1996).
Note: Total=759 species.

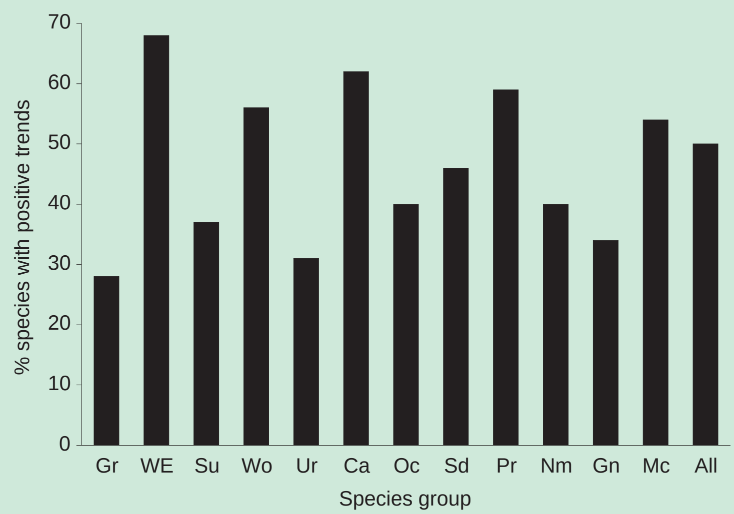
responsibility. Many efforts thus have been directed at measuring and monitoring the condition of North American's migratory birds. This monitoring task is not an easy one, because the more than 700 U.S. species of migratory birds are highly mobile with highly variable migratory patterns, and may appear in the United States only during part of their annual cycle.

As a group, bird species have the lowest ratio of imperiled to secure species in The Nature Conservancy survey. Of the total 759 bird species surveyed, only 6.2 percent were in the imperiled categories (Figure 8.12). Overall, roughly equal numbers of species appear to be increasing and decreasing over the past two to three decades. In general, species that are increasing are usually those that are able to adapt to altered habitats, while declining species are often "specialists" more vulnerable to habitat loss. The most consistent declines are among grassland birds (Figure 8.13).

Long-range data series are available on migratory and nonmigratory birds. Between 1966 and 1994:

- The populations of resident bird species have remained fairly stable over the 1966–94 period, as evidenced by the fact that nearly equal numbers of species of resident birds have increasing and decreasing population trends.

Figure 8.13 Percentage of U.S. Bird Species with Increasing Populations by Group, 1994

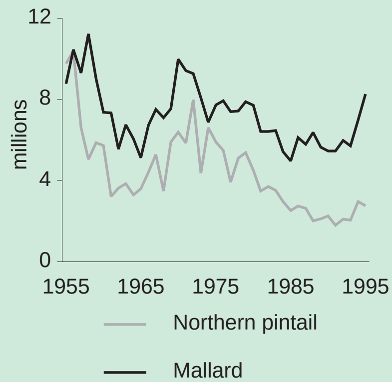


Source: U.S. Department of the Interior, National Biological Service, Breeding Bird Survey.
Notes: Gr=Grassland species. We=Wetland-open water species. Su=Successional-scrub species. Wo=Woodland species. Ur=Urban species. Ca=Cavity nesting species. Oc=Open-cup nesting passerine species. Sd=Short distance migrant species. Pr=Permanent resident species. Nm=Neotropical migrant species. Gn=Ground-low nesting species. Mc=Mid-story-canopy nesting species.

• The 1966–79 period was favorable for the majority of neotropical migrant species, which increased in population during this time. A spruce budworm outbreak in Canada was responsible for dramatic increases in a few species such as the Tennessee warbler, Cape May warbler, and blackpoll warbler.

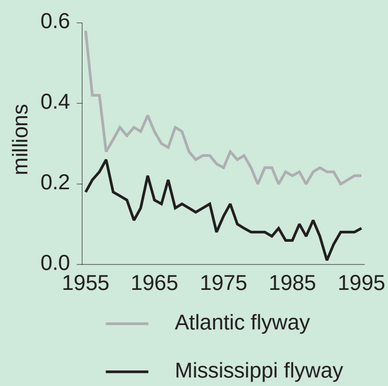
• The 1980–94 period was less favorable for neotropical migrants, with most species exhibiting declining population trends during those years. These declines largely account for overall population decreases experienced between 1966 and 1994.

Figure 8.14 Northern Pintail and Mallard Ducks, 1955-1995



Source: See Part III, Table 22.

Figure 8.15 Black Ducks by Flyway, 1955-1995

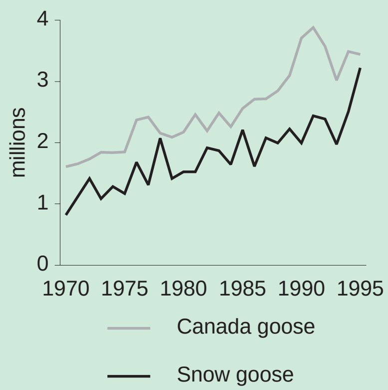


Source: See Part III, Table 22.

Ducks. Since the mid-1950s, duck surveys in North America have provided comprehensive and reliable data on some 30 duck species (Figures 8.14 and 8.15). Increased predation and habitat degradation and destruction coupled with drought, especially on breeding grounds, caused declines in some duck populations. Affected populations have since recovered from the drought of the 1980s to early 1990s, however, and many are at record highs—for example, the gadwall, northern shoveler, canvasback, and redhead. Additionally, habitat conditions, especially in the north central United States and prairie Canada, have greatly improved. The abundance of water in the prairie-pothole area is back to levels last experienced in 1970. Improved cover conditions—in part related to the Department of Agriculture's Conservation Reserve Program—have resulted in increased duck production, particularly in the Dakotas. The status of some duck species is still of concern to waterfowl managers, but, overall, ducks are doing well.

Geese. Most aggregations of wintering geese were overharvested in the early 1900s. Those subspecies that nested in temperate regions closer to humans were most heavily hunted. By 1930, the giant

Figure 8.16 Canada Goose and Snow Goose, 1970-1995



Source: See Part III, Table 23.

Canada geese that nested in the northern parts of the deciduous forest and tallgrass prairie were thought to be extirpated. Numbers of the large geese that nested in the Great Plains and Great Basin were also severely reduced.

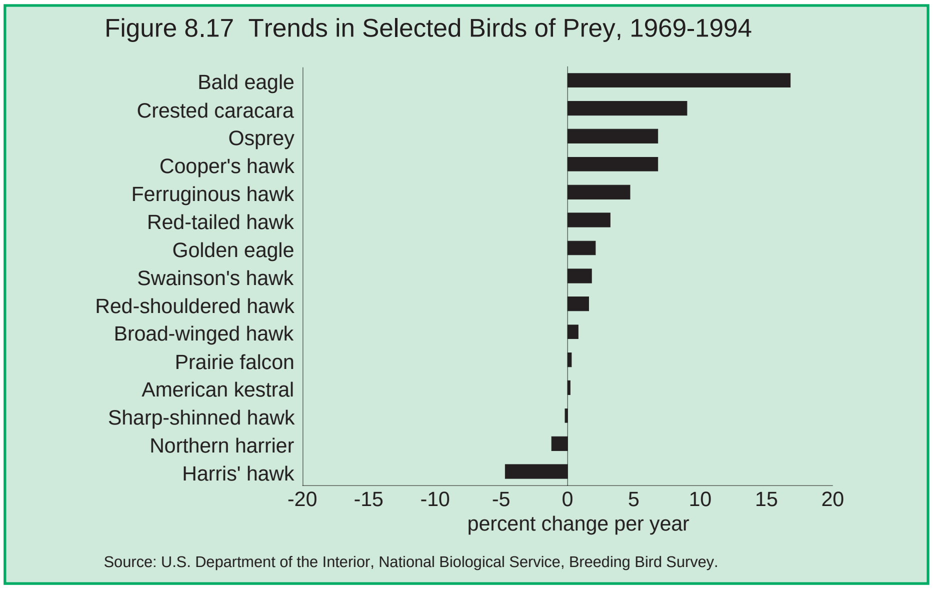
Although hunting depleted numbers of Canada geese, human activity also created new habitats for these birds. Agriculture led to the clearing of forests and plowing of prairies, creating the open landscapes preferred by geese. Today, most goose populations appear to be increasing—except for the Atlantic Canada goose, the Southern James Bay Canada goose, and the Dusky Canada goose (Figure 8.16). Snow goose populations are growing so rapidly that they may be adversely affecting their Arctic and migratory habitats.

Raptors. Raptors, or birds of prey, include the hawks, falcons, eagles, vultures, and owls that occur throughout North American ecosystems. As top predators, raptors are key species in understanding and conserving ecosystems; changes in raptor status can reflect changes in the availability of their prey species as well as more subtle, detrimental environmental changes such as chemical contamination and the occurrence of toxic levels of heavy metals (e.g., mercury and lead).

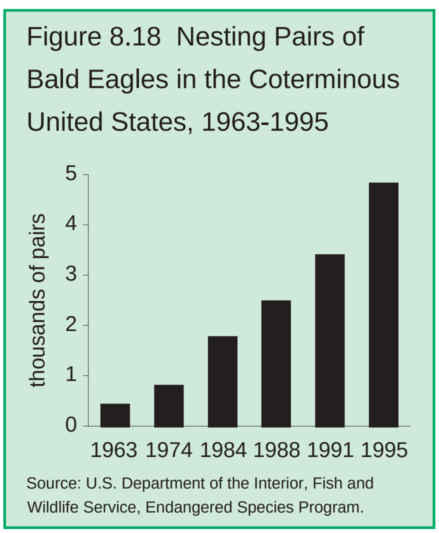
Among raptors, populations of ospreys, bald eagles, and peregrine falcons have increased in number as they recover from past effects of pesticides (Figure 8.17). The bald eagle has increased from a low of 400 nesting pairs in 1963 to just over 4,700 pairs in 1995 (Figure 8.18); the 1972 ban on DDT was a significant factor in this recovery. Populations of hawks and owls are either poorly known or believed to be stable.

Wild Turkeys. Historical information on turkeys comes from documented accounts of early explorers. Recent national population estimates are composite figures obtained from individual state wildlife management agencies. Most accounts indicate that turkeys were quite abundant at the time of European colonization of North America. As the nation grew, wild turkeys were harvested without restraint and marketed for human consumption. In addition, their forest habitat was cleared for agriculture and wood products. By 1920, wild turkeys were extirpated from 18 of the 39 states of their ancestral range. Little changed until after World War II, when resources were directed to restoring and managing the nation's wildlife populations, including the wild turkey.

Several factors have contributed to the return of the wild turkey: the maturing of



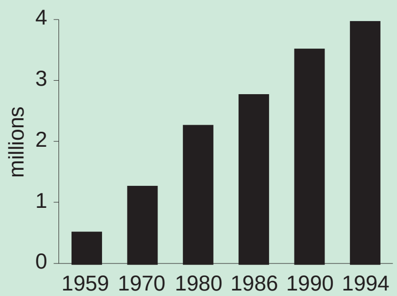
eastern forest, which had been almost eliminated; increased knowledge from research; spread of sound management practices; and better protection of new flocks vulnerable to poaching. The wild turkey, which was reduced to a population of a few tens of thousands in the early part of the century, now has a population approaching 4 million. (See Figure 8.19.)



Marine Species

At least 35 species of marine mammals are found along the U.S. Atlantic Coast and in the Gulf of Mexico; at least 50 species are found in U.S. Pacific waters, though estimates of abundance in U.S. water are variable. According to 1995 stock assessment reports, 23 stocks of marine mammals are increasing in abundance, 24 stocks are stable, and 8 are declining (Figure 8.20). With the exception of the Northern Right whale population in the Atlantic, all other increasing marine mammal populations reside in the Pacific Ocean or off Alaska. Trend data are mixed but, generally, increases result from prohibition of commercial whaling; and declines result from factors

Figure 8.19 Estimated U.S. Wild Turkey Population, 1959-1994

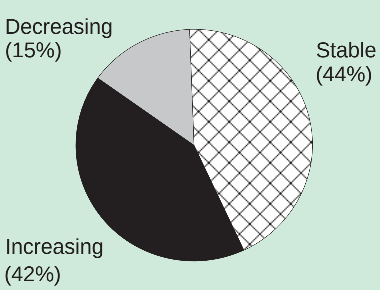


Sources: J.E. Kennamer, M. Kennamer and R. Brenneman, "History," In: *The Wild Turkey: Biology and Management,* J.G. Dickson, ed. (Stackpole Books, Harrisburg, PA, 1992) and update by editor.

such as bycatch associated with commercial fishing, illegal killings, strandings, entanglement, disease, altered food sources, and exposure to contaminants.

All six species of sea turtles found in the United States are listed as either endangered or threatened. It is difficult to determine population sizes of these highly migratory species, but there is little doubt that their populations have declined. For example, in the case of the Kemp's Ridley turtle, 40,000 females were counted nesting on a single day in 1947. The population has since plummeted due to overexploitation and incidental capture in commercial fisheries (Figure 8.21). Measures to protect nesting beaches and habitat are considered critical to recovery of these species.

Figure 8.20 Status of U.S. Marine Mammal Stocks, 1995



Source: National Marine Fisheries Service, *Our Living Oceans: Report on the Status of U.S. Living Marine Resources, 1995* (NMFS, Washington, DC, 1996). Note: Total=55 stocks (33% of total U.S. stocks) that sufficient long-term population trend information.

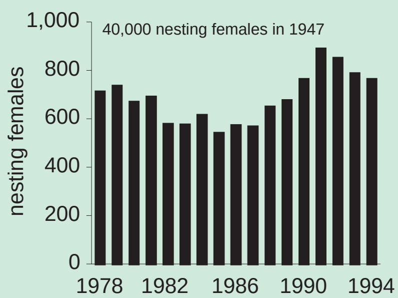
FUTURE CHALLENGES

Much has been learned about the distribution, abundance, and health of the nation's biodiversity. However, the programs that produced this information were not developed in a coordinated fashion so as to form an integrated, comprehensive picture of the status and trends of those resources. By coordinating data-gathering, resource management problems and areas for additional research on why certain ecological changes are occurring can be better identified—and thereby enable resource managers to take appropriate action.

Statistically reliable information on the status and trends of biological resources is an essential step toward better stewardship of the nation's biological wealth. Equally important is an intensive research program aimed at understanding what factors are responsible for biological changes and the incorporation of that understanding into resource management and policy decisions.

Development of tools such as standardized systematics and classification

Figure 8.21 Kemp's Ridley Sea Turtles, 1978-1994



Source: National Marine Fisheries Service, *Our Living Oceans: Report on the Status of U.S. Living Marine Resources, 1995* (NMFS, Washington, DC, 1996).

taxonomies, standardized monitoring protocols, and geographic information systems can aid in information gathering and analysis. For example, metadata for biological information—both federal and nonfederal—are accessible through the National Biological Service's National Biological Information Infrastructure. This infrastructure contributes spatial biological databases to the National Spatial Data Infrastructure. The National Biological Service works with the Federal Geographic Data Committee (FGDC) to ensure coordination of spatial data activities. Additionally, the FGDC Vegetation Classification and Information Standards are being developed to support production of uniform statistics on vegetation resources at the national level. These standards will ultimately support a detailed, quantitative, georeferenced basis for vegetation cover modeling, mapping, and analysis at the field level. Similar standards are being developed through consensus on taxonomy and systematics of biota via the Interagency Taxonomy Information System available on the World Wide Web.

Besides specific programs designed to understand components and functioning of biodiversity, the Office of Science and Technology Policy's Committee on Environment and Natural Resources is developing a working framework to coordinate the nation's environmental monitoring and research programs for biodiversity and ecological resources.

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CHAPTER NINE

Local and Regional Resource Conservation

Local and regional strategies to manage and protect land are an important tool to promote more rational development and to protect sensitive environmental areas.

Difficult issues include private property owners' concerns about the value and use of their property, and the nature and pace of urban and suburban growth. New development reduces available farmland and forests, increasing our reliance on automobile transportation and continuing the pattern of sprawl that is characteristic of most of the nation's urban areas. Some view urban sprawl as an inefficient and environmentally destructive land-use pattern; others defend it as serving consumers and communities well.

Caught in the middle are local and regional planners, trying to provide some rationality to the growth process and constantly confronted with the challenge of balancing development and environmental protection.

While the majority of the nation's land is remote and relatively unsettled, most of the challenging land use issues involve the relatively small fraction of land where people live. As rural populations shift to urban areas, cities and suburbs must address traffic congestion, development pressures, and diminishing open space.

As more Americans reach retirement age, new patterns of mobility are emerging. For example, some Americans are retiring to smaller communities in scenic areas near national parks. Growth in these communities is putting new pressures on ecosystems.

BACKGROUND

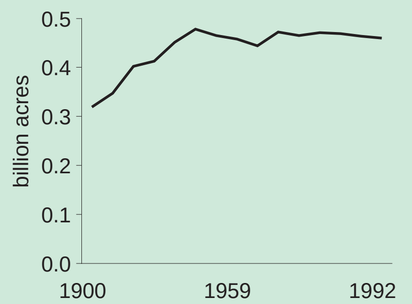
Land Area and Use

The total land area of the contiguous 48 states is approximately 1.9 billion acres. Alaska adds an additional 365 million acres and Hawaii slightly over 4 million, bringing the total to nearly 2.3 billion acres.

Cropland use—which totaled 460 million acres in 1992—increased consistently during the first half of this century; fluctuated from the late 1940s to the late 1970s, largely driven by shifting export demand; and has been declining since the late 1970s (Figure 9.1).

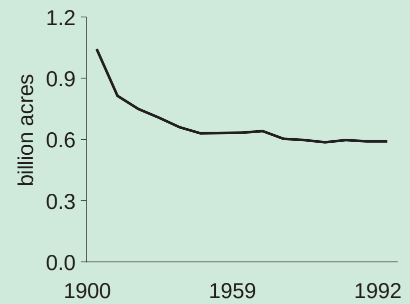
Grassland pasture and range have declined since 1900 and now total about 591 million acres (Figure 9.2). Improved quality of pastures has helped reduce the demand for pastureland, especially following World War II. Additionally, part of the decline in land reflects the dramatic

Figure 9.1 U.S. Cropland, 1900-1992



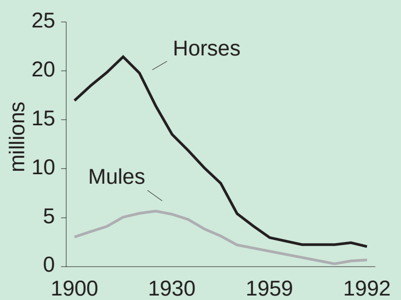
Source: See Part III, Table 49.

Figure 9.2 U.S. Grassland, 1900-1992



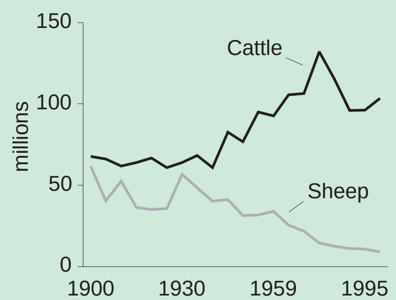
Source: See Part III, Table 49.

Figure 9.3 U.S. Horse and Mule Inventory, 1900-1992



Source: Bureau of the Census, Census of Agriculture.

Figure 9.4 U.S. Cattle and Sheep Inventory, 1900-1995

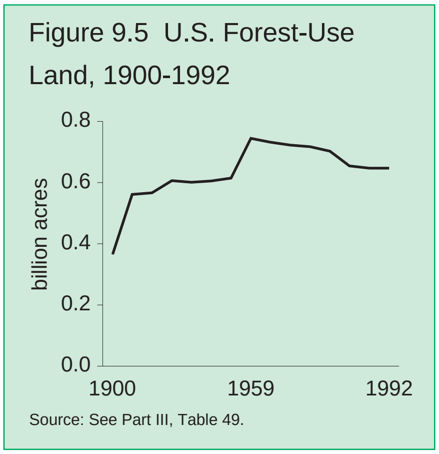


Source: Bureau of the Census, Census of Agriculture.

decrease in the number of draft animals early in the century (Figure 9.3). More recently, domestic animals, which account for most of the demand for grazed forage, also have been declining in number (Figure 9.4). The inventory of all cattle and calves reached a high in the mid-1970s and has declined in each census year since. Sheep numbers reached their peak before 1945 and have been declining since; in 1992, the sheep population was 25 percent of the 1945 total.

Forest-use land totals 648 million acres (excluding land in special uses such as national and state parks). Peaking in mid-century, the amount of forest-use land has generally declined since, albeit with periodic fluctuations (Figure 9.5).

Land devoted to “other” uses totals 564 million acres. Such land has increased since the early part of this century, especially following the inclusion of Alaska. In addition to the large increase in miscellaneous and unclassified land in Alaska, land used for transportation,



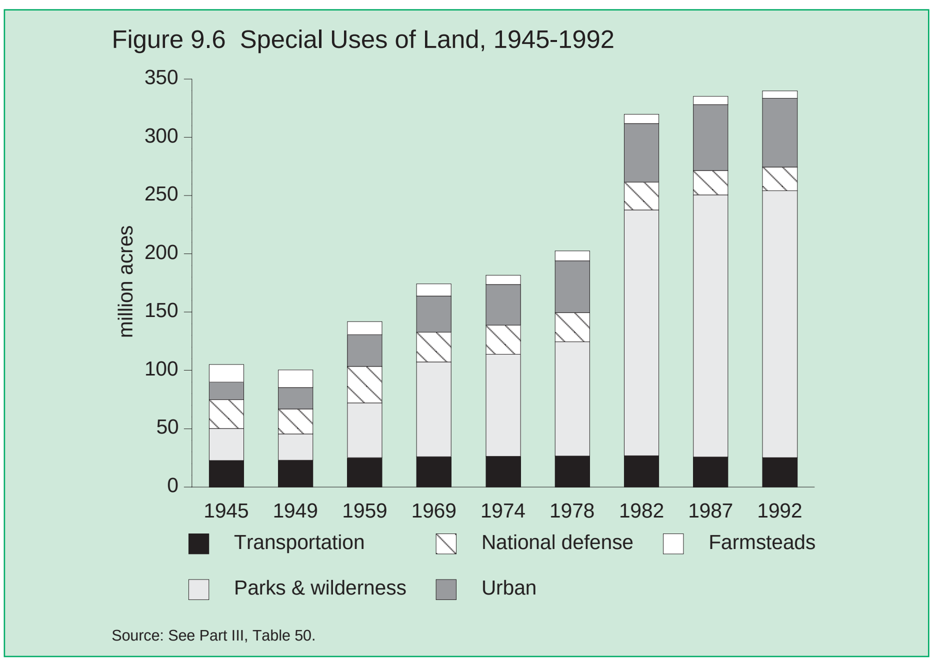
Source: See Part III, Table 49.

national defense, and urban settlements has increased throughout the United States since 1949 (Figure 9.6).

Land in urban areas totaled 58.8 million acres in 1992, up from 46.8 million acres in 1980. During the 1980s, urban areas absorbed an average of about 860,000 acres per year from other land uses. In the 1970s, by contrast, an average of 1.3 million acres per year were lost to urban areas.

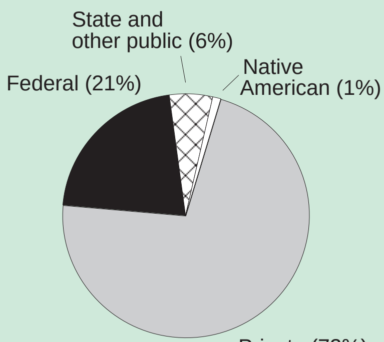
Land Ownership

Of the 1.9 billion acres in the lower 48 states and Hawaii, about 72 percent—nearly 1.4 billion acres, or almost three out of every four acres of U.S. land area—is privately owned (Figure 9.7). In the 11 Western states, the percentage of private land ownership is lower than in other states; this is because the federal government has historically owned higher percentages of lands in this area, ranging from 28 percent federal ownership in Montana to 83 percent in Nevada. The federal government also owns a large portion of the land in Alaska. Since 1959,



Source: See Part III, Table 50.

Figure 9.7 Land Ownership in the Lower 48 States, 1992



Source: See Part III, Table 49.

large portions of federal land in Alaska have been released to the state government and to Alaska Native corporations.

About 94 percent of all nonfederal land is rural, consisting mainly of cropland, rangeland, and forestland.

KEY ISSUES

Land-Use Planning

Land-use planning has a long history in the United States. As early as 1926, the U.S. Supreme Court upheld the validity of comprehensive zoning on the basis of states' constitutional authority to protect public health, safety, and welfare. By 1940, virtually all states had adopted zoning laws; most land-use planning has been delegated to local governments.

Land-use planning has many important benefits. It helps ensure that sufficient space is available for a community's essential needs, such as schools and open space. It can minimize the destruction of natural systems and prevent development in high-risk areas that are prone to flooding or other hazards. It can help protect the country's heritage and can enable communities to adapt to changing conditions by monitoring and anticipating trends.

Land-use planning can improve the efficiency of development and help protect sensitive environmental areas by closely linking development to areas with infrastructure and municipal services, to areas with sufficient water and resources to support growth, and to areas that are not hazard-prone.

Since the 1970s, the pace and environmental impact of development have prompted some states to provide localities with a comprehensive framework for managing growth. According to *Land Use in America* (from which much of the ensuing discussion is drawn), more than a dozen states have passed laws that assume at least some level of state review for projects or areas that affect state interests. Most of these laws cover the entire state; a few, such as those in California and North Carolina, affect only coastal areas.

Statewide growth management laws typically establish goals such as reducing congestion and pollution, redeveloping urban areas, preserving pristine lands, conserving farmland, and improving the quality of life. Localities generally must comply with these statewide goals and develop land-use plans with consistency provisions tying state programs to the local plans.

In Oregon, for example, the state growth management plan requires all 241 cities to establish urban growth boundaries. Areas outside these boundaries have been rezoned for agriculture and forestry, with 25 million acres now dedicated exclusively to those purposes.

In New Jersey, the state plan designates both areas where density is encouraged and areas where density decreases are needed. Part of the plan is intended to protect the Pine Barrens area in southern New Jersey. As part of the protection effort, the New Jersey Pinelands Commission developed a tradable land credit system. In exchange for restrictive covenants on their properties, landowners in conservation zones could obtain credits they can sell to landowners in growth zones.

Florida is another state struggling to manage a rapidly growing population. Its 1985 Omnibus Growth Management Act includes several provisions aimed at preventing development in high-risk coastal areas, specifying building design in areas prone to hurricane damage, and promoting compact development. The act's "pay-as-you-go" infrastructure requirements, which required infrastructure to be in place before growth could occur, had the unintended effect of driving growth to outlying rural areas. The law has since been revised.

In the 1990s, growth management in certain areas has become more contentious. For example, in Florida groups such as 1,000 Friends of Florida helped secure passage of a law that creates a cause of action for owners of real property whose land is "inordinately" burdened by state environmental or other regulation. The decision as to what constitutes an "inordinate" burden under the bill will be made by state courts, taking into account the landowner's reasonable investment-backed expectations and the availability of alternative uses of the property. The law gives landowners the opportunity to pursue dispute resolution if new laws or regulations encroach on those rights and the owner can prove an inordinate burden. If compensation is awarded, the government in return receives an interest, such as a conservation easement on the property.

There is also strong interest in Florida to protect critical environmental areas and the state's water recharge areas. The Florida Greenways Commission, which was started in 1993, will create a statewide network of greenways linking the state's parks and open spaces. The program particularly focuses on protecting corridors along waterways. For example, the Cross-Florida Greenway will eventually become a 110-mile-long conservation and recreation area along the site of the abandoned cross-Florida Barge Canal.

Similar pressures face the state of California. *Beyond Sprawl*—a 1995 report jointly produced by the Bank of America, Resources Agency of California, Greenbelt Alliance, and Low Income Housing Fund—found that growth is typified by (1) new housing developments encroaching farther into agricultural and environmentally sensitive lands, (2) an increasing dependence on automobiles, and (3) the isolation of central cities and older communities. Current development patterns, the report says, have made the state a less desirable location for businesses and their employees.

The Cost of Sprawl. Many studies have found that typical new developments characterized by large lots and single-family homes increase public costs compared to more compact development with mixed-use urban and town center planning.

For example, a 1989 study by the Urban Land Institute found that providing services to a three-unit per acre development 10 miles from employment and other centers would cost an estimated $8,000 more per house than a 12-unit per acre development located closer to facilities. An American Farmland Trust study of Loudoun County, Virginia, found that net public costs were about three times greater at a density of 1 unit per five acres compared with a density of 4.5 units per acre.

Designing Sustainable Communities. Confronted with the future prospect of growth and development, many communities across the country are using planning, visioning exercises, the development of indicators, and other tools to forge a new balance between growth and stewardship.

The best-known example is in Chattanooga, Tennessee, where a "Visions 2000" initiative in 1984 brought together thousands of residents to talk about the state of the city and their vision of the future. The exercise proved to be a remarkable success, helping launch a turnaround for the city that has emphasized pollution reduction, affordable housing, open space, and the development of "green" manufacturing.

In Seattle, volunteer committees have selected 40 indicators that will serve as a "report card" for the city and for long-term planning. In Cambridge, Massachusetts, criteria for a sustainability profile have been developed; these are intended to measure the city's impact on the environment and minimize undesirable effects.

The new ideas generated by the Chattanooga experience and those of other cities also point to the many opportunities available for reducing the environmental impact of manufacturing. Strategies include the promotion of new environmental technologies, investments in resource efficiency, using the solid waste stream to develop community-based recycling businesses, and supporting eco-industrial parks. These last are an environmentally efficient version of industrial parks. They follow a systems design in which one facility's waste becomes another facility's feedstock, and they ensure that raw materials are recycled or disposed of efficiently and safely.

Dealing with Development Pressures

High growth in areas such as California, Florida, and the Southwest has created challenging issues including a search for balance between development, protected areas and ecologically valuable unprotected areas.

In recent years, there has been significant movement out of major California cities to other areas in the West. In Phoenix, aerial photographs taken three months apart in 1995 found 5,000 new homes around the city. Population in smaller communities such as Boise, Idaho; Santa Fe, New Mexico; Jackson, Wyoming; Aspen, Colorado; and Park City, Utah; also is increasing rapidly.

The fastest growing counties in Colorado, Montana, and Wyoming are adjacent to Yellowstone and Grand Teton National Parks. Such growth puts real strains on National Park Service managers and on the carrying capacities of these communities and ecosystems. While population and development pressures are increasing, federal resources in many cases are shrinking. This conflict is creating difficult dilemmas for park and refuge managers.

Communities and land managers are trying to find new ways to protect ecosystems. In California, two important examples are the effort to save Mono Lake and to preserve the state's remaining coastal sage scrub habitat.

Mono Lake. In 1990, Mono Lake was rapidly nearing extinction. This ecologically important lake, located in a remote part of the Sierra Nevada Mountains, was succumbing to the combined effects of a seven-year drought and extensive water diversion to Los Angeles.

In 1941, the Los Angeles Department of Water and Power began diverting four of the streams that feed Mono Lake. After almost 50 years of diversions, the lake's shoreline had dropped 42 feet. The impact on the lake was catastrophic as wetlands that bordered the lake disappeared; toxic dust storms arose from the recently exposed banks; and the natural salinity of the water doubled, dramatically reducing populations of tiny brine shrimp and other organisms that were a vital food source for migrating birds. Of the 1 million ducks and geese that once migrated to the lake, fewer than 1 percent returned.

The effort to save the lake was led by the Mono Lake Committee—a citizens' group with more than 17,000 members—the Audubon Society, trout fishermen, and others. Through litigation and cooperation, remarkable progress is being made. In September 1994, the State Water Resources Control Board issued a ruling, mandating that Los Angeles reduce its diversion of water flowing into the lake until the lake reaches a stable level of 6,392 feet, or 25 feet below its prediversion level. Since the ruling, the lake has risen 6 feet.

The committee also is working with the city of Los Angeles and area businesses to "drought-proof" Los Angeles. Government and private organizations have collaborated to develop a plan to reclaim and conserve more than 135,000 acre-feet of water annually—twice the amount needed to protect the lake. State and federal agencies pledged $86 million to build two water reclamation projects. Estimates show that the reclaimed water costs $347 per acre-foot—$64 less than imported water.

The city also pledged to reduce water use by 20 percent. Ultra low-flush toilets were introduced in most homes, and higher water prices discouraged unnecessary use. By 1994, the city had exceeded its goal, and water use was identical to 1975 levels—even with 800,000 more residents.

Coastal Sage Scrub Habitat. California has been struggling for several decades to find imaginative new ways to balance environmental, economic, and social issues that cross jurisdictional boundaries.

One important experiment is the Natural Communities Conservation Planning (NCCP) program, which is trying to protect the state's remaining coastal sage scrub habitat along the south coast. This habitat is the home of the California gnatcatcher, a threatened species, and numerous other imperiled species (see also Chapter 7, "Ecosystems"). The program is intended to provide more protection for the gnatcatcher and the sage scrub area than was provided by either the federal or state endangered species laws. The program relies on a multistakeholder process that includes environmental groups, private landowners, and business groups in the region. Given specific statutory authority by the state, NCCP is trying to conserve entire habitats and ecosystems that encompass numerous species.

Federal and state laws are an important part of the process. The Interior Department added the gnatcatcher to the federal threatened species list. It also established a special rule that recognizes NCCP's role and allows partners that produce a plan protecting coastal sage scrub to develop up to 5 percent of the habitat and receive authorization for an "incidental take" of the threatened gnatcatcher during the planning process. The effect of the rule is to provide an incentive for private landowner participation in the program.

The California Department of Fish and Game's NCCP Process and Conser-

Gnatcatcher Habitat Encroachment.

Photo Credit: Claire Dobert
U.S. Fish and Wildlife Service

vation Guidelines were designed to complement the Interior Department proposal and provide guidance for the various stakeholders. Together, these two documents provide a blueprint for the development of 10 subregional preserves in Southern California. In addition, the state Fish and Game Department and the U.S. Fish and Wildlife Service signed a memorandum of understanding that eliminates the redundancy of parallel regulatory requirements. The Fish and Wildlife Service also provided a formal assurance that nonfederal landowners with approved multispecies plans will not be subjected to further land-use restrictions or mitigation requirements if additional species are listed or other regulatory action is required.

The next step is to develop plans for preserves. Some 30 projects in San Diego County and 8 in Orange County are in advanced stages of review for consistency with preserve guidelines. In San Diego County, three subregional plans are being considered: the Multi-Species Conservation Program, which covers 580,000 acres in the city of San Diego and southwestern San Diego County; the North County Multiple Habitat Conservation Program, which covers 610,000 acres in 10 of the county's northernmost jurisdictions; and a third plan covering 1 million acres, most of which are owned by the U.S. Forest Service and Bureau of Land Management and by the county park and recreation department. In Orange County, two plans covering about 340,000 acres are under way.

Limited financial resources for needed land acquisition present a difficult challenge for these conservation plans. The Interior Department has provided some federal support through the Endangered Species Act. The state has encouraged the use of tax credits and other incentives for owners to participate in voluntary habitat stewardship. Another cost-saving possibility is to acquire less than fee interests, such as development rights.

FUTURE CHALLENGES

Promising new approaches, such as the NCCP process in California, offer hope that innovative new ways can be found to balance growth and environmental protection. Such approaches can be difficult and complicated, involving many jurisdictions and economic interests. But they recognize the vital importance of balancing development needs with environmental needs including protection of large-scale ecosystems.

As U.S. population continues to grow in this decade and in the next century, the need for creative solutions will persist.

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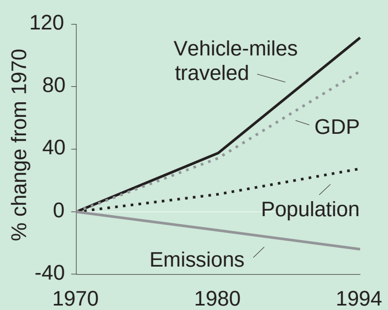
CHAPTER TEN

Air Quality

The use of regulatory approaches to manage air quality has been remarkably successful in the United States. From 1970 to 1994, total U.S. population grew by 27 percent, vehicle-miles traveled grew by 111 percent, and gross domestic product (GDP) grew by 90 percent. Yet in this same period the combined emissions of the six principal air pollutants dropped by 24 percent (Figure 10.1).

This is in stark contrast to past experience. Air pollution typically has followed economic and demographic trends. For example, during the Great Depression of the 1930s, emissions of air pollutants declined dramatically. During World War II, increased industrial production raised emissions to levels higher than those of the pre-Depression era. It has been estimated that, between 1900 and 1970, emissions of nitrogen oxides increased about 700 percent, volatile organic compound emissions increased about 250 percent, and sulfur oxides increased about 200 percent. Without the Clean Air Act, emissions of these and other pollutants would have continued to rise (see also Figure 10.2).

Figure 10.1 U.S. Emissions, Demographic, and Economic Trends, 1970-1994



Source: U.S. Environmental Protection Agency, *Air Quality Trends* (EPA, Research Triangle Park, NC, 1995).
Note: GDP=gross domestic product.

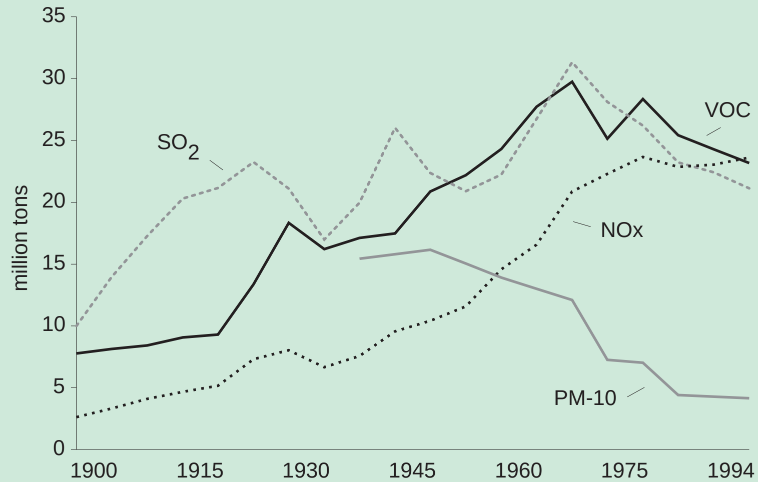
BACKGROUND

The Clean Air Act was signed into law in 1963, but it was the enactment of amendments to the law in 1970 that proved to mark a turning point in progress on air pollution control.

The basic objective of the law is to protect people and natural resources from airborne pollutants that could endanger public health and welfare or destroy the nation's natural resources.

The 1970 Clean Air Act amendments gave EPA three major tasks: (1) to set national ambient air quality standards (NAAQS); (2) to set new source performance standards (NSPS), and (3) to develop motor vehicle emission standards.

Figure 10.2 U.S. Emissions by Type, 1900-1994



Source: See Part III, Table 27.

Note: NO_x=nitrogen oxides. PM-10=particulate matter with a diameter of 10 microns or less. SO_2=sulfur dioxide. VOC=volatile organic compounds.

National ambient air quality standards set maximum allowable ambient concentrations for each pollutant. There are two kinds of standards: *primary* standards, which are designed to protect public health, and *secondary* standards, which are designed to protect public welfare (e.g., to protect against decreased visibility and damage to animals, crops, vegetation, and buildings). Primary standards are to be attained within prescribed deadlines; secondary standards are to be attained as expeditiously as possible. NAAQS have been developed for six common air pollutants, designated "criteria" pollutants: carbon monoxide (CO), lead, nitrogen dioxide (NO_2), ground-level ozone, particulate matter with a diameter of 10 micrometers or less (PM-10), and sulfur dioxide (SO_2).

Geographic areas that meet or fall below the primary standards are called "attainment areas"; areas that do not meet the standards are "nonattainment areas." In attainment areas, new sources and major modifications to existing sources must use the best available technology to control emissions, although energy, economic, and environmental concerns are considered on a case-by-case basis. In some cases, where a specific existing source causes problems in the more pristine areas (parks and wilderness), the source must use the best available retrofit technology controls.

In nonattainment areas, new sources are required to achieve the lowest possible emissions rate regardless of economic considerations. Furthermore, emissions from new sources must be offset by emissions from existing sources in the same geographic area, resulting in a net improvement in ambient air quality.

Once air quality improves and meets the primary standards, nonattainment areas must develop a contingency plan of action to ensure continued attainment of the standards and are then formally redesignated. In September 1996, there was only one nonattainment area for NO_2. There were 10 nonattainment areas for lead, 31 for CO, 43 for SO_2, 68 for ozone, and 81 for PM-10 (Figure 10.3). Altogether, 171 areas were in nonattainment for one or more pollutants.

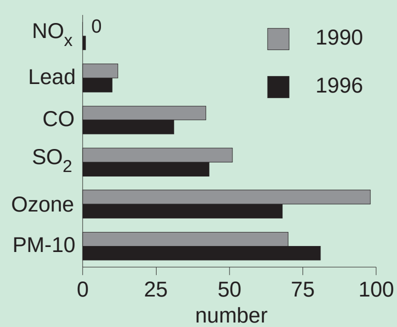
New source performance standards are nationally uniform standards based on the best demonstrated technology, taking cost into account, for a particular source category or process. These standards are designed to prevent new pollution caused by future growth and to improve air pollution as old facilities are replaced. Emissions limits have been set for about 60 source categories.

Motor vehicle emission standards control exhaust and evaporative emissions from cars, trucks, buses, and motorcycles. Emission standards were first established in the 1970s. Since then, they have become increasingly more stringent. They have accounted for much of the decline in CO, VOC, and NOx emissions: on average, a new car in 1990 is about 70 percent cleaner than a car built in 1970 without emission controls. The 1990 Clean Air Act amendments introduced a variety of new measures requiring even cleaner cars, cleaner fuels, enhanced inspection and maintenance programs, and—for the first time—emissions requirements for nonroad engines such as lawn mowers, boats, construction equipment, and farm equipment.

In addition to criteria air pollutants, the Clean Air Act also requires EPA to regulate hazardous air pollutants or "air toxics." Initially EPA regulated only seven hazardous air pollutants that caused serious health problems. The 1990 amendments expanded the list to 189 pollutants and required EPA to set technology-based control standards for 174 categories of sources.

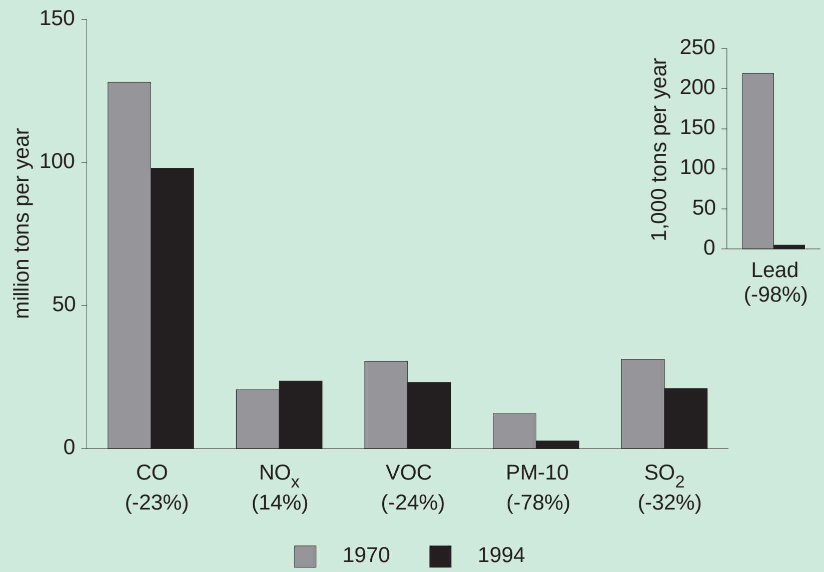
The 1990 amendments also created a national acid rain control program with reduction targets for SO_2 and nitrogen oxides (NO_x). For SO_2, the goal is to reduce annual emissions to a level 10 million tons below the 1980 level, a goal that will be largely reached by 2000. Another goal is to reach a permanent national limit, or annual cap, of 8.9 million tons for electric utility SO_2 emissions by 2000. A 1995 goal to reduce non-utility industrial SO2 emissions by 5.6 million tons has already been met.

Figure 10.3 U.S. Nonattainment Areas, 1990 and 1996



Source: U.S. Environmental Protection Agency.
Note: CO=carbon monoxide. Ozone refers to ground-level ozone.

Figure 10.4 Change in U.S. Emissions, 1970 to 1994



Source: See Part III, Table 27.

The 1990 amendments also call for a 10 percent reduction—or 2 million tons—in annual national NO_X emissions by 2000. The acid rain program is expected to account for a major part of the NO_X reductions.

Trends in Ambient Air Quality and Emissions

Except for NO_X, emissions contributing to criteria air pollutants decreased between 1970 and 1994. The most spectacular decline was for lead, for which annual emissions declined 98 percent (Figure 10.4). The declines in pollution-causing emissions have led to significant declines in concentrations of the criteria pollutants, improving air quality and yielding substantial human health, welfare, and ecological benefits.

Carbon Monoxide. Carbon monoxide is a colorless, odorless, poisonous gas formed when carbon in fuels is not burned completely. It enters the bloodstream and reduces oxygen delivery to the body's organs and tissues, representing a serious health threat for those who suffer from cardiovascular disease. Motor vehicle exhaust contributes more than two thirds of all CO emissions nationwide, and as much as 95 percent in cities. Other sources include industrial processes and fuel combustion in boilers and incinerators.

From 1970 to 1994, CO emissions declined from 128 million to 98 million tons per year, or 23 percent. During the 1985–94 period, CO emissions declined

Box 10.1
Indoor Air Pollutants

Recent evidence indicates that air in homes, schools, and workplaces can have higher levels of pollution than outdoor air, affecting health, comfort, and productivity. Common indoor air pollutants include radon; lead; environmental tobacco smoke (ETS); biological pollutants such as mold, dust mites, animal dander, bacteria, and viruses; and household chemicals and pesticides.

Potential long-term health effects include respiratory disease, damage to the brain and nervous system, cancer, and a variety of acute and chronic health problems, including asthma. The elderly and the young are particularly at risk from prolonged exposure.

Numerous federal agencies—including EPA, the Department of Labor's Occupational Safety and Health Administration (OSHA), the Department of Health and Human Services (including the Centers for Disease Control and Prevention), the Department of Energy, the Consumer Product Safety Commission, the Department of Housing and Urban Development, the General Services Administration, and others—are involved in efforts to reduce risk and improve the indoor air environment. States also have passed laws related to indoor environmental quality.

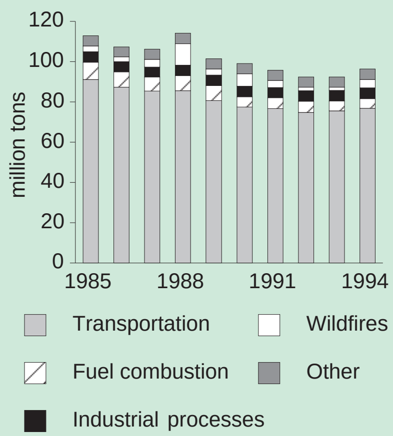
Radon, a naturally occurring gas, is the country's second leading cause of lung cancer, accounting for 7,000-30,000 deaths per year. Fortunately, radon can be managed with readily available technology. Between 1990 and 1994, the proportion of U.S. households that tested their homes for radon increased significantly. Federal goals for the next ten years include increasing the proportion of homes tested, increasing the number of jurisdictions in which testing is required as part of real estate transactions, increasing the number of jurisdictions with construction standards and techniques that minimize radon, and increasing the number of new homes built with radon-resistant features.

Although lead blood levels in children have declined significantly since the 1970s (primarily as a result of the switch to unleaded gasoline), ***lead*** continues to pose serious risks to children's health (see also Chapter 6, "Environmental Justice").

ETS is responsible for approximately 3,000 lung cancer deaths in nonsmokers annually, as well as 150,000 to 300,000 lower respiratory tract infections in infants, resulting in up to 15,000 hospitalizations per year. It exacerbates existing cases of childhood asthma and causes new ones. As public awareness of the dangers of "passive smoking" increase, children's exposure declines. Federal agencies and many private sector organizations are working toward the goal of reducing the proportion of children regularly exposed to tobacco smoke.

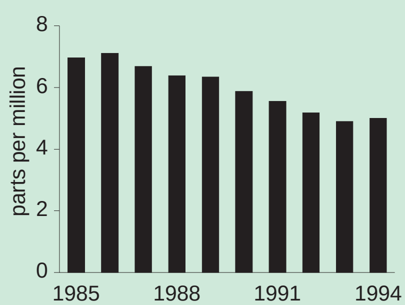
15 percent (Figure 10.5), and national average CO concentrations declined 28 percent (Figure 10.6). However, between 1993 and 1994, both emissions and concentrations increased (4 percent and 2 percent, respectively). This recent increase can be attributed to two sources: transportation emissions, which were up 2 percent, and wildfire emissions, up 160 percent.

Figure 10.5 U.S. CO Emissions, 1985-1994



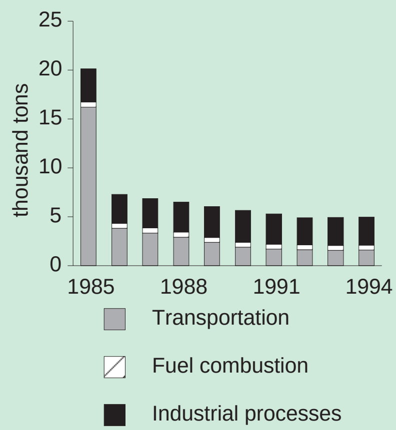
Source: See Part III, Table 27.
Note: Other includes structural and agricultural fires and slash/prescribed burning.

Figure 10.6 U.S. CO Concentrations, 1985-1994



Source: See Part III, Table 30.

Figure 10.7 U.S. Lead Emissions, 1985-1994



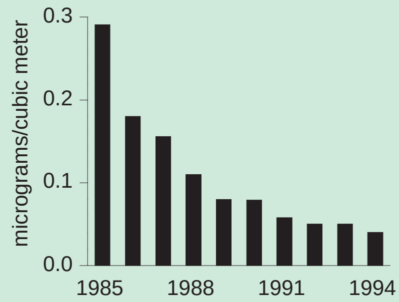
Source: See Part III, Table 27.

Lead. Lead is unquestionably a serious health hazard. Excessive exposure can cause anemia, kidney disease, reproductive disorders, and neurological impairments such as seizures, mental retardation, and behavioral disorders. Even at low doses, lead exposure can be harmful. Fetuses and children are especially susceptible.

The transition to unleaded gasoline in automobiles is responsible for most of the remarkable 98 percent decline in lead emissions between 1970 and 1994—from 219,500 tons to only 5,000 tons annually. Emissions decreased 75 percent in the 1985–94 period alone (Figure 10.7). Between 1993 and 1994, lead emissions remained unchanged while national average lead concentrations decreased 20 percent (Figure 10.8). Violations of the standard that still occur generally are in the vicinity of nonferrous smelters and other stationary sources.

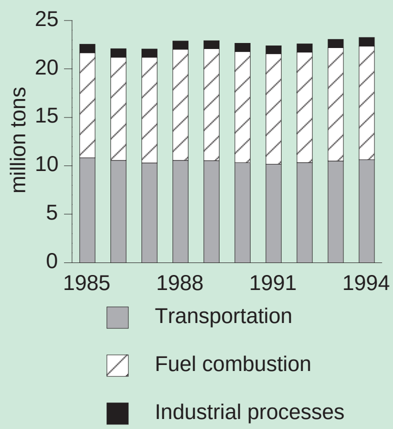
Nitrogen Dioxide. The pollutant NO_2 belongs to a family of highly reactive gases called nitrogen oxides (NO_X). These gases form when fuel is burned at high temperatures and come principally from motor vehicle exhaust and from stationary sources such as electric utilities

Figure 10.8 U.S. Lead Concentrations, 1985-1994



Source: See Part III, Table 30.

Figure 10.9 U.S. NO_x Emissions, 1985-1994



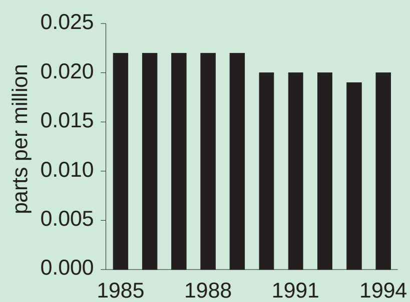
Source: See Part III, Table 27.

and industrial boilers. No human health effects of short-term exposure to typical levels of NO_2 have yet been demonstrated, but continued or frequent exposures to very high concentrations may cause increased incidence of acute respiratory illness in children. NO_x and the atmospheric nitrogen species formed from it contribute to the acid rain problem, and is now thought to be among the chemicals promoting the decline in aquatic ecosystems, especially along the Atlantic coast.

Over the 1970–94 period, emissions of NO_x increased 14 percent, from 20.6 million to 23.6 million tons per year. Since 1985, emissions from highway vehicles decreased 7 percent while fuel combustion emissions increased 8 percent (Figure 10.9). Between 1993 and 1994, both NO_x emissions and NO_2 concentrations increased (Figure 10.10), largely as a result of increased emissions from off-highway vehicles and wildfires. Even with this increase, 1994 was the third year in a row that all monitoring stations across the country, including Los Angeles, met the NO_2 national air quality standard.

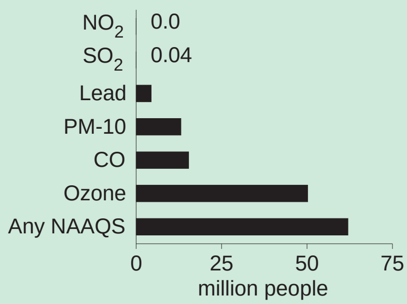
Ozone. Ground-level ozone (smog) remains the most complex, difficult to control, and pervasive of the six principal pollutants. Ozone is not emitted directly, but is created by sunlight acting on NO_x and volatile organic compounds (VOC)

Figure 10.10 U.S. NO_2 Concentrations, 1985-1994



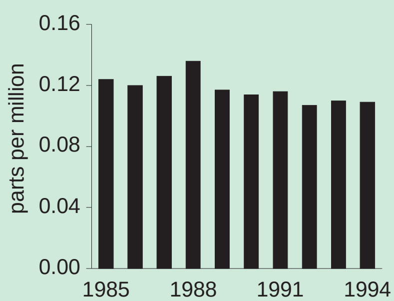
Source: See Part III, Table 30.
Note: NO_2=nitrogen dioxide.

Figure 10.11 U.S. Population in Counties with Air Quality Levels Above the NAAQS, 1994



Source: See Part III, Table 34.
Note: NAAQS=National Ambient Air Quality Standards.

Figure 10.12 U.S. Ozone Concentrations, 1985-1994



Source: See Part III, Table 30.
Note: Data refer to ground-level ozone.

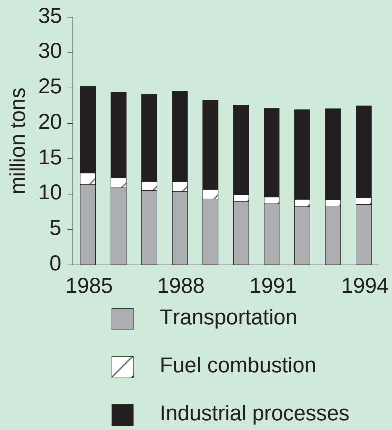
emissions. NO_X and VOC emissions are precursors of ozone formation. In addition to numerous nonanthropogenic sources, there are thousands of sources of VOC, including gasoline vapors, chemical solvents, combustion products of various fuels, and consumer products. They can originate from large industrial facilities, gas stations, and many other large and small businesses.

At high levels of activity, exposure to ozone near the current NAAQS level for six or seven hours can reduce lung function and produce symptoms such as chest pain, coughing, nausea, and pulmonary congestion. Results from animal studies indicate that repeated exposure at high levels for several months can produce permanent structural damage to the lungs, although there are limits to the extent to which these results can be extrapolated to humans. Ozone can also damage forest ecosystems and lower agricultural crop yields.

High levels of ozone persist in many heavily populated areas, including much of the Northeast, the Texas Gulf Coast, and Los Angeles. In 1994, about 50 million people were living in counties with ozone levels above the national standard (Figure 10.11). Average ambient ozone concentrations reported by monitoring networks were about 12 percent lower in 1994 than in 1985, even though meteorological conditions in 1994 were conducive to ozone formation (Figure 10.12 and Table 30). Recent control measures, including regulations to reduce evaporation of fuel and to limit NO_X and VOC emissions from tailpipe exhaust, may be responsible for the reduction. Emissions of anthropogenic VOC decreased 10 percent between 1985 and 1994 (Figure 10.13).

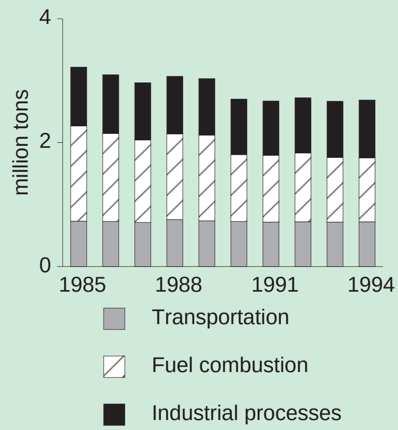
Particulate Matter. Particles are emitted from a variety of sources, including diesel trucks, wood stoves, and power plants. The PM-10 standard applies to small particles with a diameter of 10 micrometers or less. Such particles can damage respiratory systems and cause

Figure 10.13 U.S. VOC Emissions, 1985-1994



Source: See Part III, Table 27.

Figure 10.14 U.S. PM-10 Emissions, 1985-1994



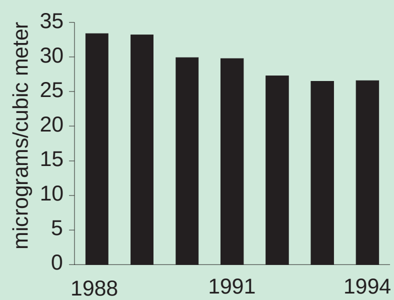
Source: See Part III, Table 27.

premature death. The smaller-sized particles (less than 2.5 micrometers in diameter) include many precursors to ozone and affect visibility.

Over the 1970–94 period, anthropogenic PM-10 emissions from sources such as fuel combustion, industrial processes, and transportation declined 78 percent. During the 1988–94 period, emissions declined 12 percent (Figure 10.14). Over the same 1988–94 period, average ambient concentrations declined about 20 percent, from 33.4 to 26.6 micrograms per cubic meter (Figure 10.15).

Sulfur Dioxide. Sulfur dioxide, which is part of the family of sulfur oxide gases (SO_X), is formed when fuel containing sulfur (mainly coal and oil) is burned. Health concerns related to high exposure levels include breathing difficulty, respiratory illness, alterations in pulmonary defenses, and aggravation of existing cardiovascular disease. Asthmatics or people with chronic lung disease or cardiovascular disease are particularly sensitive to high levels of SO_2. SO_2 emissions can damage the foliage of trees and agricultural crops, and SO_2 and NO_X are precursors to acid rain, which is associated with the acidification of lakes and streams. Sulfur compounds also con-

Figure 10.15 U.S. PM-10 Concentrations, 1988-1994



Source: See Part III, Table 30.

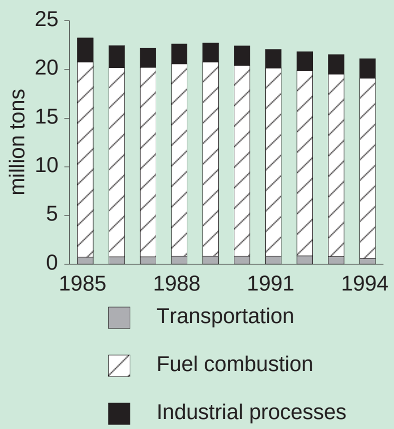


Figure 10.16 U.S. SO_2 Emissions, 1985-1994

Source: See Part III, Table 27.

tribute to visibility degradation, depletion of nutrients in forest soils, and materials damage (e.g., buildings and monuments).

Over the 1970–94 period, emissions of $S0_2$ declined 32 percent. Between 1985 and 1994, emissions declined 9 percent (Figure 10.16) and concentrations declined 25 percent (Figure 10.17).

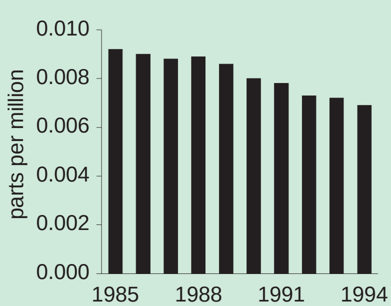


Figure 10.17 U.S. SO_2 Concentrations, 1985-1994

Source: See Part III, Table 30.

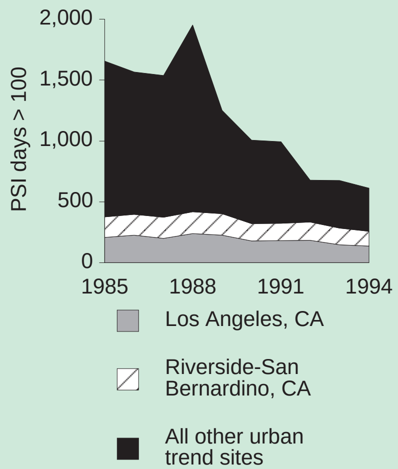
Overall Trends. The Pollutant Standards Index (PSI) is an overall assessment of air quality for a given day. These values are reported daily in all cities with populations over 200,000. A PSI value over 100 indicates that at least one criteria pollutant exceeded air quality standards on a given day. Between 1985 and 1994, the total number of reported days per year nationwide with a PSI value greater than 100 declined 72 percent (not including Los Angeles and Riverside, California). In Los Angeles, the number of days per year with a PSI value greater than 100 declined 35 percent during that time; in Riverside, the decline was 27 percent (Figure 10.18).

Hazardous Air Pollutants

The 1990 Clean Air Act amendments introduced important innovations for controlling air toxics—pollutants that are known or suspected to cause cancer, poisoning, nausea, and a variety of immunological, neurological, reproductive, developmental, and respiratory effects. These pollutants also contaminate soil, streams, and lakes, affecting ecological systems and further threatening human health through consumption of contaminated foods (especially freshwater fish).

Air toxics include benzene, dioxin, chromium, mercury, formaldehyde, and toluene. Prior to passage of the 1990 amendments, EPA had regulated only seven of the hundreds of hazardous air pollutants emitted from motor vehicles, factories, and other sources, reducing annual air toxics emissions by only 125,000 tons. The problem under the

Figure 10.18 U.S. Urban Air Quality, 1985-1994



Source: See Part III, Table 33.
Note: PSI=Pollutant Standards Index. PSI days > 100 are within the unhealthy range. See notes for Table 33.

1970 amendments was that EPA first had to establish that pollutants cause death or serious illness before regulating these air toxics to levels that protect public health "with an ample margin of safety." Under this risk-based approach, EPA could not clearly define a "safe" level of exposure to these cancer-causing pollutants, and it became almost impossible to issue regulations where there was no clear evidence of public harm.

The 1990 amendments called for a new approach. EPA must identify categories of "major" sources that emit any of the 189 toxic air pollutants listed specifically under the act. A major source is one that emits more than 10 tons per year of a single air toxic or 25 tons per year of any combination of air toxics. By the year 2000, EPA is required to develop technology-based emissions standards for these source categories that reflect the "maximum achievable control technology" for all of the toxic pollutants emitted by them. These standards must reflect some of the best control technologies that have already been demonstrated (they must be at least the average of the best performing 12 percent).

As of July 1996, EPA had issued regulations affecting 46 industrial categories that emit one or more hazardous pollutants. By 1999, these regulations will have reduced annual air toxics emissions by nearly 1 million tons.

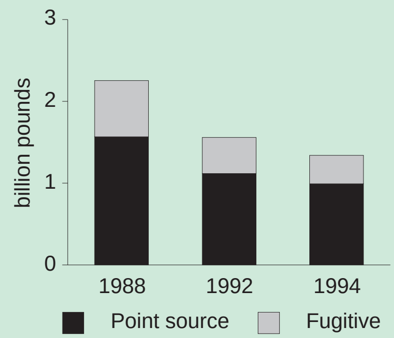
Data on air toxics have been collected since 1987 in the Toxics Release Inventory (TRI). This inventory covers 300 chemicals and is submitted annually by manufacturing facilities with 10 or more employees. The TRI does not provide a complete picture of air toxics emissions. For example, it does not include all toxic pollutants and does not include small companies and the mobile, commercial, and residential sectors, which can be significant sources of emissions. Nevertheless, it is useful to note that between 1988 and 1994, total TRI air emissions declined by 41 percent, from 2.3 billion pounds per year in 1988 to 1.3 billion pounds in 1994 (Figure 10.19). Of the 10 toxic air pollutants that together account for more than half of total TRI air emissions, all but hydrochloric acid have declined since 1988.

Benefits and Costs of the Clean Air Act, 1970 to 1990

In May 1996, EPA completed a draft study on benefits and costs of the Clean Air Act during the 1970–90 period. The draft analysis, which has been reviewed by the EPA Scientific Advisory Board and is undergoing revision, found that spending for Clean Air Act programs during this 20-year period yielded benefits that far outweighed the costs.

The authors stress that many uncertainties could broaden the range of outcomes, particularly regarding the human health, human welfare, and ecological benefits of emissions reduction, as well as the economic valuation of those benefits. On the other hand, inclusion of non-monetized and unquantified benefits would be likely to raise both the lower and upper bounds of the range, perhaps by significant amounts. The additional value of reductions in air toxics, protection of ecosystems, and a variety of other health and environmental effects could not be quantified or monetized. For example, the reduction in both criteria pollutants and air toxics probably yielded widespread improvements in the health and quality of terrestrial and aquatic ecosystems. In some cases, strong scientific evidence of a health effect existed, but data were still too limited to support quantitative estimates of incidence reduction (e.g., changes in lung function associated with long-term exposure to ozone). Similarly, the contribution of air pollution deposition to water quality problems was not well enough established to quantify costs and benefits.

Figure 10.19 U.S. Emissions of Air Toxics, 1988, 1992, and 1994



Source: See Part III, Table 72.

Not all clean air regulations yielded equally favorable comparisons of costs and benefits. A large proportion of the benefits are linked to the dramatic reduction in two pollutants in particular: lead and PM-10. However, PM-10 is caused by a wide variety of precursor emissions, such as SO_2 from utilities and NO_X from motor vehicles. Reductions in these emissions yield a variety of direct and indirect health, ecological, and visibility benefits, including reduced ambient particulate concentrations.

RECENT DEVELOPMENTS

In recent years, there have been several significant new developments in air pollution control. For example, market-oriented, economic incentive-based approaches increasingly are used as complements to traditional command-and-control regulation. The trend toward more flexible, performance-based implementation is growing, and there is increased recognition of the value of voluntary and cooperative initiatives.

Emissions Trading

Emissions trading among stationary sources is an increasingly important regulatory tool. Under emissions trading systems, a company that reduces emissions below the level required by law can receive credits usable against higher emissions elsewhere. Companies can trade emissions among sources within their own company and with other companies so long as combined emissions stay within an aggregate limit. Companies also can trade emission credits or store earned emission credits for future use.

The largest emissions trading program is the SO_2 allowance trading system established by the acid rain control program. This system uses market incentives to reduce pollution. Under this system, the highest-emitting utilities are allocated allowances based on their historic consumption and a specific emissions rate. Each allowance authorizes a utility to emit one ton of SO_2 during a specified year. Allowances can be bought, sold, or traded.

In 1995, because all 445 affected utility units met their compliance obligations, SO_2 emissions did not exceed allowances. In fact, these utilities together held 8.7 million SO_2 allowances, permitting up to 8.7 million tons of SO_2 emissions, but only emitted 5.3 million tons—39 percent less than allowed. The remaining allowances were banked to allow emissions in later years. The General Accounting Office has estimated that by 2010, the cost of compliance with SO_2 emissions reduction goals will be less than half what they would be without the allowance trading system.

A similar system of allowance trading is being developed for NO_X emissions in the northeastern United States by the Ozone Transport Commission (OTC). The OTC was established by the 1990 Clean Air Act amendments to coordinate state efforts to reduce ground-level ozone in 12 northeastern states and the District of Columbia. Other regions are also looking to allowance systems. The Southern California Air Quality Management District has started RECLAIM (Regional Clean Air Incentives Market) to limit new and existing sources of SO_X and No_X. Illinois has proposed an allowance system for VOC in the Chicago region.

A second major system of emissions trading is open-market trading. In August 1995, EPA proposed an open-market trading program for ozone-creating NO_X and VOC emissions. Under this program, a company that exceeds its required pollution reductions would have the opportunity to sell its "surplus" reductions (or "credits") to companies that find credits a cost-effective way to comply with the emissions reduction requirements. Once a state adopts and EPA approves an open-market trading plan, companies would be able to freely engage in trades without prior approval as long as reporting and public health standards are met.

Expanded use of market trading on local and regional levels will give companies broad flexibility to find lowest-cost approaches to emissions reductions. The system will encourage experimentation with new trading options.

Cutting Red Tape

In August 1995, EPA proposed ways to simplify the complex procedures under which air pollution permits are issued. Companies will be better able to keep their processes up-to-date without needing to meet burdensome procedural requirements.

In March 1996, EPA proposed reforms that will further simplify the process by combining multiple, overlapping Clean Air Act requirements into one permit. EPA also proposed significant revisions to streamline the permitting process for new sources of air pollution, making it easier for companies to certify compliance. These actions are expected to reduce paperwork burdens for businesses by as much as 10 million hours over the next 3 years, allowing companies to focus time and effort on productive activities and on avoiding violations of air pollution controls, and saving about $600 million.

Overall, the regulation of air pollution in the United States is going through a significant transition, with increased emphasis on cost-effectiveness, flexibility, community participation, and the use of market-based incentives.

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CHAPTER ELEVEN

Stratospheric Ozone

The ozone layer is vital to life as we know it. Ozone shields living things from the most biologically damaging wavelengths of solar ultraviolet radiation, known as UV-B and UV-C, which can alter the structure of genetic material and lead to harmful mutations. Scientists believe that land-based life could not have evolved on Earth without the ozone layer's protection.

Ninety percent of the Earth's ozone resides in the stratosphere, forming a layer that begins 6 miles above the planet's surface and extends to a height of 25 miles.

This layer absorbs all UV-C radiation and most UV-B, while allowing the longer, largely beneficial wavelengths (UV-A) of sunlight to penetrate to the land and ocean below.

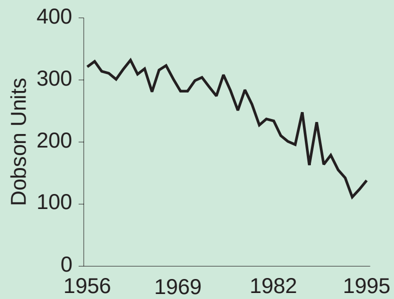
The ozone layer normally exists in a state of dynamic balance, with the gas continually being formed and destroyed at equal rates. Except for seasonal variations, this balance maintains ozone concentrations at relatively constant levels over time. (Short-term natural fluctuations occur in response to changes in solar activity, volcanic eruptions, shifts in wind patterns, and other phenomena.)

THE PROBLEM AND ITS CONSEQUENCES

In the past several decades, however, increasing amounts of chlorine- and bromine-containing compounds, used by society for a wide range of applications, have drifted up to the stratosphere. Increasing concentrations of chlorine and bromine from these chemicals have upset the ozone layer's balance, causing more of the chemical to be destroyed than is produced. The cumulative decline in stratospheric ozone over the Northern Hemisphere since 1979 has been roughly 5 percent, with record lows measured in late 1994 and early 1995. The seasonal Antarctic ozone "hole," first detected in 1985, has covered an area of roughly 9.5 million square miles—larger than North America—each austral spring since 1990. The 1995 ozone hole was the longest lasting on record (Figure 11.1).

United Nations projections indicate that as ozone depletion reaches its peak before the year 2000, mid-latitudes in the Northern Hemisphere may experience a 15 percent increase in UV-B exposure during winter and spring and an 8 percent increase in summer, compared with levels of the late 1960s. (These projections assume that other factors affecting the

Figure 11.1 Ozone Thickness over Antarctica, 1956-1995



Source: J.D. Shanklin, British Antarctic Survey (BAS).
Note: Mean October ozone column thickness is measured at the BAS station, Halley Bay, Antarctica.

amount of UV-B that reaches the surface, such as cloud cover and atmospheric pollution, remain unchanged.)

For humans, the potential consequences of such increases in UV-B exposure include a higher risk of skin cancers and cataracts and lower resistance to infectious diseases. Agricultural, ecological, climatological, and biogeochemical impacts are also possible, including reductions in crop productivity, changes in plant communities, disruption of aquatic food webs, reductions in fish and amphibian populations, changes in stratospheric circulation, and changes in the atmospheric concentrations of greenhouse gases such as methane and carbon dioxide.

THE INTERNATIONAL RESPONSE

December 31, 1995, the date on which the industrialized nations of the world officially ended their production of ozone-depleting chlorofluorocarbons (CFCs), stands as the defining milestone of an extraordinary 22-year endeavor that has united scientists, policymakers, diplomats, corporate officials, and engineers in service to the global environment.

The process began in 1974, when Nobel Prize-winning chemists Mario Molina and F. Sherwood Rowland published their seminal paper linking CFCs to the destruction of stratospheric ozone. At the time, over 5 million metric tons of CFCs were being produced worldwide each year, for use in refrigeration, air-conditioning, insulating foams, and aerosol cans.

Political leaders were initially reluctant to ban such valuable chemicals on the strength of an uncertain scientific hypothesis. But, over time, further research began to confirm that CFCs indeed posed a serious threat.

In 1976, the National Academy of Sciences upheld Molina and Rowland's conclusions, and 2 years later the United States and several other countries banned the sale of nonessential aerosol cans containing CFCs. Although the ban had a significant impact on CFC emissions and temporarily reduced demand for the chemicals, global production began climbing again as new applications were developed.

By 1985, concern about the continued increase in global CFC production, along with additional scientific evidence, prompted 22 nations to negotiate and subsequently sign the Vienna Convention for the Protection of the Ozone Layer, an agreement that established mechanisms for international scientific cooperation and committed the parties to take action to protect stratospheric ozone.

Although the Convention did not alter the production or use of CFCs, it created the legal framework for a binding protocol to be negotiated in the future.

While significant uncertainties remained, growing scientific evidence led international negotiators to discuss specific limits on the production and use of CFCs and halons (related chemicals that also adversely affect stratospheric ozone). These talks culminated in the signing, in September 1987, of the Montreal Protocol on Substances That Deplete the Ozone Layer.

The Protocol initially required its parties to freeze CFC production at 1986 levels by 1989, phasing down to a 50 percent reduction by 1998. It also froze, but did not reduce, halon production. The agreement provided a 10-year delayed compliance schedule to developing countries with CFC and halon consumption below 0.3 kilograms per capita.

In addition, the Protocol established a process for periodic international assessments of ozone depletion science, the environmental effects of ozone depletion, and technological and economic options. These assessments, performed by expert panels under the auspices of the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), have played a key role in the subsequent negotiation of amendments to strengthen the Protocol's provisions.

In March 1988, just 6 months after the Montreal Protocol was signed, the WMO's Ozone Trends Panel reported that statistically significant levels of ozone depletion were occurring over middle latitudes as well as the poles, and it provided the strongest evidence yet that CFCs and halons were the cause. These findings prompted a reassessment of the Protocol and its effectiveness. Meeting in London in 1990, the parties negotiated the first schedule for a total phaseout of CFCs and other ozone-depleting compounds.

The London amendments banned production and importation of CFCs and halons in industrialized nations by the year 2000 and added two new ozone-depleting compounds—the industrial solvents carbon tetrachloride and methyl chloroform—to the list of controlled chemicals. The London meeting also established a fund to assist developing countries, which must complete their CFC phaseout by 2010, in fulfilling their obligations under the agreement.

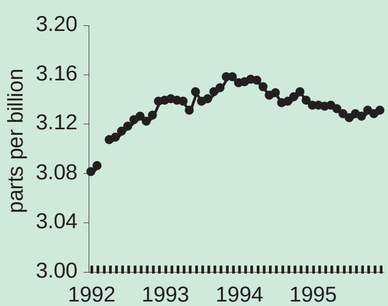
In February 1992, the United States, responding to new scientific information about ozone losses, announced that it would accelerate its phaseout of CFCs to December 31, 1995. This decision, coupled with the conclusions of UNEP/WMO assessments published since the London amendments, helped lead the Montreal Protocol parties to negotiate an accelerated and expanded phaseout later that year.

These amendments, adopted at a meeting in Copenhagen, phased out halons in 1994, and CFCs, carbon tetrachloride, and methyl chloroform by January 1, 1996. The new agreement also set restrictions on hydrochlorofluorocarbons (HCFCs)—CFC substitutes that have a relatively small but not insignificant ozone-depleting potential—and froze the production of methyl bromide, an agricultural fumigant that new research had shown to be an important contributor to ozone depletion.

Meeting again in December 1995, the parties—now numbering more than 150 countries—agreed to phase out the production of methyl bromide in industrialized countries by 2010. Developing countries agreed to new restrictions on methyl bromide and HCFCs.

As a direct result of the Montreal Protocol and its amendments, chlorine concentrations in the troposphere peaked in early 1994 and began declining in 1995 (Figure 11.2). Stratospheric chlorine concentrations are expected to peak before the year 2000. Assuming continued global compliance with the amended Protocol, the ozone layer is projected to gradually recover over the coming decades, returning to pre-ozone-hole levels by around 2050 (Figure 11.3).

Figure 11.2 Tropospheric Abundance of Ozone-Depleting Chemicals from Humans, 1992-1995



Source: Montzka et al., *Science* (May 31, 1996).
Note: Data refer to chlorine and bromine as "equivalent chlorine" in the troposphere.

THE U.S. APPROACH TO OZONE LAYER PROTECTION

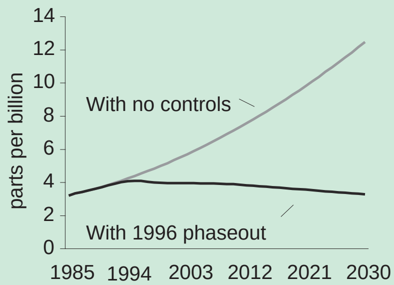
In implementing its commitments under the Montreal Protocol and the Vienna Convention, the United States has aimed to achieve an orderly phaseout of ozone-depleting substances (ODSs) and a smooth transition to alternatives, minimizing costs to producers, manufacturers, and consumers.

The government's approach has emphasized flexibility, facilitation, and close cooperation with affected parties, while attempting to send clear and unambiguous signals that ODS production and imports will be eliminated on schedule.

The phaseout of ODS production and importation has been, and continues to be, implemented through an array of general and sector-specific measures, including:

- a progressively increasing excise tax on controlled substances;
- tradable production and importation allowances;
- a halon banking system;
- monitoring and reporting requirements;
- mandatory recovery and recycling of refrigerants during service and disposal;
- product labeling requirements;

Figure 11.3 Adjusted Atmospheric Chlorine Loading, 1985-2030



Source: U.S. Environmental Protection Agency.

- a program to review the health effects, safety, and availability of alternatives;
- federal procurement regulations;
- bans on nonessential products (such as party streamers);
- interdiction of illegal imports; and
- training of law enforcement officers in the U.S. and abroad.

Narrow exemptions for health- and safety-related applications are allowed, as are small levels of CFC production for export to developing countries. Recycled or surplus ODSs produced or imported prior to the 1996 phaseout may be used to service existing equipment.

Many agencies play a role in these programs, including EPA, the Internal Revenue Service, the Federal Trade Commission, the Customs Service, the State Department, the Commerce Department, the Justice Department and the Department of Agriculture. Individual states and municipalities have also passed legislation or launched programs to reduce emissions of ODSs.

The effective use of market instruments, such as the CFC excise tax and tradable permits, has been a hallmark of the government's phaseout strategy. The excise tax, which took effect in 1990, established a base level (initially $1.37 per pound), with adjustments according to each chemical's ozone-depleting potential. The base tax rose incrementally as the phaseout deadline approached—reaching $5.35 per pound in 1995— providing a clear price signal and an incentive for users to switch to alternatives. The tax applies to floor stocks as well as sales, thus discouraging excessive hoarding of virgin ozone-depleting chemicals for use after the production phaseout. An exemption for recycled and reprocessed CFCs, used primarily to service refrigeration and air-conditioning equipment, is making the transition more affordable for building and automobile owners.

The tradable permit system ensured an orderly phaseout of production and consumption of ODSs by allocating steadily diminishing allowances to producers and importers. To provide flexibility, unused allowances could be sold, with certain restrictions, to companies that were still manufacturing or importing the chemicals. Allowances could also be used, with restrictions, to make or import larger quantities of other chemicals with a lower ozone-depleting potential.

The federal government has combined regulatory controls with a collaborative and flexible approach, working closely with producers, manufacturers, and users to ensure a smooth transition away from ozone-depleting substances. For example, when it first became apparent that supplies of CFC-12—a refrigerant used in car air conditioners and some chillers (air-conditioning units for commercial buildings)—might not be adequate to service existing equipment after the phaseout, EPA encouraged affected industries to establish banks of virgin and recycled CFC-12 while the chemical was still readily available. The agency provided information on alternatives to CFC-12 and encouraged industry to extensively evaluate low-cost alternatives for use in existing car air conditioners.

EPA currently operates a nationwide CFC-12 clearinghouse on the Internet to improve public access to information about price and availability of the refrigerant. The U.S. government has played an important facilitative role in the development of alternative chemicals and technologies. The Significant New Alternatives Policy (SNAP) program, officially established in early 1994, has evaluated the safety and environmental acceptability of a wide range of ODS substitutes in nearly 100 specific end uses. SNAP has listed viable alternatives for virtually every ODS application (with the exception of methyl bromide), and it has helped users direct investments appropriately.

EPA also serves as a clearinghouse for practical information on ODS alternatives. In 1994, the agency began publishing case histories documenting the ways in which individual companies eliminated their use of CFCs, and it has sponsored an international conference on CFC and halon alternatives each year since 1988. EPA operates a toll-free Stratospheric Ozone Hotline to answer queries from businesses, organizations, and the general public.

Key policy developments at the federal level in 1994 and 1995 include publication of the final SNAP rule and subsequent updates, mobilization of a multiagency effort to crack down on illegal imports of CFCs, and continued support for development of alternatives to methyl bromide. EPA also revised controls for imports of used and recycled ODSs, modified requirements for exporting ODSs to developing countries, and implemented a number of other administrative changes in the program. EPA, the National Weather Service and the Centers for Disease Control and Prevention launched the UV index, a public health information program aimed at preventing dangerous exposures to ultraviolet radiation.

INDUSTRY'S ROLE

In the 1980s, U.S. companies were using hundreds of thousands of tons of CFCs to manufacture more than $100 billion in products each year.

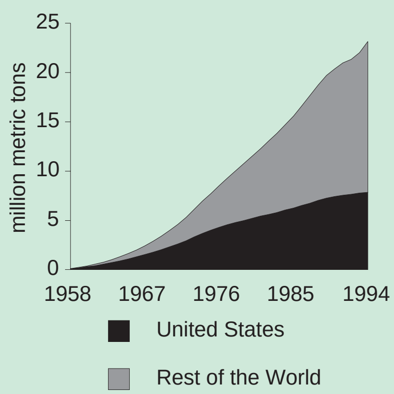
By the end of 1995, the production and importation of CFCs was banned in the United States and the rest of the industrialized world. The fact that such a rapid transition to alternatives occurred without massive economic disruption owes much to the creative and proactive initiatives undertaken by industry.

Industry groups and individual companies, large and small, dedicated substantial resources toward meeting this challenge. Many set stringent, self-imposed deadlines that went well beyond those required by law. For example, in 1988, food-service packaging manufacturers voluntarily phased out their use of CFCs in foam products. In 1991, in response to new scientific evidence, DuPont announced that it would halt its production of CFCs by 1997, three years ahead of the schedule then imposed by the Montreal Protocol. In early 1993, DuPont announced it would stop producing CFCs by the end of 1994. Many other companies eliminated their use of ODSs ahead of schedule, or voluntarily improved their products to reduce emissions, and found that their actions gave them a competitive advantage.

Industry groups such as the International Cooperative for Environmental Leadership (launched in 1989 as ICOLP, the International Cooperative for Ozone Layer Protection) have been valuable allies in the effort to eliminate ODSs. Member companies credit ICOLP with helping them achieve their phaseouts ahead of schedule; in some cases up to 4 years ahead of Montreal Protocol deadlines. In partnership with EPA, ICOLP has published and distributed seven technical manuals on ODS alternative technologies and practices, and many developing countries have profited from ICOLP technical assistance projects.

EPA has provided public recognition for these dedicated companies and organizations through its annual Stratospheric Ozone Protection Awards program.

Figure 11.4 Cumulative Production of CFCs,1958-1994



Source: See Part III, Table 71.
Note: Data refer to production of CFC-11 and CFC-12.

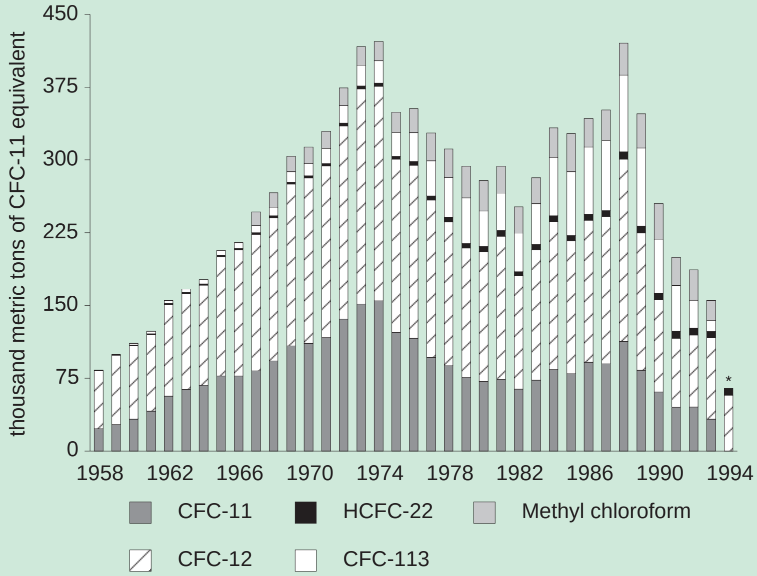
RESULTS OF THE U.S. PHASEOUT

Before 1970, the United States was the world's leading producer of CFCs. But after the aerosol ban and subsequent Clean Air Act controls, the U.S. share of global production rapidly declined. However, by the mid-1990s, the United States still accounted for about one third of world production (Figure 11.4).

Production of CFCs in the United States peaked in 1987 at nearly 400,000 metric tons, dropping to approximately 180,000 metric tons by 1995 before ending in 1996 (Figure 11.5). Without controls, the production of CFCs was estimated to reach almost 3 million metric tons by 2005.

In some cases, the phaseout has had economic as well as environmental benefits. For example, some ozone-benign technologies and practices have proved more cost-effective than those employing

Figure 11.5 U.S. Production of Selected Ozone-Depleting Chemicals, 1958-1994



Source: See Part III, Table 71.
Note: *1994 data for CFC-11, CFC-113, and methyl chloroform not available.

ODSs. For example, when solvent users began researching alternative cleaning methods, many found that they could reduce or eliminate the use of chemicals without sacrificing product quality. Water- and citrus-based solvents have replaced CFCs in many applications, and some manufacturers have managed to eliminate the cleaning process altogether.

Significant improvements in energy efficiency are expected to result from the conversion of existing refrigeration equipment to CFC alternatives. By 1998, according to the Air Conditioning and Refrigeration Institute, 44 percent of existing chillers will be converted or replaced with equipment that uses non-CFC refrigerants. For new equipment owners, the resulting efficiency improvements are expected to reduce energy use by almost 7 billion kilowatt-hours per year, saving them $480 million annually. These estimated energy savings would avoid some 4 million metric tons of carbon dioxide and 34,000 metric tons of sulfur dioxide emissions from fossil fuel power plants.

FUTURE CHALLENGES

The successful phaseout of CFCs, halons, methyl chloroform, and carbon tetrachloride is not the end of the ozone protection story. Many issues remain to be addressed, on both the domestic and the international level.

Stockpiles of virgin and recycled CFCs will be used to service existing air-conditioning and refrigeration equipment for some time to come. Mobile air-conditioning (in cars and trucks) is the largest source of ODS emissions in the United States, and some 90 million older vehicles on the road in 1995 still use CFC-based air conditioners. Mandatory recovery and recycling of refrigerants have greatly reduced emissions, but leaky systems still pose a problem.

Fortunately, in many cases the cost to convert these vehicles to alternative refrigerants is far less than some engineers originally thought. For some vehicles and some refrigerants, the cost to convert is only slightly more than that of recharging the system with CFC-12.

Emissions of two leading classes of ODS alternatives, the HCFCs and hydrofluorocarbons (HFCs), must be controlled to reduce their environmental impacts. Both HCFCs and HFCs contribute to global climate change; HCFCs, while contributing much less to ozone depletion than CFCs, still contribute some chlorine to the stratosphere. EPA now requires that both be recycled during servicing of air-conditioning and refrigeration equipment.

The Montreal Protocol eliminates HCFCs by 2030, allowing them to serve as interim substitutes. The U.N. Framework Convention on Climate Change and its future protocols, if any, may eventually require countries to control emissions of HFCs. EPA intends to continue working with industry to identify alternatives to HCFCs and HFCs and to mitigate their effects through containment and recycling. EPA is also rejecting (through the SNAP program) those alternatives that exhibit very high global warming potential unless there is no other feasible substitute available.

Non-ozone-depleting alternatives for halons are still needed for about 10 percent of total halon use. These include military applications (e.g., fire protection in personnel carriers and command centers), industrial processing of flammable liquids and gases, and aviation. Several U.S. and international groups, including the U.S. military, EPA, the British Ministry of Defense, and U.S. industry, are seeking alternatives for these applications.

Public awareness and concern about the health impacts of ozone depletion may be waning. A number of recent media reports on scientific findings have given the impression that ozone depletion is a “solved problem” and that there is little to worry about. In fact, the ozone layer is expected to continue thinning until around the year 2000, and will recover only gradually after that. It is not expected to return to pre-ozone-hole conditions until the middle of the next century.

The phaseout of methyl bromide poses challenges in the United States and internationally. Under the Montreal Protocol, production and consumption of methyl bromide must be phased out in industrialized countries by 2010. The United States, which accounts for 41 percent of global consumption, froze methyl bromide production at 1991 levels in 1994 and will phase out its production and importation by 2001. Many alternatives to methyl bromide have been identified, but their effectiveness depends on the specific crop and target pest being addressed. The U.S. Department of Agriculture is taking the lead on research and development of additional alternatives.

The control of illegal imports of CFCs into the United States will require continued vigilance. Illegal importers have established a black market for new CFCs that are claimed as recycled (and therefore not subject to an import ban), disguised as other substances, or listed as intended for export to other countries. Estimates of CFCs that illegally entered the United States during 1994 and 1995 range from 10 million to 30 million pounds.

EPA and the Justice Department will continue to work with the Customs Service, the Internal Revenue Service, the Commerce Department and the State Department to crack down on this problem.

Over 1 million pounds of CFCs that were illegally imported into the United States were seized by Customs officials in 1995, and numerous convictions have resulted from these seizures. Illegal imports have been significantly curtailed in 1996.

EPA has also instituted a petition process, by which importers intending to bring in used CFCs must submit extensive information to EPA that indicates the material's former use and handlers. The agency must then approve that petition before the substance can be imported as a legitimately recycled compound.

CONCLUSIONS

The global response to the ozone crisis stands as a model for policy-science dialogue, international cooperation, and regulatory and industrial innovation. As a world leader in this process, the United States has demonstrated that flexible, market-based policies, developed in cooperation with affected parties, along with effective enforcement, can help achieve ambitious environmental goals without significant economic disruption. While the job of protecting the ozone layer is not yet complete, the successful phaseout of CFCs less than 10 years after controls were first negotiated remains a remarkable achievement, a powerful testimony to the effort, ingenuity, and cooperation of thousands of dedicated individuals worldwide.

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CHAPTER TWELVE

Climate Change

The effort to understand and respond to the risks of global climate change entered a critical period in the mid-1990s.

At the end of 1995, the Intergovernmental Panel on Climate Change (IPCC) released its Second Assessment Report. Prepared by 2,500 of the world's leading experts on climate change, this report provides an exhaustive review of all aspects of climate change and its health, environmental, and economic impacts. The report concludes that "the balance of evidence suggests that human activities are having a discernible influence on global climate."

Efforts to address the risks of climate change have moved forward under President Clinton's Climate Change Action Plan, though reduced Congressional funding has limited the plan's effectiveness. By the end of 1995, over 5,500 businesses, schools, churches, and state and local governments were participating in voluntary programs under the plan aimed at reducing net emissions of greenhouse gases. These activities will reduce greenhouse gas emissions by millions of metric tons of carbon equivalent, saving United States' industries and consumers billions of dollars in reduced energy costs.

International efforts to limit greenhouse gases have focused on discussions underway to strengthen the Framework Convention on Climate Change (FCCC). Originally signed at the Rio Summit in 1992, the convention includes a "non-binding aim" of stabilization of greenhouse gas emissions at 1990 levels in the year 2000. In July 1996, at the Second Conference of the Parties to the Climate Convention, the United States announced its support for a framework based on "realistic, verifiable, and binding" medium-term targets that would include the use of trading to enhance flexibility and reduce costs. The current round of negotiations under the Climate Convention is scheduled to conclude in December 1997.

BACKGROUND

The IPCC's recently completed Second Assessment is the scientific community's most exhaustive and thorough review to date of issues related to climate change. Key findings from the IPCC report include the following:

Physical Climate System

- The atmospheric concentrations of greenhouse gases and aerosols are increasing because of human activities.

- Greenhouse gases tend to warm the atmosphere, and sulfate aerosols cause regional cooling. Most greenhouse gases will remain in the atmosphere for many decades to a century or more; sulfate aerosols are removed after several years.
- The Earth's surface temperature has increased by about one degree Fahrenheit over the last century.
- Sea level has increased 4-10 inches during the last century, and mountain glaciers are retreating worldwide.
- Models that account for the observed increases in the atmospheric concentrations of greenhouse gases and sulfate aerosols are simulating the recent history of observed changes in surface temperature with increasing realism.
- The balance of evidence suggests a discernible human influence on the Earth's climate, remaining uncertainties notwithstanding.
- Without global climate-specific policies to mitigate greenhouse gas emissions, the Earth's temperature is projected to increase by roughly 2 to 6 degrees Fahrenheit by 2100, a rate of warming faster than any determined for the last 10,000 years.
- These changes in temperature are projected to be accompanied by an increase in sea level of 6 to 38 inches by 2100.
- The atmospheric lifetime of many greenhouse gases, coupled with the thermal inertia of the oceans, means that the warming effect of anthropogenic emissions will be long-lived—even sharp reductions in greenhouse gas emissions would reverse warming only slowly.

Ecological and Socioeconomic Systems

- Regional and global changes in temperature, precipitation, soil moisture, and sea level from climate change add important new stresses on ecological and socioeconomic systems that are already affected by pollution, increasing resource extraction, and nonsustainable management practices.
- Most systems are sensitive to both the rate and magnitude of climate change.
- Projected changes in climate will result in adverse effects on human health (particularly via vector-borne diseases) and many ecological systems (especially forests) and socioeconomic sectors (e.g., the regional production of food).
- Developing countries would be particularly vulnerable to these impacts.

Adaptation and Mitigation

- Stabilization of atmospheric concentrations of carbon dioxide at three times the pre-industrial concentrations or less will eventually require global emissions to drop below today's levels.
- A range of cost-effective technologies and policies can be used in both

developed and developing countries to markedly reduce the emissions of greenhouse gases from industrial, energy supply, energy demand, and land management practices.

- Deep long-term cost-effective reductions will require an intensive R&D program in energy, industrial, and crop technologies.
- Flexible, cost-effective policies relying on economic incentives and instruments, as well as internationally coordinated instruments, can considerably reduce mitigation and adaptation costs.
- Potential adaptation options for many developing countries are extremely constrained due to the limited availability of technological and economic options.
- International and intergenerational equity issues are critical for policy formulation.
- There is justification for going beyond a "no-regrets" action strategy. "No-regrets" actions are those that save money or achieve other environmental goals while also reducing greenhouse gas emissions.

CONDITIONS AND TRENDS

The Climate System

A natural "greenhouse effect" keeps the Earth about 33^{o} C (nearly 60^{o} F) warmer than it would otherwise be. Water vapor, carbon dioxide, and other gases trap heat as it is radiated from the Earth's surface back to space—much as the glass panels of a greenhouse trap heat inside. Without this natural greenhouse effect, life as we know it would not be possible.

Over the entire history of the planet, global climate has varied substantially. During the last ice age, which ended roughly 17,000 years ago, the Earth was an average of 9^{o} F cooler, and much of North America was covered in several thousand meters of ice. As the Earth warmed over the next 10,000 years, the glacial ice melted back and sea levels rose approximately 3 feet per century, among other things flooding our continental shelves and shallow estuaries like the Chesapeake Bay. As human society evolved, it adapted to regional climates and to slow shifts in natural variations.

As a result of global industrialization and the spread of agriculture over the past 200 years, human activities have added to the natural greenhouse effect by releasing additional greenhouse gases to the atmosphere. Carbon dioxide (CO_2) from burning fossil fuels is the primary source of emissions. Since plants and soils store large amounts of carbon, clearing forests for agriculture and other uses also contributes a significant share. Other greenhouse gases include methane (CH_4) and nitrous oxide (N_2O), as well as chlorofluorocarbons and their substitutes (see Chapter 11, "Stratospheric Ozone," for a discussion of the impact of chlorofluorocarbons on stratospheric ozone). The resulting buildup of greenhouse gases in the atmosphere is enhancing the natural greenhouse effect.

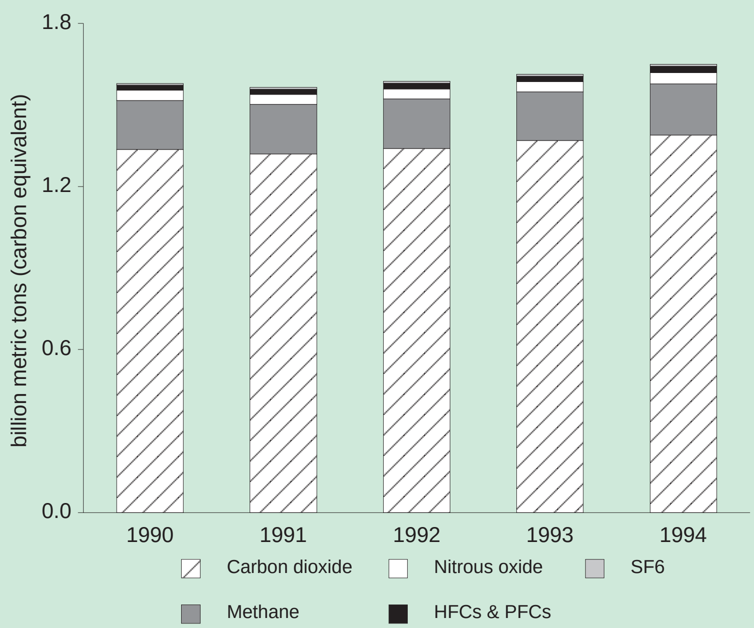
Emissions Trends

Since the preindustrial era, atmospheric concentrations of carbon dioxide have increased by nearly 30 percent, methane concentrations have doubled, and nitrous oxide concentrations have risen by 15 percent. Since 1958, carbon dioxide concentrations have increased by approximately 12 percent.

Figure 12.1 illustrates recent trends in U.S. emissions of greenhouse gases, which include carbon dioxide, methane, nitrous oxide, and various halogenated compounds. These contributions were calculated on the basis of each gas's potential to increase the greenhouse effect—its global warming potential (Box 12.1). Changes in CO_2 emissions from fossil fuel consumption had the greatest impact on total U.S. greenhouse gas emissions from 1990 to 1994. By 1994, CO_2 emissions from fossil fuels were 4 percent above 1990 levels. Emissions have risen with economic growth and falling energy prices.

Although the heat-trapping abilities of methane and nitrous oxide are relatively high, CO_2 has accounted for 65 percent of the increased radiation caused by greenhouse gases over the past 100 years. Carbon dioxide is released primarily from the combustion of fossil fuels and deforestation. According to the Department of Energy, approximately 85 percent of U.S. primary energy is produced from the

Figure 12.1 U.S. Emissions of Greenhouse Gases, 1990-1994



Source: See Part III, Table 28.
Notes: HFCs=hydrofluorocarbons. PFCs=perfluorocarbons. SF6=sulfur hexafluoride. Sinks not included.

Box 12.1
Global Warming Potential

Since some greenhouse gases trap more heat in the atmosphere than others, measurements of global warming potential have been developed to allow scientists and policy-makers to compare the ability of greenhouse gases to trap heat in the atmosphere over time. Although any time period may be selected, the average warming over a 100-year period is recommended by the IPCC and is used in this report. Carbon dioxide is often used as a reference gas, and units are often millions of metric tons of carbon equivalent.

Over a 100-year period, methane is 24.5 times as effective as carbon dioxide at trapping heat in the atmosphere. In 1990, methane emissions were 27.1 million metric tons. However, their contribution to the greenhouse effect was equal to 181 million metric tons of carbon dioxide emissions.

Some human-induced gases that influence the climate system—such as sulfates and aerosols—actually have a cooling effect. However, aerosols are short-lived and vary regionally, and therefore they should not be counted as a simple offset to greenhouse gases. In addition, their buildup will likely be limited because of their health effects.

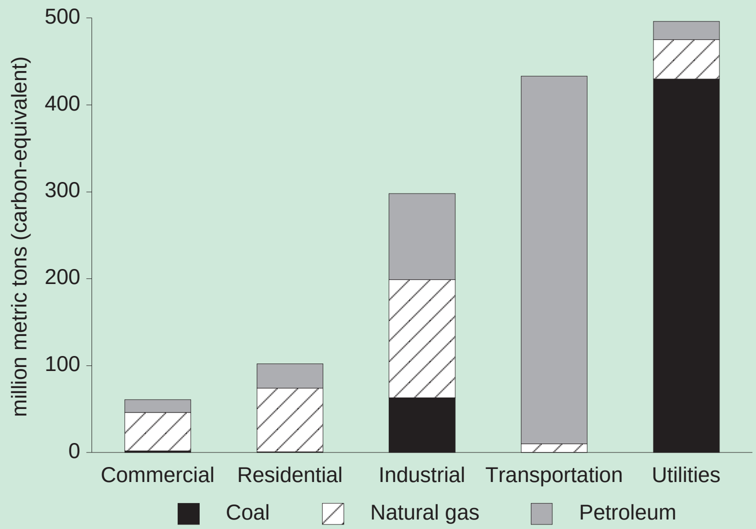
combustion of fossil fuels, and this combustion accounts for roughly 88 percent of annual emissions of all U.S. greenhouse gases on a carbon-equivalent basis. Petroleum supplies just over 38 percent of national energy needs, and natural gas and coal supply 25 and 22 percent, respectively. The amount of CO_2 produced in burning varies significantly across fuels. For example, coal has the greatest amount of carbon per unit of energy, followed by petroleum (about 25 percent less) and natural gas (about 45 percent less).

In the United States, it is estimated that electric utilities account for 36 percent of annual CO_2 emissions; coal supplies 55 percent of their energy requirements. Transportation (32 percent) is the second largest and fastest growing source of CO_2. Nearly two thirds of transportation emissions are the result of gasoline consumption. Industry (21 percent) relies on gas, oil, and coal. The residential (7 percent) and commercial (4 percent) sectors rely mainly on natural gas (Figure 12.2).

Carbon dioxide is absorbed by the oceans, trees, and soils and is emitted through natural processes. Forests cover about 737 million acres of the United States and absorb and store CO_2. Atmospheric concentrations of CO_2 are thus affected by changes in agricultural and forestry practices. From 1990 to 1992, U.S. forests, soils, and wood products sequestered approximately 125 million metric tons of carbon equivalent each year (see Chapter 17, “Forestry”).

Methane is second only to CO_2 as a source of the enhanced greenhouse effect. Atmospheric methane concentrations have more than doubled in the last two centuries. Although methane is released by many natural processes (including the decay of organic matter),

Figure 12.2 U.S. Emissions of Carbon Dioxide from Fossil Fuel Combustion by Sector and Fuel Type, 1994



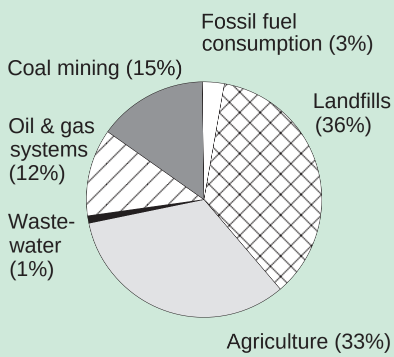
Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1994* (EPA, Washington, DC, 1995).
Note: Although not shown, U.S. territories account for slightly less than 1% of total emissions.

the increased atmospheric concentration is mostly due to human activities. The largest sources of U.S. methane emissions are landfills, agriculture, coal mining, and the production and processing of petroleum (Figure 12.3).

Nitrous oxide is approximately 320 times more heat absorbent than CO_2, although nitrous oxide emissions are much smaller by volume. Nitrous oxide is produced naturally from a wide variety of biological sources in soil and water. The use of fertilizer represented 45 percent of U.S. emissions in 1994. Manure, fossil fuel combustion, burning crop residues, and production of adipic and nitric acids also generate nitrous oxide emissions.

Halogenated compounds were first emitted to the atmosphere early this century. This family of engineered compounds includes chlorofluorocarbons (CFCs), partially halogenated compounds (HFCs and HCFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Industrial processes and consumer products that employ these substances include refrigeration and air-conditioning, solvent cleaning, and foam production. HFCs and PFCs were recently introduced as alternatives to CFCs, which are being phased out under the 1987 Montreal Protocol on Substances That Deplete the Ozone Layer. HFCs, PFCs, and SF_6 are all powerful green-

Figure 12.3 Sources of U.S. Methane Emissions, 1994



Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1994* (EPA, Washington, DC, 1995).

house gases whose manufacture and emissions are expected to rise.

Climate Trends

The surface temperature this century is as warm as, or warmer than, that of any other century since at least 1400 A.D. Global temperatures do, in fact, appear to be rising. According to the IPCC, land-based observations as well as data collected from ships show that the Earth's average surface temperature has warmed 0.5^{o} to 1.0^{o} F in the last century. Although satellite observations provide only a 16-year series, too short to infer a trend, these data show the same pattern over land masses as the surface temperature measurements. The observed warming is consistent with what climate models calculate should have occurred due to the combined effects of greenhouse gases, depletion of the stratospheric ozone layer, and sulfate aerosols.

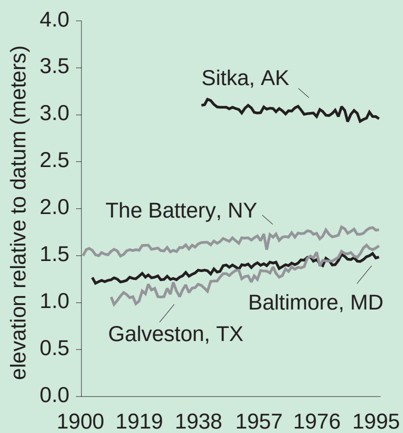
Temperature trends in the United States are also generally consistent with the climate model projections. The western states have been warming more rapidly than the global average. In the eastern states, however, where sulfates would be expected to have the greatest cooling effect, temperatures have cooled slightly in the last 50 years. U.S. nighttime temperatures are rising more rapidly than daytime temperatures.

Rainfall is tending to be more concentrated in heavy downpours, according to a new study by the National Oceanic and Atmospheric Administration. At the beginning of the 20th century, only 8 percent of the nation experienced a storm each year in which more than 2 inches of rain fell in a 24-hour period. In recent decades, such a severe storm occurs each year over about 12 percent of the nation.

Sea level is rising along the U.S. coast in all but a few northern areas, where the Earth's crust has been rising since the glaciers retreated at the end of the last ice age (Figure 12.4). The majority of U.S. shorelines are eroding, owing to sea level rise and other factors. In Maryland alone, for example, 30 miles of natural shoreline each year are replaced by rock revetments. Sea level has risen about 4-10 inches over the past century; about half of the rise is believed due to oceanic warming and half due to melting mountain glaciers.

Unless the world takes steps to reduce the emissions of carbon dioxide, the IPCC estimates that concentrations of atmospheric carbon dioxide will roughly double by 2100. Model calculations project that the average global surface tem-

Figure 12.4 Sea Level Trends Along the U.S. Coast, 1900-1995



Source: NOAA, Tide Station Data, unpublished, 1996.
Note: Data refer to yearly mean sea level values relative to tide station datum at each location.

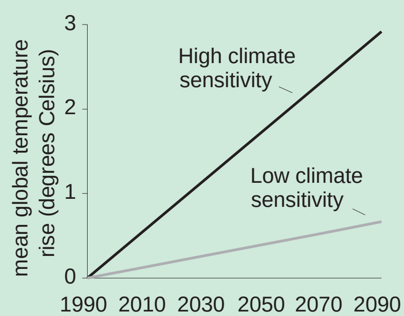
peratures will rise by about 1.8^{o} to 6.3^{o} F by 2100. Global average temperature changes of this magnitude would be greater than recent natural fluctuations and would occur at a rate significantly faster than has occurred over the last 10,000 years (Figure 12.5).

Based on these calculations, sea level is projected to rise by 6 to 38 inches by 2100, continuing the trend of thermal expansion of the oceans and glacial melting. Rising global temperatures are generally expected to increase the rate of evaporation and to lead to changes in precipitation and soil moisture. The models also suggest that the frequency of intense rainfall will increase and there will be a marked decrease in soil moisture over some mid-latitude continental regions during the summer. Such changes could have adverse effects on agriculture, forests, human health, and coastal communities.

Although it is unclear whether climate will become more variable, the frequency and intensity of some extreme weather events of critical importance to ecological systems (e.g., droughts, floods, frosts, frequent hot or cold spells, and associated fire and pest outbreaks) could increase with a global rise in temperature. Climate change cannot be unambiguously related to specific weather events; however, when they do occur, these events can be costly. For example, weather-related disasters since 1992 have resulted in $70 billion in damage and several hundred deaths from floods, heat waves, hurricanes, blizzards, and hailstorms.

The relatively long atmospheric residence times of many greenhouse gases—typically decades to centuries—coupled with the thermal inertia of the oceans, mean that the warming effect of human-induced emissions will be long-lived. Even with a stabilization of atmospheric

Figure 12.5 Alternative Global Temperature Rise Estimates*



Source: Intergovernmental Panel on ClimateChange, *Summary for Policy Makers* (Washington, DC, 1995).
Note: *Projections based on rising CO2 concentrations.

greenhouse gas concentrations in 2100, temperatures would continue to increase for several decades, and sea level would continue to rise for centuries. Although much is already known about the greenhouse effect and the basic heat-trapping property of the gases is essentially undisputed, substantial reduction in key uncertainties (detailed quantification of timing, magnitude, and regional patterns of change) may require a decade or more.

DIRECT IMPACTS AND SOCIAL RESPONSES

The regional and global impacts from human-induced climate change could add significant new stresses on ecological systems that are already affected by pollution, increasing resource extraction, and unsustainable management practices. The most vulnerable systems are those with the greatest sensitivity and the least adaptability. To varying degrees, natural ecosystems, socioeconomic systems, and human health are sensitive to both the rate and the magnitude of climate change. Further, developing countries—which have historically had the lowest emissions—are generally more vulnerable to climate change than industrialized nations because of their geographic, socioeconomic, and cultural conditions, according to the IPCC.

Rising global temperatures are expected to raise sea level and change precipitation and other local climate conditions. Changing climate could alter crop yields, water supplies, and the composition of forest species and threaten human health, air and water quality, and some forests and other ecosystems.

Human Health. Throughout the world, the prevalence of particular diseases and other threats to human health depends partly on local climate. Insects and other pests that carry diseases are often limited by climate. For example, the parasite that causes malaria cannot develop at temperatures below 57^{o} to 61^{o} F. Heat itself can threaten human health. In July 1995, for example, a 5-day heat wave contributed to the deaths of more than 400 people in Chicago alone.

The most direct effect of changing climate on human health is heat stress. Statistics on mortality and hospital admissions show that death rates increase during extremely hot days, particularly among very old and very young people living in cities. The indirect effects of climate change, however, could be more serious. The potential transmission of diseases spread by mosquitoes and other insects, for example, could increase as warmer temperatures enable the cold-blooded insects to survive farther north, at higher altitudes, or for longer seasons. Other pest-borne diseases that may become more severe include malaria, dengue fever, yellow fever, and encephalitis. Climate change may also cause outbreaks of diarrheal diseases, such as cholera. It could also promote toxic algal blooms, which are often associated with contaminated seafood.

Although climate change could increase malaria by as many as 50-80 million cases a year, according to the IPCC, existing public health resources would make a reemergence of this disease in the United States very unlikely. Similarly, heat-related deaths can be reduced by accurate warning systems, appropriate emergency response measures (e.g., moving vulnerable people to air-conditioned buildings), and behavioral changes on the part of individuals (e.g., curtailing physical activities, drinking fluids). Other impacts of climate change on health could be minimized through maintenance of strong public health programs to monitor, quarantine, and treat the spread of infectious diseases. However, these measures may be costly to implement and developing countries may not have the infrastructure to cope with these health-related impacts.

The American Public Health Association (APHA) recently adopted a resolution expressing concern about the human health effects of climate change. In view of the scale of potential impacts, the APHA recommended precautionary primary preventative measures (e.g., reductions in greenhouse gases) to avert climate change.

Water Resources. Precipitation and evaporation are both likely to increase worldwide. In those areas where evaporation increases more than precipitation, soil will become drier, lake levels will drop, and rivers will carry less water.

Lower river flows and lake levels could impair navigation and water quality and reduce the amount of water available for ecological, agricultural, residential, and industrial uses, as well as for hydropower. Some areas may experience both increased flooding during winter and spring and lower supplies during summer. In California's Central Valley, for example, melting snow provides much of the summer water supply; warmer temperatures would cause the snow to melt earlier and thus reduce summer supplies even if rainfall increased during the spring. More generally, the tendency for rainfall to be more concentrated in large storms as temperatures rise would tend to increase river flooding, without increasing the annual amount of water available.

Many federal and state agencies are actively engaged in reducing the nation's vulnerability to these types of impacts. In the western United States, where freshwater is scarce, a trend toward allowing farmers to sell water is enabling scarce water to be used more efficiently. Along the Mississippi River and other flood plains, the Federal Emergency Management Agency and others are reviewing structural and land use measures for reducing vulnerability to floods. Finally, both the Corps of Engineers and the Bureau of Reclamation are developing better ways to manage the federal system of reservoirs in the face of changing climate to meet the competing needs of navigation, hydropower, water supply, recreation, and environmental quality.

Coastal Zones. Sea level is rising more rapidly along some U.S. coasts than worldwide. A 1995 study by EPA estimates that along the Gulf and Atlantic coasts, a 1-foot rise in sea level is likely by 2050 and could occur as soon as 2025. Such a rise would cause most sandy beaches to erode 100 to 200 feet. In undeveloped areas, beaches and wetlands would simply migrate inland. Along developed coasts, however, homes are often less than 100 feet from the water's edge. Thus, even a 1-foot rise in sea level would require many ocean beach resorts to incur the costs of periodically pumping sand onto their beach or removing beachfront houses.

Over the longer term, a 1.5- to 3-foot rise in sea level could inundate up to one half of U.S. coastal wetlands and 4,000 to 7,000 square miles of dry land, if developed areas were not adequately protected with bulkheads or other structures. Most of these losses would be concentrated in the southeastern and mid-Atlantic states, particularly Louisiana and Florida. If bulkheads are built to protect developed areas, the loss of dry land will be less, but the wetlands and beaches would be lost if the structures are built and block their landward migration.

To protect the coastal environment and the public's right to use the shore, several states have adopted policies to ensure that beaches, dunes, or wetlands are able to migrate inland as sea level rises. Some states prohibit new houses in areas likely to be eroded in the next 30 to 60 years. Concerned about the need to protect property rights, Maine, South Carolina, and Texas have implemented some version of "rolling easements," in which people are allowed to build, but only on the condition that they will remove the structure if and when it is threatened by an advancing shoreline.

Agriculture. The success or failure of a harvest has always depended on climate, with the most important factor being a sufficiently moist soil during the growing season. During extended droughts such as the Dust Bowl of the 1930s, crop failures have been widespread. Some climatologists suggest that such conditions could become even more widespread because of the drier soils that may accompany changing climate. Increased heat stress, more frequent flooding, and salinization of soils due to sea level rise could also threaten agriculture in some areas.

There may also be some offsetting benefits to agriculture. In colder areas, warmer temperatures would lengthen the growing season. Moreover, higher levels of atmospheric carbon dioxide have a fertilizing effect, which enables plants to grow more rapidly. Finally, up to a certain concentration higher carbon dioxide levels also increase the efficiency with which plants use water, which may tend to offset some of the adverse effects of drier soils.

Recent assessments of the impact of climate change on agriculture have suggested that the beneficial effects would offset the adverse impacts, at least in the United States. A 1995 study by USDA, for example, concluded that even a 5^{o} to 9^{o} F warming would be unlikely to significantly affect total U.S. agricultural production.

Nevertheless, there may be significant dislocations. Several studies have suggested that Appalachian farmers could be particularly vulnerable. Other, drier areas could become permanently lost to agriculture or require expensive irrigation.

Forests and Terrestrial Ecosystems. A 3.6^{o} F warming could shift the ideal range for many North American forest species by about 200 miles to the north. If the climate changed slowly enough, warmer temperatures would enable the individual species to migrate north into areas that were previously too cold, at about the same rate as southern areas became too hot for the species to survive. If Earth warms 3.6^{o} F in 100 years, however, the species would have to migrate 2 miles per year, which is much faster than most tree species are able to migrate.

Several other impacts associated with changing climate further complicate the picture. On the positive side, it is possible that the fertilization effect of carbon dioxide on plants may enable some species to resist the adverse effects of warmer temperatures or drier soils (as long as nutrients are not limiting). Nevertheless, increased severity of fires and droughts, or changes in pest populations, could further increase the stress on forests. Managed forests may tend to be less vulnerable than unmanaged forests, because the managers will be able to shift to tree species appropriate for the warmer climate.

The potential impacts of climate change on wildlife are poorly understood. If habitats simply shift to higher latitudes or higher altitudes, many forms of wildlife could potentially adapt to climate change, although the complete ecosystem on which they depend may not be able to move in tandem. Unlike previous climatic shifts, roads, development, and other modifications to the natural environment may block the migration routes. Moreover, the rate of climate change is predicted to be far faster than has occurred in the past, further limiting natural adaptation. For example, nature reserves, often established to protect particular species, may no longer be located in a climate hospitable to that species.

Impact on Other Forms of Pollution. Changing climate will have ramifications for efforts to protect the environment described in other chapters of this report, particularly air and water pollution efforts. In those areas where river flows decline, water could become more polluted because there would be less freshwater to dilute existing effluents. Even in areas where river flows are maintained, warmer temperatures would tend to lower the level of dissolved oxygen, threatening the ability of several southern states to attain their water quality criteria standards. Increasing amounts of rainfall during severe storms would increase the frequency with which combined municipal wastewater systems are overwhelmed, necessitating more discharges of raw sewage; more severe storms would also increase nonpoint pollution runoff.

Changing climate could also impair urban air quality. For example, warmer temperatures enhance the process of photochemical oxidation and would thus be likely to increase ozone levels in metropolitan areas.

RECENT POLICY DEVELOPMENTS

The Climate Change Action Plan

In 1992, as part of the Earth Summit in Rio de Janeiro, the United States joined with more than 150 other nations in signing the Framework Convention on

Climate Change. This landmark treaty called for cooperation among all nations in addressing the risks of climate change and established as a non-binding aim that developed countries seek to return their greenhouse gas emissions to 1990 levels by the year 2000.

On Earth Day in 1993, President Clinton announced the U.S. program to meet this goal. The Climate Change Action Plan included almost 50 largely voluntary measures aimed at reducing net greenhouse gas emissions while saving industry and the public billions of dollars in reduced energy costs. The plan relied extensively on innovative public-private partnerships to encourage development and enhanced diffusion of energy- and cost-saving technologies (Box 12.2). The original goals outlined in the plan called for reductions in emissions of over 100 million metric tons of carbon equivalent (roughly 8 percent below baseline growth). These reductions would be achieved at an estimated cumulative savings of $61 billion to the U.S. economy between 1990 and 2000.

In the two years since the Plan was announced, considerable progress has been made in implementing many of the actions. For example, the Climate Challenge program has attracted participation by utilities representing over half of the Nation's electricity production. These companies have agreed to undertake a wide range of activities aimed at reducing net greenhouse gas emissions (Box 12.3).

Other actions have facilitated the increased market diffusion of energy efficient lighting through the Green Lights programs (Box 12.4) and the use of energy-saving office computers, printers, and other office equipment through Energy Star products (Box 12.5).

Box 12.2
Highlights of the Climate Change Action Plan

The Clinton Administration's Climate Change Action Plan:

- **Identifies and promotes the use of energy-efficient products.** The plan provides opportunities for corporate purchasers and consumers to make educated decisions on energy use.
- **Promotes large-scale purchasing of energy-efficient and renewable technologies.** By helping to improve economies of scale and by moving these technologies into the market, the plan helps prices fall to levels equal to or below those of alternatives that result in higher greenhouse gas emissions.
- **Encourages industry to commercialize more resource-efficient technologies.** The plan demonstrates that these technologies will sell by providing clear "market-pull" that is organized through mass-purchase initiatives and program coordination.
- **Promotes sensible regulatory and legal frameworks.** The plan encourages cost-effective investments in energy efficiency and methane recovery programs.

Box 12.3
Emissions Reductions by Electric Utilities—Climate Challenge

"*In the global warming debate, proactive management, willingness to negotiate and leadership through voluntary initiatives are our strongest trump cards. . . Through a series of positive actions, we can become participants in positive progress instead of negative rule.*"

Mark DeMichele, President and CEO, Arizona Public Service

"*This voluntary, flexible initiative is the best way to tap the utility industry's technical skill and problem solving capabilities, while obviating the need for costly command and control requirements.*"

E. Linn Draper, Jr., Chairman, American Electric Power

Despite the substantial success of actions under the Plan, it now appears likely that the U.S. will fall far short of the original goal of returning net greenhouse gas emissions to 1990 levels by the year 2000. Actions under the Plan have been scaled back due to significant budget reductions and policy restrictions that have been imposed by Congress over the past several years. In addition, stronger-than-expected economic growth and lower-than-expected energy prices have pushed energy use higher, thus requiring greater reductions than initially called for in the Plan to achieve stabilization at 1990 levels.

In related activities, the Clinton Administration has started several initiatives that would help to substantially reduce greenhouse gas emissions over the period beyond 2000. For example, the Administration has joined with automobile manufacturers and suppliers in the United States in a research and developmnent program called the Partnership for a New Generation Vehicle. The program's goal is the development of technological and manufacturing breakthroughs that would lead to a car with three times

Box 12.4
EPA's Green Lights Program

EPA's Green Lights program encourages commercial businesses and government agencies to reduce their lighting energy consumption by introducing them to the economic and environmental benefits of investing in energy-efficient lighting technology.

The program has partnered with over 2,000 participants committed to upgrading the lighting in over 5 billion square feet of commercial, manufacturing, retail, and government facilities nationwide (the equivalent of 1 out of every 14 commercial buildings). Green Lights partners have already upgraded over 1 billion square feet of office space.

In 1995, the Green Lights program prevented the emission of over 3 billion pounds of carbon dioxide and saved over 2 billion kilowatt-hours of electricity, leading to $200 million in savings for program partners.

Box 12.5
EPA's Natural Gas STAR Program

EPA's Natural Gas STAR Program is a voluntary program that works closely with the natural gas industry to reduce leaks and losses of methane (the primary component of natural gas). The program consists of two initiatives, one focused on the transmission and distribution sectors, and the other concentrating on the production and processing sectors. EPA provides support for partners by providing public recognition and technical expertise on new technologies. Working with EPA regional offices and state agencies, the program has been successful in removing many state barriers that prevent the use of pollution prevention as a method for reducing emissions.

By encouraging companies to adopte cost-effective best management practices that reduce leaks and losses of natural gas, Natural Gas STAR promotes innovative processes and technologies that save companies money, save natural gas resources, and reduce greenhouse gas emissions. Partners of the program currently represent 62 percent of transmission company pipeline mileage, 30 percent of distribution company pipeline mileage, and 25 percent of U.S. natural gas production.

In 1995, the Natural Gas STAR Program reduced emissions by over 4 billion cubic feet, equivalent to over 3 billion pounds of carbon dioxide. This is enough gas to heat 55,000 homes per year. The greenhouse gas impact was equivalent to removing 250,000 cars from the roads. Program partners saved about $8 million in 1995.

the fuel efficiency of current models without sacrificing cost, comfort, or safety.

Substantial energy savings and greenhouse gas reductions also appear possible in the buildings sector. The Building and Construction Initiative aims to improve the competitive performance of this $800 billion industry by developing better construction technologies through reducing waste and pollution as well as through improved performance, comfort, cost, safety, and durability.

The Administration's Environmental Technology Initiative represents another opportunity to encourage private sector efforts to develop and disseminate superior environmental technologies, including those that reduce greenhouse gas emissions. Overall, environmental technologies represent an estimated market of $180 billion in the United States and support more than 1.2 million jobs. Global markets are estimated at 3-4 times the U.S. market. This market opportunity represents one of the most promising opportunities for growth in sustainable, high-paying jobs.

Finally, given the need to involve all nations in reducing the risks of climate change, the United States has initiated a number of programs to encourage actions by developing countries to reduce their emissions of greenhouse gases. Under the 1992 climate convention, all nations (including developing nations) are required to prepare inventories of their emissions of greenhouse gases and to adopt measures aimed at addressing climate change.

To encourage sustainable development, and to demonstrate the potential effectiveness of "joint implementation" activities (e.g., projects where technology is transferred to and reductions are achieved in developing countries) under the convention, the U.S. has engaged in an active program with a number of developing countries (Box 12.6).

Box 12.6
Country Studies Program and the U.S. Initiative on Joint Implementation

The United States continues to look for cost-effective means to reduce emissions of greenhouse gases internationally. The Action Plan encourages U.S. businesses to develop economic opportunities for international greenhouse gas emissions reductions through the U.S. Initiative on Joint Implementation (USIJI). A pilot program, USIJI encourages organizations in the United States to implement projects internationally that reduce, avoid, or sequester greenhouse gases. Since its launch in 1993, this interagency program has become the largest effort worldwide to explore options for countries to jointly reduce greenhouse gases. In addition, the Countries Studies Program provides financial and technical support to some 55 developing countries and countries with economies in transition to help them better understand their greenhouse gas emissions, potential impacts from climate change, and opportunities for emissions reductions.

Next Steps

Climate change represents one of the most complex problems facing our society. Scientific knowledge has improved dramatically, as reported in the latest IPCC assessment. Nonetheless, many uncertainties remain concerning the exact timing, magnitude, and regional impacts of climate change. Continued research through the U.S. Global Change Research Program (Box 12.7) and the international assessment process is needed to improve our understanding of the rate and magnitude of future climate change.

This is not a problem that any one country or even the developed countries acting in concert can solve. All nations must join together in developing a response to climate change.

The critical next point in that process involves negotiations underway to strengthen the Climate Convention agreed to in 1992. These negotiations are scheduled to conclude at the Third Conference of the Parties in December 1997.

At a recent negotiating session in July 1996, the United States proposed a new framework for the Convention. The U.S. rejected proposals by other countries calling for significant near-term reductions and for inflexible harmonized policies and measures. Instead, the U.S. called for realistic, verifiable, legally binding medium-term targets utilizing flexible approaches. The United States also called on all nations, including developing nations, to take actions to limit their emissions of greenhouse gases.

Box 12.7
The U.S. Global Change Research Program

The U.S. Global Change Research Program (USGCRP) was established in 1989 in recognition of the importance of a strong research base for understanding, predicting, and assessing global environmental changes, such as ozone depletion and climate change, their regional impacts, and their consequences for human health, food production, ecological systems, and sustainable economic development.

The USGCRP coordinates the global change research activities of 15 departments and agencies of the U.S. government. It is the largest coordinated environmental R&D effort under the auspices of the National Science and Technology Council. The USGCRP will invest approximately $1.7 billion in climate change research during 1997. All U.S. Government climate change research is carried out as part of the USGCRP, and the findings from USGCRP-sponsored research have been important contributions to the Intergovernmental Panel on Climate Change science assessments and have assisted U.S. decision-making on climate issues.

The objectives of the USGCRP are to: (1) observe and document changes in the Earth system; (2) understand what changes are occurring and why; (3) improve predictions of future global change; (4) analyze the environmental, socioeconomic, and health consequences of global change; and (5) support state-of-the-science assessments of global environmental change issues.

In support of these general objectives, the program is focused on four key, inter-linked science issues:

- Seasonal to interannual climate variability, with the goal of obtaining a predictive understanding and the skills to produce forecasts of short-term climate fluctuations and to apply these predictions to social and economic development in the United States and abroad.
- Climate change over decades to centuries, with the goal of understanding, predicting, assessing, and preparing for changes in the climate and the global environment resulting from projected changes in population, energy use, land cover, and other natural and human-induced factors.
- Changes in ozone, UV radiation, and atmospheric chemistry, with the goal of understanding and characterizing the chemical changes in the global atmosphere and their consequences for human and ecological health and well-being.
- Changes in land cover and in terrestrial and marine ecosystems, with the goal of providing a stronger scientific basis for understanding, predicting, assessing, and responsing to the causes and consequences of ecosystem change resulting from human-induced and natural influences.

Participants in the program include the Agriculture, Commerce (the National Oceanic and Atmospheric Administration and National Institute of Standards and Technology), Defense, Energy, Health and Human Services (the National Institute of Environmental Health Sciences), Interior, Transportation, and State departments, as well as the Environmental Protection Agency, the National Aeronautics and Space Administration, the Smithsonian Institution, the Tennessee Valley Authority, the Office of Science and Technology Policy, the Office of Management and Budget, the Council of Economic Advisers, and the intelligence community.

The approach proposed by the United States was widely accepted by other nations and was incorporated into the Geneva Declaration that was adopted as a Ministerial Statement by most nations at the meeting.

The rationale for the U.S. position is threefold. First, the 1995 IPCC report has reinforced the strong concerns about the likelihood and implications of climate change, as well as the role of human activities. Second, the existing framework of nonbinding national targets is unlikely to achieve expected results. Third, clear, realistic, and agreed-upon objectives are needed to ensure that all nations will honor their commitments to reduce emissions both for environmental and for competitiveness reasons.

The United States is working through the multilateral negotiations to reach agreement on a verifiable and binding medium-term emissions target in time for the next Conference of the Parties in December 1997. The following principles will guide the Administration in these discussions: environmental protection, realism and achievability, economic prosperity, flexibility, fairness, and comprehensiveness.

Specifically, the Administration believes any medium-term target must be met through maximum flexibility in the selection of implementation measures, including the use of reliable joint implementation measures and emissions trading systems around the world. Any future commitment must ensure that the U.S. economy remains robust and internationally competitive and that early voluntary actions are recognized.

All countries—developed and developing—should take steps to limit emissions. While the developed countries have a responsibility to lead, this effort must be a partnership, with all nations contributing to the objective of the climate treaty.

The Administration is committed to continuing discussions with the public, Congress, industry, nongovernment organizations, and other experts on U.S. emissions trends and on strategies to reduce emissions in the next century. Scientific, economic, and technical analysis will continue to guide evaluation of the practicality of specific targets and options for achieving them.

President Clinton has urged all Americans to prepare for the economic challenges of the 21st century. While climate change is a serious long-term problem, progress must be made in the medium term by involving the public and private sectors. Sustained long-term investment and the creativity of the marketplace are required to develop and utilize the technologies that will ensure the nation's long-term environmental and economic prosperity.

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CHAPTER THIRTEEN

Water

In the late 1960s, cities and towns were routinely discharging untreated human waste into the Hudson River in New York, robbing the water of needed oxygen. The river's sediments and water were loaded with toxic wastes. The fish were diseased, inedible, and rapidly declining in number. A 1966 headline in *The New York Times* read: "Life Abandoning Polluted Hudson."

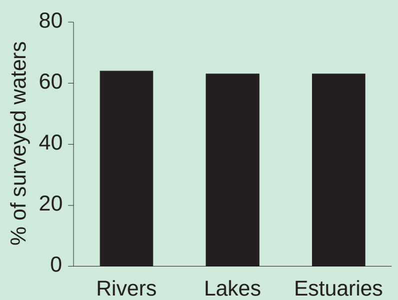
Three decades later, the Hudson is alive again. According to a recent count, 206 species of fish now live in or visit the river. Blue crabs have become common in the lower river, and fish-eating raptors such as bald eagles are back.

Much of the credit belongs to the Clean Water Act, which established a body of law and regulations backed by federal financial support that gradually led to a significant reduction in discharges of sewage and toxic chemicals in the Hudson and across the nation generally.

Yet the effort to improve water quality, in the Hudson and elsewhere, remains unfinished. Clean water, in short, is a resource still at risk:

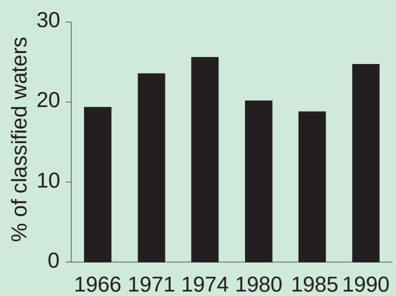
- Our rivers, lakes, and coastal waters are cleaner today than 25 years ago, yet nearly 40 percent are still too polluted to support all their designated uses (Figure 13.1).
- Contaminated fish advisories or bans were issued in 1995 for more than 1,700 water bodies—a 14 percent increase over the previous year—to protect the public from eating chemically- or disease-contaminated fish.
- One of every four shellfishing beds was closed for harvest in 1990 because of pollution (Figure 13.2).
- More than 4,000 beaches were closed in 1995 to protect the public from harmful bacteria and other pollutants found in the water.
- Our drinking water supply is one of the safest in the world, but one of every five people receive water from a facility violating a national safety requirement.

Figure 13.1 U.S. Surface Waters with Good Water Quality, 1994



Source: See Part III, Table 38.
Note: Data are the sum of fully supporting and threatened categories in Table 38.

Figure 13.2 Harvest-Limited U.S. Shellfish Waters, 1966-1990



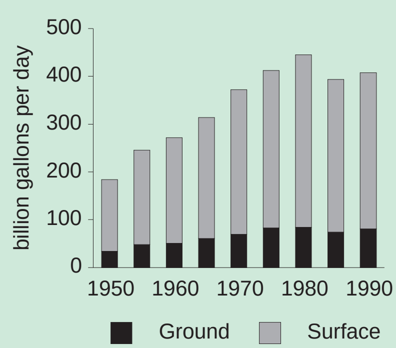
Source: NOAA, National Shellfish Register.
Note: Harvest-limited=shellfish growing waters that are not available for direct marketing all of the time.

Polychlorinated biphenyls (PCBs), a toxic chemical used until the 1970s, still linger in the sediments of the Hudson and in fish such as striped bass. Controlling nonpoint runoff from farms continues to be a difficult challenge. Many older cities depend on combined sanitary and storm water sewer systems, which can become overloaded during heavy rainfall and discharge a mix of raw sewage and storm water into surface waters.

Many federal agencies—the Environmental Protection Agency, Department of the Interior, Agriculture Department, Army Corps of Engineers, and Department of Commerce, among others—manage a wide variety of programs to manage and protect the nation's water resources. For example:

- EPA has the main responsibility for water quality and pollution issues.
- The Commerce Department's National Oceanic and Atmospheric Administration (NOAA) monitors coastal and marine resources.
- The Army Corps of Engineers has nationwide responsibility for building flood protection, river engineering, and coastal protection works and also administers the Clean Water Act Section 404 dredge-and-fill permit program.
- The Department of the Interior has several agencies with water-related responsibilities. The Bureau of Reclamation, which for many decades carried out water development projects west of the Mississippi, is now charged primarily with water resource management in these areas. The U.S. Geological Survey carries out water quantity and quality monitoring on nationally important rivers and aquifers. The Fish and Wildlife Service is responsible for freshwater ecosystems.
- The Department of Agriculture manages a wide variety of water resource conservation and water quality programs, focusing particularly on farm-related resource management and conservation issues.

Figure 13.3 U.S. Water Use by Source, 1950-1990



Source: See Part III, Table 37.

CONDITIONS AND TRENDS

Trends in Water Resources

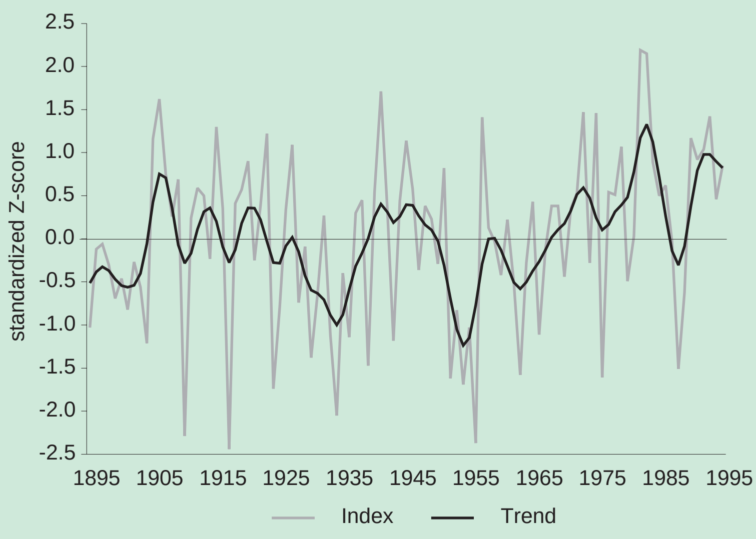
The United States is a water-rich nation, blessed with 3.5 million miles of rivers and streams, 41 million acres of lakes, 34,000 square miles of estuaries (excluding Alaska), and 33,000 trillion gallons of groundwater.

There is significant geographic and seasonal variation in precipitation. For example, the area east of the Mississippi River typically receives more than twice as much annual rainfall as the area west of the Rocky Mountains.

Surface waters provide about three fourths of overall freshwater requirements and groundwater one fourth (Figure 13.3). Groundwater is the source of drinking water for about half the general population and nearly all the rural population. The renewable water supply is more than 4 times the amount withdrawn and almost 15 times the amount consumed. But some parts of the country, especially the West and Southwest, are beginning to approach the physical limits of their water resources. Continued growth will require some combination of importing more water and/or managing water more efficiently.

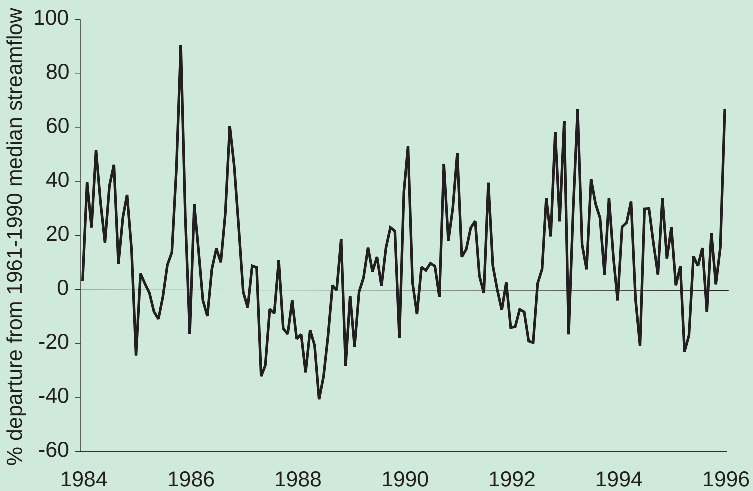
For the nation as a whole, precipitation trends have been generally above normal during the 1970–95 period (Figure 13.4). During 1994, about 6.9 percent of the area in the lower 48 states was characterized by severe to extreme drought, while about 14.8 percent was characterized by severe to extreme wetness. In 1995, only 1.6 percent was drought-stricken, while 24.9 percent of

Figure 13.4 U.S. Precipitation Trends, 1895-1995



Source: See Part III, Table 35.
Note: The standardized z-score is derived from precipitation records. See Table 35 for explanation.

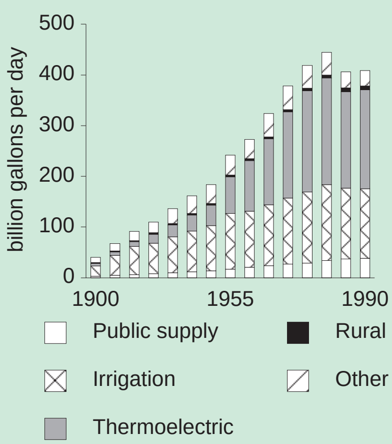
Figure 13.5 Monthly Departure of Actual Streamflow (January 1984-January 1996) from Median Streamflow (1984-1995)



Source: U.S. Department of the Interior, Geological Survey.
Note: Data represent the streamflow of 12 major river basins in the United States and southern Canada.

the nation was characterized by severe to extreme wetness (Part III, Table 36).

Figure 13.6 U.S. Water Use by Sector, 1900-1990

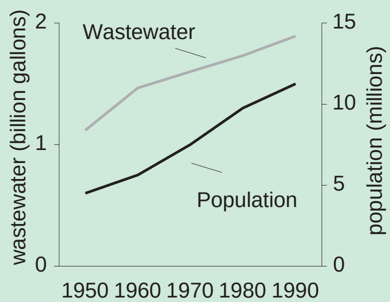


Source: See Part III, Table 37.

The United States has been struck repeatedly by natural disasters in the past few years. For example, throughout July and August 1993, devastating floods hit the lower Missouri River, the upper Mississippi River, the Illinois River, and many of their tributaries. Thirty-eight lives were lost, and estimated damages were between \$10 billion and \$16 billion. Over the 1979–89 period, flood-related damages cost the nation an average of about \$14 billion annually.

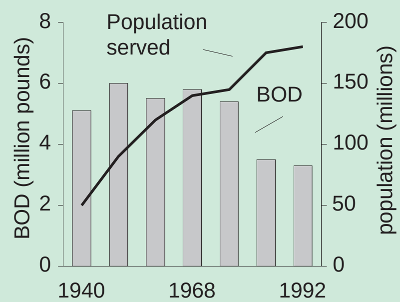
With the exception of 1992, streamflow for the nation as a whole has been generally above normal since 1991 (Figure 13.5). Regional streamflow totals have seen some unusual fluctuations in recent years. Since 1991, streamflow has been generally below normal in the three major Western basins—the Columbia

Figure 13.7 Chesapeake Bay Watershed Trends, 1950-1990



Source: Environmental Protection Agency.

Figure 13.8 U.S. Population and Sewage Discharge Trends, 1940-1992



Source: U.S. Environmental Protection Agency.
Note: BOD=biochemical oxygen demand.

River, Pacific Slope, and Great Basin in Nevada. Streamflow in the rest of the nation has been generally above normal, notably after great floods in the upper Mississippi River basin in 1993 and in parts of the Southeast in 1994.

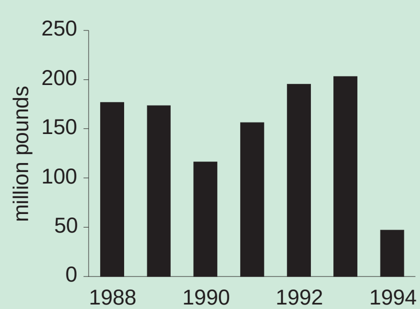
The bulk of national water use is for irrigation and the thermoelectric utility industry. In 1990, irrigation accounted for about 33 percent of water use and electric utilities for about 47 percent of use (Figure 13.6 and Part III, Table 37).

Trends in Water Quality

Since passage of the Clean Water Act in 1972, most of the conspicuous water pollution of the late 1960s and 1970s has been eliminated. During the 1972–92 period, the amount of sewage treated at wastewater treatment plants and U.S. population each rose about 30 percent (e.g., see Figure 13.7 for the Chesapeake Bay watershed), yet biochemical oxygen demand (BOD) from treatment plants declined by 36 percent (Figure 13.8). Direct discharges of toxic pollutants are down dramatically since 1988 (Figure 13.9). Water pollution controls on industry prevent about 1 billion pounds of toxic pollutants from entering our waters every year.

According to the 1994 EPA National Water Quality Inventory survey (Table 13.1), about 57 percent of surveyed rivers and streams showed good water quality and supported their designated use and 7 percent were in good condition but

Figure 13.9 Toxic Discharges to U.S. Surface Waters, 1988-1994



Source: See Part III, Table 72.

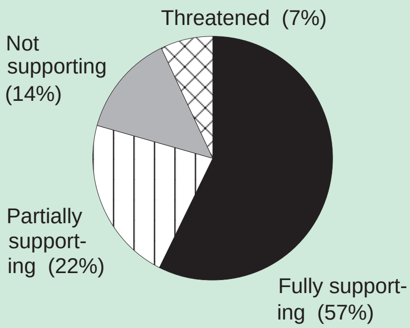
Table 13.1 Levels of Use Support

Use Support Level	Water Quality Condition	Definition
Fully Supporting	Good	Water quality meets designated use criteria.
Threatened	Good	Water quality supports beneficial uses now but may not in the future unless action is taken.
Partially Supporting	Fair (impaired)	Water quality fails to meet designated use criteria at times.
Not Supporting	Poor (impaired)	Water quality frequently fails to meet designated use criteria.
Not Attainable	Poor	The State, Tribe, or other jurisdiction has performed a use-attainability analysis and demonstrated that use support is not attainable due to one of six biological, chemical, physical, or economical/social conditions specified in the *Code of Federal Regulations.*

threatened. About 22 percent were in fair condition, partially supporting their designated uses. Another 14 percent showed poor quality. In less than 1 percent, designated uses were not attainable (Figure 13.10). Bacteria and siltation were the pollutants most often found in surveyed rivers and streams, each affecting 34 percent of all impaired river miles. Agricultural activities were the most widespread source of pollution, generating pollutants that degraded aquatic life or interfered with public use in 60 percent of the impaired river miles.

In the same survey, about 50 percent of the surveyed lake acres were in good condition and met designated use standards, 13 percent were in good condition but threatened by future degradation, 28 percent partially met the standards, and 9 percent had poor quality (Figure 13.11). Leading pollutants included nutrients, which were found in 43 percent of all impaired lake acres, followed by siltation

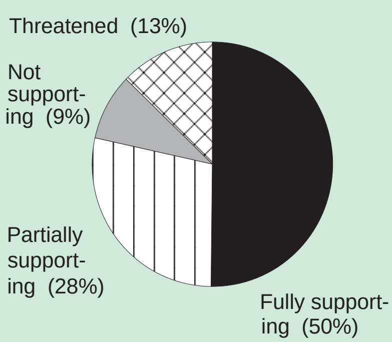
Figure 13.10 Overall Use Support in U.S. Rivers and Streams, 1994



Source: See Part III, Table 38.

Note: Based on an assessment of 17% of U.S. river and stream miles. Designated uses are not attainable in less than 1% of assessed waters.

Figure 13.11 Overall Use Support in U.S. Lakes, Ponds and Reservoirs, 1994



Source: See Part III, Table 38.

Note: Based on an assessment of 42% of U.S. lakes, ponds and reservoirs. Designated uses are not attain-able in less than 1% of assessed waters.

(28 percent), oxygen-depleting substances (24 percent), and metals (21 percent).

Of the nation's total estuarine area, the EPA survey found that 57 percent of the surveyed square miles were in good condition and met designated use standards, 6 percent were in good condition but threatened, 27 percent partially met the standards, and 9 percent had poor quality (Figure 13.12). Nutrients and bacteria were the pollutants most often found in impaired estuaries.

Fish consumption advisories provide another indication of water quality. In 1995, the number of consumer advisories to limit or restrict consumption of certain fish species rose by 14 percent over the previous year. The study found that advisories were issued in 1995 for 1,740 water bodies in 47 states, an increase of 209 warnings from the previous year.

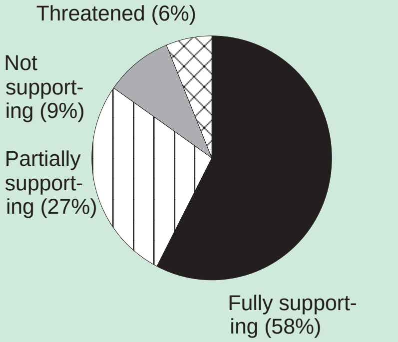
Mercury accounted for 1,308 advisories, up from 899 the previous year. Warnings for PCBs rose 37 percent, and for chlordane, 16 percent. Warnings for DDT, which has been banned in the United States since 1972, were up 3 percent. (DDT has not been banned in Mexico, which shares several bodies of water with the United States.)

These increases are attributed primarily to more surveys being done by the states, and do not necessarily indicate that conditions are worsening nationwide. Advisories do, however, show where local water quality problems exist.

Trends in the Great Lakes

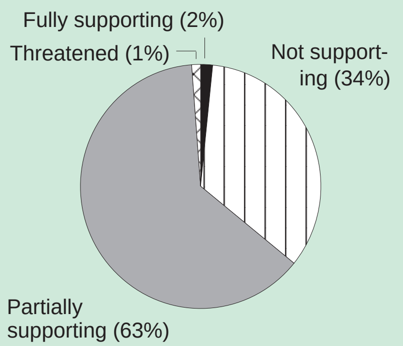
Despite dramatic declines in the occurrence of algal blooms, fish kills, and localized "dead" zones depleted of oxygen, less visible problems continue to degrade the Great Lakes.

Figure 13.12 Overall Use Support in U.S. Estuaries, 1994



Source: See Part III, Table 38.
Note: Based on an assessment of 78% of U.S. estuary square miles.

Figure 13.13 Overall Use Support in the Great Lakes, 1994



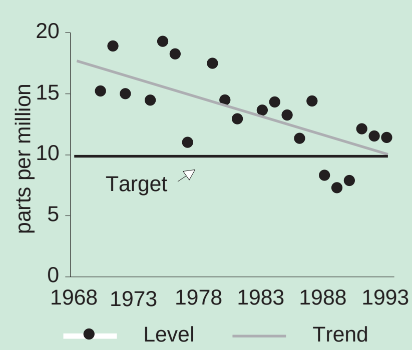
Source: See Source for Part III, Table 38.
Note: Based on an assessment of 94% of Great Lakes shoreline miles.

According to EPA's National Water Quality Inventory, most of the Great Lakes nearshore waters were found to be safe for swimming and other recreational activities and for use as a source of drinking water with normal treatment. However, only 2 percent of the surveyed nearshore waters fully supported designated uses, while 34 percent partially supported designated uses (Figure 13.13). About 63 percent were not supporting their designated uses, largely because fish consumption advisories are posted throughout the nearshore waters of the Great Lakes and water quality conditions are not favorable for aquatic life in many cases. Aquatic life impacts are caused by persistent toxic pollutant burdens, habitat degradation and destruction, and competition from and predation by nonnative species such as the zebra mussel and the sea lamprey. Toxic organic chemicals—primarily PCBs—are present in 98 percent of the impaired shoreline miles.

According to the 1995 *State of the Great Lakes* report, water quality in the Great Lakes is generally improving:

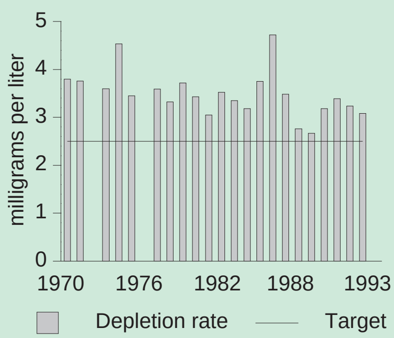
- Overall, there has been a general decrease in concentrations of toxic chemicals over the last 20 years, but the rate of decrease has slowed.
- Nutrient levels have decreased

Figure 13.14 Spring Phosphorus Levels in Lake Erie, 1968-1993



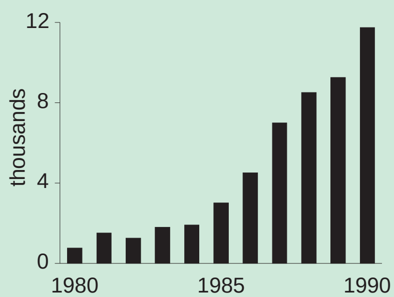
Source: P. Beltran, EPA Great Lakes Program Office.

Figure 13.15 DO Depletion Rate in Lake Erie, 1970-1993



Source: P. Beltram, EPA Great Lakes Program Office.
Note: DO=dissolved oxygen in lake bottom waters.

Figure 13.16 Double-crested Cormorant Nests, 1980-1990

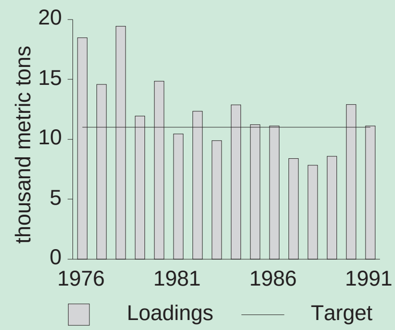


Source: Environment Canada.
Note: Data refer to Great Lakes-wide populations.

(Figure 13.14), and dissolved oxygen levels have improved (Figure 13.15), but chloride and nitrogen levels appear to be increasing. (The primary source of chloride seems to be municipal wastewater discharges and the use of salt in road deicing.)

- Fisheries have generally improved. Contaminant levels in fish have decreased, but the rate of decrease has slowed.

Figure 13.17 Phosphorus Loadings to Lake Erie, 1976-1991



Source: See Part III, Table 41.

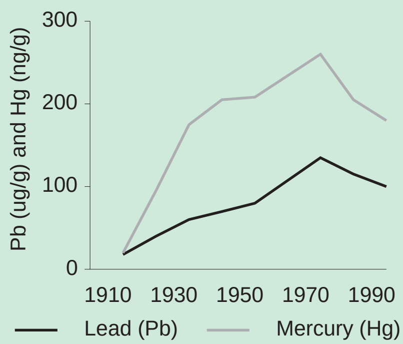
- Populations of fish-eating birds have increased (Figure 13.16).
- Habitat destruction and exotic species remain serious concerns.

Lake Erie has shown the greatest improvement. Average annual concentrations of conventional contaminants have been reduced by approximately 50 percent over the last 15 years (Figure 13.17).

Metal concentrations rose steadily from about 1915 to the mid-1970s but have been generally declining since then (Figure 13.18). PCB levels in herring gull eggs have declined significantly since 1974 (Figure 13.19). Toxic concentrations of DDE (a derivative of DDT) in bald eagle eggs on the north shore of Lake Erie show a significant downward trend (Figure 13.20). Nesting pairs of eagles have increased from an estimated 83 pairs in Michigan in 1973 to 227 pairs in 1993.

In Lake Erie, water clarity has increased dramatically from the combined effects of lower phosphorus levels

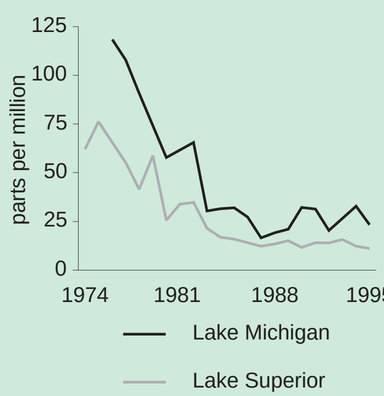
Figure 13.18 Lead and Mercury in Lake Sediment, 1910-1990



Source: Michigan Department of Environmental Quality, *State of the Great Lakes: Annual Report for 1995* (DEQ, Lansing, MI, 1996).
Note: Data are from Lake Michigan sediment cores. ug/g=micrograms per gram. ng/g=nanograms per gram.

due to pollution control and zebra mussel filter feeding. The improvement in clarity has resulted in an increased abundance of aquatic rooted plants. As the lake ecosystem has changed, some fish species—notably lake whitefish, smallmouth bass, and walleye in the western and central basins—are prospering. The change may also be a positive sign for bottom-feeding fish such as yellow perch. Populations of open-water species such as smelt, which feed on plant and animal plankton, have been reduced.

Figure 13.19 PCB Levels in Herring Gull Eggs, 1974-1995



Source: See Part III, Table 74.
Note: PCB=polychlorinated biphenyls.

U.S. members of the joint U.S./Canadian Lake Erie Committee recommended an increase in allowable harvests of walleye in the western and central basins of Lake Erie from 9 million fish in 1995 to 11 million fish in 1996. Consistent stocks of yellow perch also warrant increases in allowable harvests in those areas.

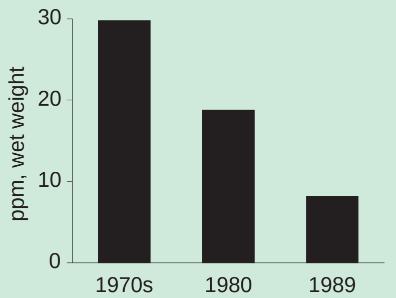
Program Overview

The two principal federal laws governing water quality are the Clean Water Act of 1972 (amended in 1977, 1981, and 1987) and the 1974 Safe Drinking Water Act (amended in 1986 and 1996). Nonpoint pollution protection programs, which are authorized by the Clean Water Act and other laws, are discussed separately.

The Clean Water Act. The Clean Water Act provides a comprehensive framework of pollution control standards, technical tools, and financial assistance to address the many stressors that can cause water pollution and adversely affect water quality.

The National Pollution Discharge Elimination System (NPDES) provides a permitting mechanism to limit the amount of pollution that can be discharged into receiving waters from indus-

Figure 13.20 DDE in Bald Eagle Eggs in the 1970s and 1980s



Source: Ontario Ministry of Natural Resources.
Note: DDE=Derivative of DDT. ppm=parts per million.
Data are from populations on Lake Erie's north shore.

tries and sewage treatment plants as well as other sources that can affect water quality. Industrial facilities, for example, are required to comply with technology-based effluent limitations that are based on the demonstrated performance of a reasonable level of treatment that is within the economic means of the specific categories of industrial facilities. These technology-based controls, defined as effluent limitation guidelines, have been specified for over 50 kinds of industries. Collectively, they reduce pollution loadings by about 90 percent. Similarly, municipal sewage treatment plants are required in most areas to provide at least secondary treatment to assure that 85 percent of conventional pollutants, such as organic waste and sediment, are removed. NPDES permits to control water pollution have been issued for about 48,000 industrial facilities and about 15,000 municipal facilities nationwide, and today, most facilities are in compliance with their permit conditions. General permits control wastewater discharges from an additional 160,000 sources, including storm water discharges.

When these technologies are not sufficient to meet water quality standards, the act provides for progressively more stringent limits to ensure that conditions are improved. Water quality standards are set by the states for every waterbody and approved by EPA. They include a designated use for the waterbody, such as drinking water or recreation, and specific criteria to protect those uses. This water quality-based approach provides an additional safeguard, triggering more stringent pollution control, if and when more needs to be done.

Protecting valuable aquatic habitat, such as wetlands, is another important component of this law. Filling wetlands with dredged or fill material can destroy or degrade these important areas and have a profound impact on water quality. To minimize these impacts, the law establishes a permitting program to ensure that these types of activities are conducted in an environmentally sound manner.

The law also provides funding to help states and local governments protect and improve water quality. In addition to providing funding to implement state programs, the act has been a major source of funding for building wastewater infrastructure projects. The original 1972 act established a construction grants program, in which the federal government agreed to pay up to 75 percent (later reduced to 55 percent) of the construction and design cost for municipal treatment plants. From 1972 to 1990, the program provided nearly $60 billion in federal assistance; state and local governments contributed over $20 billion.

Amendments to the act in 1987 began a transition from grants to loans through state revolving funds. Localities now must repay the cost of construction financing. Federal contributions (83 percent) to the funds are matched by states (17 percent of total capitalization). In addition to municipal wastewater treatment, loans may also be used for storm water outfalls and projects that reduce agricultural and urban runoff.

The transition from grants to loans has meant a substantial increase in the share of wastewater treatment expenditures borne by local governments. The program has also been an effective way to leverage limited dollars. Over a 20-year period, an initial federal investment can result in the construction of up to four times as many projects as a one-time federal grant. With new streamlined requirements, state revolving fund projects are completed about 30 percent faster than those funded with grants. The typical cost of a state revolving fund loan is about 30 to 50 percent less than the cost of the same project funded through the commercial bond market.

The Clean Water Act also has provided substantial federal support for nonpoint source pollution control projects. Under the act's section 319, EPA has provided over $470 million in grants to nonpoint source projects through fiscal year 1996.

The Safe Drinking Water Act. The 1974 Safe Drinking Water Act required EPA to establish national primary drinking water regulations that incorporate enforceable maximum contaminant levels or treatment techniques, underground injection control regulations to protect underground sources of drinking water, and groundwater protection grant programs for the administration of state wellhead protection area programs. States are permitted to implement these activities.

The 1986 amendments required EPA to issue final regulations for 83 drinking water contaminants by June 1989 and for 25 additional contaminants every 3 years thereafter. Thus far, EPA has issued regulations for 84 contaminants. The 1986 amendments also require extensive monitoring of public water supplies to ensure that safety standards are being met.

As discussed in the Recent Developments section, the act was substantially amended again in mid-1996.

EPA and the states regulate approximately 200,000 public drinking water systems that serve over 240 million people. About 60,000 of these systems are community drinking water systems, which provide water to the same population year-round. In 1994, 81 percent of the population served by community systems had no reported violations, 9 percent were served by systems with surface water treatment violations, 8 percent with total coliform violations, 1 percent with lead and copper treatment violations, and 1 percent with chemical/radiological contamination violations.

Drinking water systems supplied by surface waters can sometimes withdraw water that contains harmful levels of disease-causing microbiological contaminants, such as *Giardia lamblia, Legionel-*

la, and viruses. Under the Surface Water Treatment Rule, EPA and the states require all inadequately protected drinking water systems using surface water sources to disinfect and install filtration treatment to remove any microbiological contaminants. In 1993, over 12 million people were provided drinking water from more than 1,000 unfiltered community water systems not in compliance with the rule. By the end of fiscal 1995, the number of systems not complying was reduced to 400 and the population at risk had dropped to 9.9 million.

The Administration will take strong enforcement action against violations, which threaten the health of our families and communities.

EPA also is working with states and tribes to protect sources of drinking water, particularly groundwater used for drinking. The Wellhead Protection Program covers four areas: (1) delineating a wellhead protection area; (2) identifying potential sources of contamination; (3) developing a contingency plan in case of a threat to the drinking water source; and (4) developing a source management plan to control potential sources of contamination. Of the 60,000 community systems, by 1993 about 18,700 systems (31 percent) had initiated the program and 3,800 systems (6 percent) were covered by all four parts of the groundwater protection program.

Nonpoint Pollution Protection. Nonpoint pollution sources include cropland, livestock, urban runoff, storm sewers, construction sites, mining and logging, and drainage from waste disposal sites.

For example, cropland erosion delivers sediments, nutrients, and pesticides to receiving waters. As a result of a wide variety of federal programs, sediment loadings from cropland has declined substantially, from an estimated 1.93 billion tons annually in 1977 to about 1.18 billion tons in 1992.

In fiscal 1995, the Department of Agriculture spent an estimated $3.5 billion on voluntary resource conservation and other environmental programs and activities, many of which address water quality.

Under the Agricultural Conservation Program (ACP), cost-share expenditures on water-quality-related practices rose from $13.4 million in 1988 to $44.2 million in 1994. The most frequently cost-shared practices were conservation tillage, irrigation water management, and nutrient management. All have been shown to increase net returns in many parts of the country.

Since 1990, USDA also has managed (with EPA, Interior, and Commerce) a Water Quality Program, with annual expenditures ranging from $83 million to $116 million. Through 1993, nitrogen management practices (including cover and green manure crops) have been implemented on 1 million acres. Annual nitrogen reductions averaged almost 42 pounds per acre on land receiving treatments. Phosphorus management, implemented on about 850,000 acres by 1993, showed similar reductions of about 40 pounds per acre. The program also includes erosion and sediment control practices, which had been installed on about 1 million acres by 1993.

The Conservation Reserve Program, which is discussed in the chapter on agriculture, also provides substantial water quality benefits. Erosion reductions for the 36.4 million acres enrolled in the program in 1995 are estimated to generate about $437 million annually in benefits to water users.

RECENT DEVELOPMENTS

In recent years, corporations and others among the regulated community have increasingly embraced the need for and value of environmental protection, while EPA and other regulatory institutions have increasingly appreciated the fact that creative alternatives can provide cleaner, cheaper, smarter pollution management. Occasionally, however, the legal requirements of federal environmental statutes create impediments to creative alternatives.

For example, in 1989 Amoco and EPA sponsored a voluntary effort to identify multimedia pollution prevention opportunities at Amoco's refinery in Yorktown, Virginia. Project staff developed an assessment of releases to air, water, and land. They then formulated reduction options. Finally, they compared their innovative solutions with those presecribed by statutes. In many cases, the creative approaches provided comparable or better pollution control at substantially less cost, yet EPA did not have the statutory flexibility to support such alternatives.

Finding Creative Alternatives

Despite these limitations, opportunities do exist to build greater flexibility and cost-effectiveness into water quality programs. A few examples follow:

Effluent Trading in Watersheds. Under an effluent trading program, an industry or sewage plant that can reduce water pollution discharges below the minimum level required to meet water quality standards can sell its excess pollution reductions to other facilities within the same watershed. Effluent trading can allow dischargers to take advantage of economies of scale and the treatment efficiencies that vary from facility to facility, and it could provide an economic incentive for dischargers to go beyond minimum pollution reductions. Trading programs also could be established for other sources of water pollution, including nonpoint sources (e.g., runoff from farms) and facilities whose wastewater is not directly discharged, but sent to a local municipal sewage treatment plant for treatment.

To get the process started, EPA is developing a framework promoting different types of effluent trading and providing technical analyses to determine an appropriate amount of pollution to allow in a given watershed.

Project XL. On a demonstration project basis, EPA is supporting company projects to replace existing regulatory requirements with alternative environmental management strategies if the company can promise better environmental results than would be expected under existing regulations. Of course, with flexibility must come accountability. In addition, such projects must be consistent with congressional mandates.

Ten companies and two state agencies are currently taking part in Project XL. For example, Lucent Technology will take an innovative approach to monitoring water pollution at its Allentown, Pennsylvania, facility by utilizing outside auditors. Weyerhauser will operate its Flint River, Georgia, plant as a "minimum impact mill," a comprehensive approach to minimize the overall impact of the mill on the environment.

Combined Sewer Overflows. Problems associated with combined sewer overflows (CSOs)—spills of raw sewage, untreated industrial wastewater, and street debris—can be a considerable public health menace. They are a leading cause of beach closures and shellfishing restrictions. Working closely with the states, affected cities, and environmental groups, EPA in 1994 developed a consensus policy to guide action on CSOs. It encourages cities to pursue certain minimum, low-cost controls and to develop a full understanding of local CSO occurrences and impacts before making longer-term investments in additional wastewater treatment, temporary storage capacity, and sewer rehabilitation.

Refocusing Programs

Many other opportunities exist to focus existing programs on the highest-priority risks.

For example, EPA is seeking to improve the performance of the drinking water program in three areas:

- Establishing priorities for rule making based on health risks. EPA is seeking a delay for all court schedules for drinking water rules and, based on a reassessment of health risks and consultation with stakeholders, will set new priorities and schedules for drinking water rule making.
- Encouraging voluntary treatment. EPA is working with public water suppliers and states to develop a voluntary drinking water treatment program that will reduce the occurrence of *Cryptosporidium* and other microbiological pathogens. These efforts will help reduce risks to the public while EPA completes the scientific work needed to develop an appropriate safety standard.
- Simplifying monitoring requirements. EPA is streamlining monitoring requirements for chemical contaminants in drinking water and allowing further "tailoring" of monitoring based on the existing quality of the drinking water source.

A similar approach is being taken to reduce unnecessary monitoring and reporting for industries, municipalities, and other entities that have permits to discharge wastewater into rivers and other receiving waters. Under the Clean Water Act NPDES program, EPA is now allowing permit holders to reduce their monitoring and reporting if they show and maintain a strong permit compliance record. This performance-based approach is expected to cut monitoring and reporting time by an estimated 4.5 million hours nationwide, and create incentives to further improve environmental quality.

The Safe Drinking Water Act Amendments of 1996. In mid-1996, Congress passed and President Clinton signed The Safe Drinking Water Act (SDWA) Amendments of 1996. The amendments establish a new emphasis on preventing contamination problems through source water protection and enhanced water system management. The amendments also set up a state revolving fund (SRF) system to provide money to communities to improve their drinking water facilities. The SRF is authorized at $1 billion for each of fiscal years 1994 to 2003. The states may use set asides from the SRF to pay for programs such as source water assessments; voluntary source water quality protection partnerships with public water systems, local governments, and private companies; and capacity development and implementation efforts.

Another significant provision of the 1996 amendments is the recognition of the importance of public involvement in addressing and preventing threats to drinking water quality in the years ahead. Within two years, EPA must issue regulations requiring all community water systems to prepare at least annually a report with information about the system's source water and the level of contaminants in the drinking water purveyed. Systems serving 10,000 or more people must mail these reports to their customers; smaller water systems are given other options for distributing this information.

In addition, the 1996 amendments repeal the current requirement that EPA promulgate standards for 25 additional contaminants every three years. These requirements, instituted by Congress as part of the 1986 SDWA amendments, have proved impossible to meet within the mandated time frames. Under the 1996 amendments, new standards must undergo a cost-benefit analysis.

Other provisions of the 1996 amendments include the establishment of a priority list of unregulated contaminants, a streamlining of the enforcement process and increases in penalties, and requirements that EPA promulgate rules on arsenic, enhanced surface water treatment incorporating standards for *Cryptosporidium*, and a radon standard using the new standard-setting authorities. EPA is also directed to conduct research on sensitive subpopulations that may experience greater adverse health effects from drinking water contaminants than the general population.

Building a New Consensus

Bringing all affected parties together to find solutions to difficult problems holds great promise. The San Francisco Bay/Delta accord and the Great Lakes agreement are two recently negotiated cooperative efforts.

San Francisco Bay/Delta Accord. After 2 years of intensive consultation with local interests, EPA published final water quality standards for the San Francisco Bay/Delta. The plan takes a comprehensive, ecosystem approach rather than single-pollutant, individual source approach. The Clinton Administration helped facilitate a solution that will protect endangered species and the ecosystem while ensuring reliability in federal water allocations to support farmers and urban water users.

Great Lakes Agreement. Working in partnership with eight Great Lakes states, EPA produced a comprehensive plan to reduce toxic chemicals from the Great Lakes basin. The final plan provides the Great Lakes states and tribes with community-based flexibility to tailor solutions to local conditions.

Building New Partnerships

Increasingly, EPA is establishing new partnerships to improve water quality through voluntary means. Through the Partners in Prevention program, EPA is working with agricultural groups to accelerate the voluntary adoption of modern, economical management practices that reduce polluted runoff while maintaining or even enhancing farming and livestock operations.

A new partnership to improve water quality has been established with the golf industry. In 1995, EPA, golf industry representatives, and environmental groups worked together to determine how golf courses could be built and maintained in a more environmentally sound manner. A consensus set of principles were developed to improve operations in a number of areas, including fertilizer and pesticide usage.

Under EPA's voluntary "Partnership for Safe Water," suppliers that use surface waters carefully survey their filtration systems, operating and maintenance procedures, and other management activities to determine whether action is needed to reduce the risk of *Cryptosporidium* and other microbial contaminants. This action is especially important given the resistance of these contaminants to normal disinfection processes. To date, 140 water companies have joined the program.

The Groundwater Guardian Program is another voluntary way to improve drinking water safety. With help from EPA, a nonprofit organization in the Midwest provides special recognition and technical assistance to help communities protect their groundwater from contamination. Since beginning in 1994, Groundwater Guardian programs have been established in nearly 100 communities in 31 states.

Improving National Water Quality Data

In order to make better use of water quality monitoring data, a national Intergovernmental Task Force on Monitoring Water Quality (ITFM) was established in January 1992. The mission of the ITFM is to develop and implement a national strategic plan to achieve effective collection, interpretation, and presentation of water quality data and to improve the availability of existing information for decison-making at all levels of government. Major products will include guidelines and support for comparable field and laboratory methods, quality assurance and control, data management and sharing, data interpretation techniques, and environmental indicators. These products will be available for use by agencies nationwide.

A major improvement in water quality assessment capabilities was made in 1996 when a set of water quality indicators were agreed upon and released for future use by multiple agencies, including state and tribal agencies. These indicators, which reflect various water quality and ecological parameters, provide for a more accurate characterization of how conditions are changing over time.

FUTURE CHALLENGES

In a time when nearly 40 percent of rivers and lakes surveyed are found to be unsafe for fishing, swimming and other uses, and when drinking water supplies are threatened by microbial and other contaminants, it is clear that the national commitment to protecting and improving water quality must remain strong.

In particular, federal investments are needed to help communities ensure safe drinking water and wastewater treatment. It is estimated that $137 billion will be needed over the next 20 years to replace aging infrastructure, deal with outdated sewage collection systems, and control polluted runoff. EPA is now gathering information to develop a similar cost estimate for national drinking water needs.

While important, continued improvements in water quality will require more than infrastructure investment. Better solutions are needed to control polluted runoff—now the leading source of pollution in rivers and lakes, to protect wetlands and other critical aquatic areas, and to further reduce toxic pollution. These challenges, along with the challenge of providing safe, reliable drinking water, point to the need for more tailored, comprehensive approaches that take into account the unique stressors and conditions in any given area. This need has been recognized, and there is growing interest in and use of watershed-based management approaches. Increasingly, public and private organizations, including EPA and many other federal agencies, are using watersheds as a basis for developing and implementing water resource protection and restoration activities. This approach provides greater opportunity for leveraging resources, for involving and gaining the support of local stakeholders, and most importantly, for finding the most effective solutions.

Opportunities to improve water quality are evolving in other areas.

- In many cases, old adversaries are now partners in trying to find creative ways to reduce water pollution.
- States and municipalities have built up expertise and gained experience in water management and are taking on a larger role.
- Pollution prevention measures may reduce the burden on treatment plants.
- Market-based incentives, such as effluent trading, can provide new impetus for pollution reduction.

These changes in approach and attitude, coupled with improving science and technology, offer promise for the future. Together, they suggest that despite many challenges, continued improvement in water quality can be achieved.

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CHAPTER FOURTEEN

Coastal and Marine Resources

Coastal and nearshore marine areas are some of the nation's richest, most diverse, and most productive ecosystems. Many are heavily used to fulfill human needs.

One of the notable developments of the past quarter-century has been the increased understanding of the environmental and economic benefits of coastal and marine resources. Almost 70 percent of the commercially and recreationally important species of fish and shellfish spend part of their life cycle in coastal or nearshore marine waters. At least 30 percent of North American waterfowl winter in coastal areas, and many other migratory birds depend on coastal areas for feeding, breeding, or migration rest areas. Naturally vegetated coastal habitats help to purify runoff, dissipate flood waters, trap sediments, and protect shorelines from erosion.

Although it is difficult to quantify accurately the economic benefits of these habitats and ecosystems, experts agree that coastal ecosystems contribute billions of dollars to the national economy. The National Marine Fisheries Service has estimated that the marine fishing industry contributes over $24 billion annually to the U.S. economy. The commercial shipping industry provides $52 billion in personal income in the U.S. In east-central Florida, as a local example, it is estimated that the total value of all uses of the Indian River estuary is over $700 million per year. Coastal tourism and recreation generate substantial revenues for states and localities.

BACKGROUND

The nation's coastal and marine domain is vast. It includes some 34,000 square miles of estuaries (excluding Alaska) and 95,000 miles of ocean shoreline. U.S. fisheries extend 200 nautical miles off the U.S. shoreline; beyond this Exclusive Economic Zone (EEZ)—at 3.5 million square miles, the world's largest—are international waters regulated by international laws and multilateral arrangements. (The nation's coastal zone also includes 5,559 miles of Great Lakes shoreline. See Chapter 13, "Water").

Up to 3 nautical miles from shore, resource management responsibility belongs primarily to the coastal states. Within the zone that stretches to 200 nautical miles offshore, prime responsibility for living marine resources, with some exceptions, lies with the National Marine Fisheries Service (NMFS), which is part of the Commerce Department's National Oceanic and Atmospheric Administration.

Most of NMFS's conservation responsibilities emanate from four statutes: the Magnuson-Stevens Fishery Conservation and Management Act, which regulates fisheries within the EEZ; the Endangered Species Act, which protects threatened or endangered species; the Marine Mammal Protection Act, which regulates the taking of marine mammals; and the Fish and Wildlife Coordination Act, which authorizes collection of fishery data and coordination with other federal agencies for environmental decisions affecting living marine resources. A fifth statute, the Federal Power Act, requires NOAA to protect aquatic habitat in concert with the U.S. Fish and Wildlife Service.

Fishery resources are managed within the EEZ largely through fishery management plans (FMPs), which are coordinated and developed by eight regional fishery management councils. Fishery resources are managed to protect their maximum sustainable yield. The plans are developed after extensive consultation with state and other federal government agencies, public interest groups, and in some cases international science and management organizations. In 1995, NOAA reported 39 FMPs in place.

A number of programs protect coastal and ocean waters from pollution. The Environmental Protection Agency has prime responsibility under the Clean Water Act, Oil Pollution Act, and international agreements such as the London Dumping Convention and the International Convention for the Prevention of Pollution from Ships. EPA and the U.S. Army Corps of Engineers regulate the disposal of dredged material in inland waters, including coastal areas, under Section 404 of the Clean Water Act; they regulate dredged material disposal in ocean waters under Titles I and II of the Marine Protection, Research and Sanctuaries Act (MPRSA). These programs both require that material meet stringent criteria before it is disposed of, thus protecting public health and marine resources such as fisheries.

Coastal waters are also protected by the Ocean Dumping Ban Act. Under this act, ocean dumping of industrial waste and sewage sludge was stopped in 1988 and 1992, respectively. Coastal waters are also beginning to receive better protection from another major stressor—polluted runoff. States have begun to implement management measures to reduce polluted runoff from urban and rural lands, as required by section 315 of the Clean Water Act and the Coastal Zone Management Act Reauthorization Amendments of 1990.

The Coastal Zone Management Act encourages states to produce and enforce their own coastal zone management programs consistent with federal law. The National Estuary Program encourages creation of plans to protect estuaries identified as nationally significant that are threatened by pollution, development, or overuse. The National Marine Sanctuary Program preserves and protects areas that have special significance based on their "conservation, recreational, ecological, historic, research, educational, or aesthetic qualities."

CONDITIONS AND TRENDS

Coasts and estuaries are stressed by a wide range of human activities. They receive pollutants from farmland and developed areas; support marinas, commercial fishing fleets, and recreational activities; and are highly prized areas for both commercial and residential development. These pressures have increased over the past few decades as the population in coastal areas has grown.

Nearshore ocean waters are vulnerable to pollution from numerous sources, including storm sewers, outfalls from sewage treatment plants, overboard disposal of debris and sewage, oil spills, bilge discharges that contain oil and grease, ballast discharges that contain exotic species, and a host of non-point sources.

Over the past 25 years, the United States has made substantial progress in correcting some of these problems. This includes curbing the loss and modification of some types of coastal habitats and reducing environmental loadings of some types of contaminants. However, many coastal areas continue to suffer from overutilization, loss of important habitats, and damage from pollution. One-third of the nation's assessed estuarine waters do not fully support designated uses. Nonpoint pollution sources continue to affect thousands of acres of shellfish growing waters. Nonindigenous species are increasing in coastal waters where they threaten to displace native species. And the futures of some fisheries depleted by over-utilization, habitat alteration, and other factors seem to be in question. These and other trends in coastal and marine environmental quality are reviewed in this chapter.

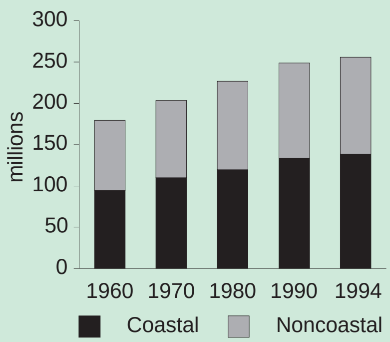
Trends in Coastal Population

Because of their rich bounty and natural transportation routes, coastal areas have been inhabited by humans since pre-historic times. Today, coastal areas support major population and industrial centers, retirement and "second home" communities, and popular tourist attractions. Population growth and development in coastal areas brings changing and sometimes conflicting land uses; pressures and demands for infrastructure and services; pollutant discharge increases from point and nonpoint sources; and possible diminution of coastal habitats and associated living resources.

The U.S. coastal zone represents only about one fourth of total U.S. land area, yet the Bureau of the Census estimates that in 1994 nearly 140 million people—roughly 53 percent of the total U.S. population—were living within the coastal zone area. Coastal corridor densities range from 69 people per square mile along the Pacific coast to over 410 people per square mile along the Atlantic coast. Regardless of coast, population density in the coastal zone far exceeds that of the interior portion of the country (Part III, Table 6).

The U.S. coastal population increased by about 44 million people from 1960 to 1994, which is slightly more than half of the total U.S. population increase (Figure 14.1). The pattern of population growth ranges from traditional growth outward from an inner city, characteristic

Figure 14.1 Coastal and Non-coastal Population, 1960-1994



Source: See Part III, Table 6.

of older urban centers in the North Atlantic and Middle Atlantic, to suburban sprawl along narrower coastal strips, characteristic of sections of the South Atlantic and Gulf of Mexico region.

Trends in Coastal Habitats

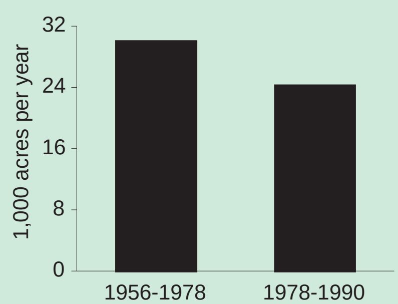
Important coastal habitats include estuaries, salt and fresh water marshes, tidal flats, estuarine forested wetlands, sandy beaches, barrier islands, seagrass beds, coral reefs, and deltas and dunes. These habitats are nurseries and spawning grounds for many commercially valuable species.

Along the Gulf of Mexico, for example, coastal wetlands and seagrass beds are diminishing. This loss is of special interest because of the role these coastal habitats play in supporting fish and shellfish of economic importance. The Gulf of Mexico is an exceptionally productive sea that, according to NMFS, yields between 1.5 and 2 billion pounds of fish and shellfish annually and contains three of the top five fishing ports in the nation (by weight of fish harvest).

According to the National Biological Service, the loss of wetlands in Louisiana is the largest of any state and accounted for 67 percent of the nation's total loss for the period 1978–90 (Figure 14.2). The rate of wetlands loss has been reduced from 30,000 acres per year in the 1956–78 period to 24,000 acres per year in the 1978–90 period. Much of the loss is due to altered hydrology stemming from navigation, flood control, and mineral extraction and transport projects. In the northern Gulf, losses of seagrass have also been extensive over the last five decades—from 20 to 100 percent for most estuaries—largely because of coastal population growth and accompanying deterioration of water quality.

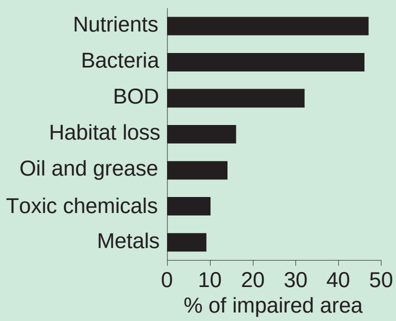
Some portion of wetland and seagrass bed losses are attributable to natural processes such as hurricanes and coastal

Figure 14.2 Louisiana Wetlands Losses, 1956-1990



Source: Johnson et al., "Gulf of Mexico Coastal Wetlands: Case Studies of Loss Trends," In: *Our Living Resources,* LaRoe et al, eds., U.S. Department of the Interior, National Biological Service (GPO, Washington, DC, 1995).

Figure 14.3 Causes of Impairment in U.S. Estuaries, 1994



Source: See Source for Part III, Table 38.
Note: Total impaired area=9,700 sq. mi. (37% of U.S. estuarine area). BOD=biochemical oxygen demand.

storms. Rising sea level and coastal subsidence (natural processes that are probably accelerated by human activities) are also causing coastal habitat losses.

Coastal barrier islands—dynamic, shifting, sandy areas such as the Outer Banks of North Carolina—are experiencing greatly increased pressures, largely as a result of development in areas of high risk. Long-term survey data by the U.S. Geological Survey show that coastal erosion is affecting each of the 30 coastal states. About 80 percent of U.S. coastal barriers are undergoing net long-term erosion at rates ranging from less than 3.3 feet to as much as 65 feet per year. Natural processes such as storms may be the immediate precipitating cause of this erosion, but human factors such as mineral extraction, construction of hard coastal structures, and dredging are now recognized as having major effects on shoreline stability. Rising sea level is also implicated in the erosion of barrier islands.

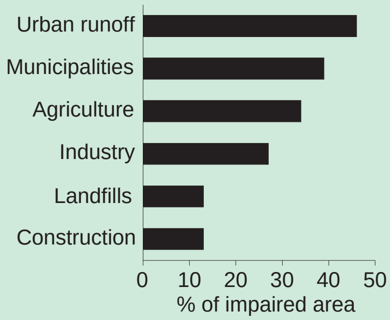
Water Quality

In 1992–93, 25 coastal states and jurisdictions surveyed 78 percent of the nation's total estuarine waters. The results, published in December 1995 in EPA's *National Water Quality Inventory*, indicate that 63 percent of the surveyed estuarine waters have good water quality that fully supports designated uses; 27 percent have fair water quality; and 10 percent have poor water quality.

Enhanced nutrient and bacteria loads are the most widespread causes of impairment in estuaries: 15 states reported that excess nutrients pollute 4,548 square miles of estuarine waters, and 25 states reported that bacteria contaminate 4,479 square miles. Oxygen depletion from organic wastes (3,127 square miles), habitat alteration (1,564 square miles), and oil and grease (1,344 square miles) also are significant environmental problems (Figure 14.3). The states reported that urban runoff and storm sewers, including combined sewer overflow discharges, are the most widespread sources of pollution in estuaries, followed by municipal sewage treatment plants, agriculture, and industrial discharges (Figure 14.4).

Where the nation's largest river, the Mississippi, discharges into the northern Gulf of Mexico, excess nutrient enrichment from anthropogenic sources is one of the major stresses on the coastal ecosystem. An extensive and severe zone of oxygen-depleted (hypoxic) waters in which fish and shrimp cannot survive forms each spring and summer off the coast of Louisiana; in summer 1995, this so-called "dead zone" covered an area

Figure 14.4 Sources of Impairment in U.S. Estuaries, 1994



Source: See Source for Part III, Table 38.
Note: Total impaired area=9,700 sq. mi. (37% of U.S. estuarine area).

estimated at 18,200 kilometers (7,032 square miles).

Between 1990 and 1996, 30 federal and academic scientists participated in the interdisciplinary Nutrient Enhanced Coastal Ocean Productivity Program (NECOP) of NOAA's Coastal Ocean Program in order to better understand this coastal ecosystem's response to nutrient enrichment. The researchers conducted a series of integrated retrospective analyses, process and monitoring studies, and modeling exercises. The results confirm suspected linkages between nutrients derived from the extensive Mississippi drainage basin and the current low oxygen conditions. NECOP findings have aroused concern over oxygen depletion in the northern Gulf of Mexico and helped managers and scientists develop a plan to deal with the problem.

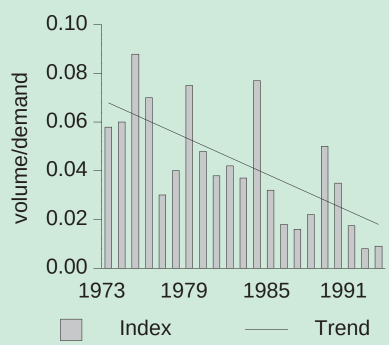
The 1994 EPA water quality report also included ocean shoreline miles, but the sample reported by the participating coastal states represents only 9 percent of the nation's ocean coastline. (States may be targeting their limited ocean coastal sampling in areas with suspected problems.) Of this area, 93 percent was reported to have good quality; only 5 percent had fair quality and 2 percent had poor quality.

Trends in Oil Spills

By nearly every measure, the volume of oil spilled in U.S. coastal waters declined during the 1973–93 period, according to a recent report by the Department of Transportation, U.S. Coast Guard (USCG).

Though interrupted by a few catastrophic events such as the 1989 *Exxon Valdez* spill and 1996 spills off Rhode Island and Texas, the general downward trend suggests that tightened regulations and the threat of severe financial penalties are having a positive effect (Figure 14.5).

Figure 14.5 U.S. Oil Spills as a Function of Demand, 1973-1993



Source: U.S. Coast Guard, *Pollution Incidents In and Around U.S. Waters: A 25 Year Compendium, 1969-1993* (USCG, Washington, DC, 1996).

The USCG report found that 95 percent of all spills reported each year are less than 1,000 gallons, but these spills constitute only 5 percent of total spill volume. Of the 170,340 spills reported between 1973 and 1993, only 287 were more than 100,000 gallons, but these constituted nearly 70 percent (153 million gallons) of the total volume spilled (222 million gallons).

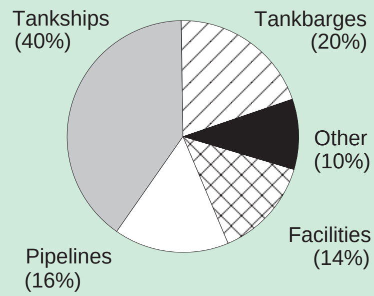
Although the decline in oil spill volume in recent years suggests a diminished risk of catastrophic spills, the risk may actually be increasing. Oil imports are primarily transported by tankers, which historically have been responsible for the lion's share of spill volume (Figure 14.6). Because oil imports have increased from 21 percent of domestic consumption in 1970 to about 45 percent in 1994—a trend that is expected to continue—the opportunity for accidents may be growing.

Trends in Coastal Contaminants

Chemical contaminants can be detected in coastal sediments and in the tissues of bottom-feeding fish and shellfish. Several federal projects monitor these contaminants.

NOAA's National Status and Trends Program measures trace metals and synthetic organic compounds in fish livers and coastal sediments at about 100 sites nationwide as part of its National Benthic Surveillance Project. Since 1986, NOAA's Mussel Watch Project has measured about 70 contaminants in mussel and oyster tissues and coastal sediments at more than 240 sites nationwide.

Figure 14.6 U.S. Oil Spill Volume by Source,1973-1993

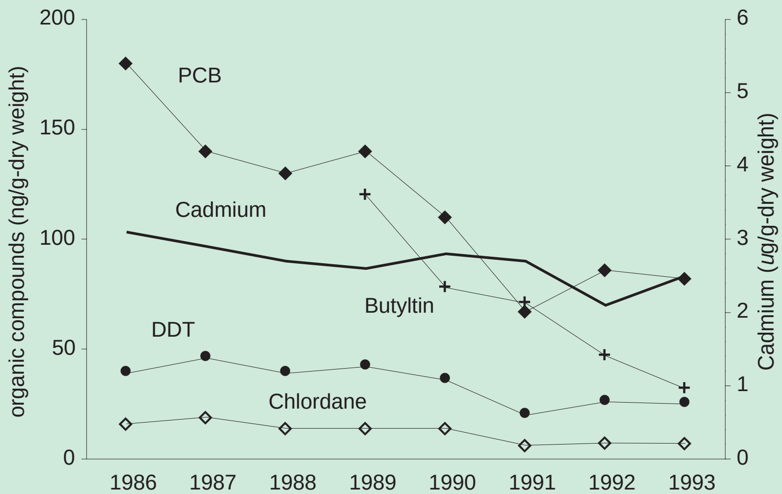


Source: U.S. Coast Guard, *Pollution Incidents In and Around U.S. Waters: A 25 Year Compendium, 1969-1993* (USCG, Washington, DC, 1996).
Note: Data refer to cumulative volume (155.6 million gallons which is 70% of the total 222 million gallons) spilled from 1973 through 1993.

Not surprisingly, both projects have found that the highest concentrations are near urban and industrial areas. Using sediment cores to reconstruct the history of contamination, NOAA has found that contaminants increased slowly in the late 1800s, accelerated in the mid-1900s, and peaked around the 1970s. Since then, many contaminants have been decreasing (Figure 14.7). Lower concentration levels generally are observed for banned chemicals (chlorinated pesticides, polychlorinated biphenyl (PCB), and tributylin) and for substances whose use is declining (cadmium and arsenic). Sites with decreases in contaminant concentrations are more numerous than sites with increases.

The NOAA mollusc and fish liver projects are valuable indicators of long-term trends in sediment contamination. To a large extent for organic chemicals and to a lesser extent for trace metals, the

Figure 14.7 Mean Contaminant Concentrations in Molluscs from U.S. Coastal Waters, 1986-1993



Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, *Recent Trends in Coastal Environmental Quality: Results from the Mussel Watch Project* (NOAA, Silver Spring, MD, 1995).

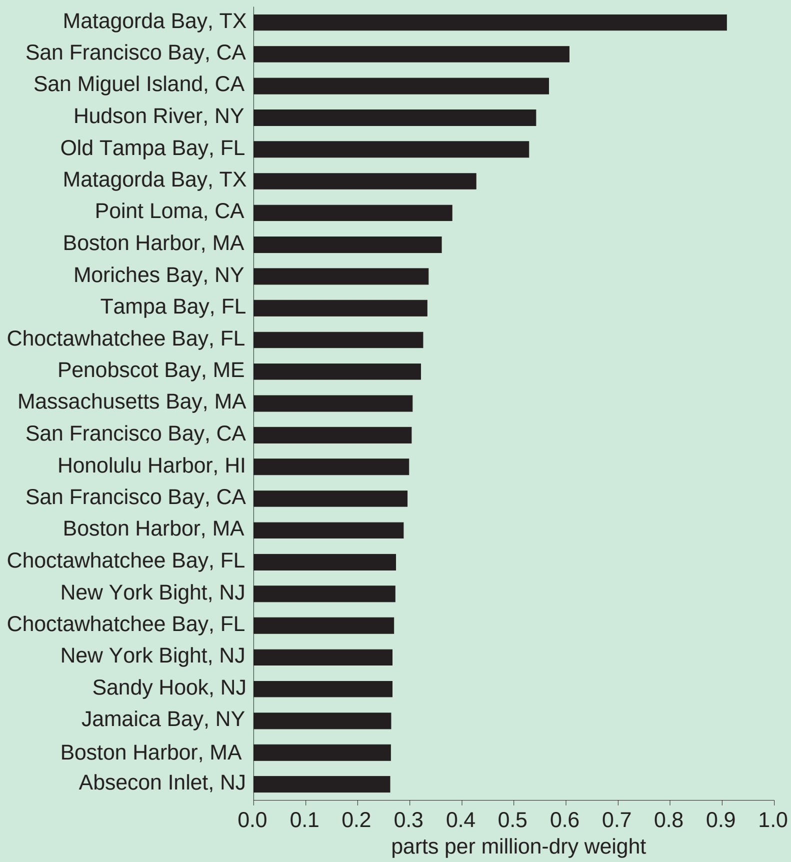
Note: PCB=polychlorinated biphenyls; sum of concentrations at each level of chlorination. DDT=dichloro-diphenyl-trichloro ethane and metsabolites. Butylin=sum of monobutylin, dibutylin, and tributylin.

national distribution of contaminants in molluscs reflects that in sediments (Figure 14.8). Similarly, high levels of contaminants in sediments were closely associated with high levels in fish livers.

Monitoring results indicate the following:

- The highest concentrations of chemicals in fish livers are near urbanized areas in the Northeast (New York City, Boston, and Baltimore) and the West (San Diego, Los Angeles, and Seattle). State advisories remain in effect warning against consumption of fish and shellfish from these areas.
- Relatively high incidences of nontumorous disease occur in fish from contaminated sites. At Morris Cove, a highly contaminated site in New Haven, Connecticut, up to 90 percent of the cells in winter flounder livers have a precancerous condition with large numbers of nonfunctioning cells.
- Fin erosion is unusual, except in a few highly contaminated sites. However, at the Houston Ship Channel at Green Bayou, Texas, up to 90 percent of the Atlantic croaker, 100 percent of the sand sea trout, and 17 percent of spot experience fin loss due to disease.
- The highest concentrations of organic contaminants in molluscan tissues are at urban sites near Boston, New York City, Mobile, San Diego, San Francisco, and Los Angeles.

Figure 14.8 Mean Mercury Concentrations in Molluscs from U.S. Coastal Waters, 1986-1993



Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, *Recent Trends in Coastal Environmental Quality: Results from the Mussel Watch Project* (NOAA, Silver Spring, MD, 1995).
Notes: Some coastal bays and harbors are listed above more than once because data are reported for more than one sampling station per location. See source document for locations of sampling stations. Another 206 stations not shown above have mean concentrations ranging from 0.045 to 0.26 ppm-dry weight.

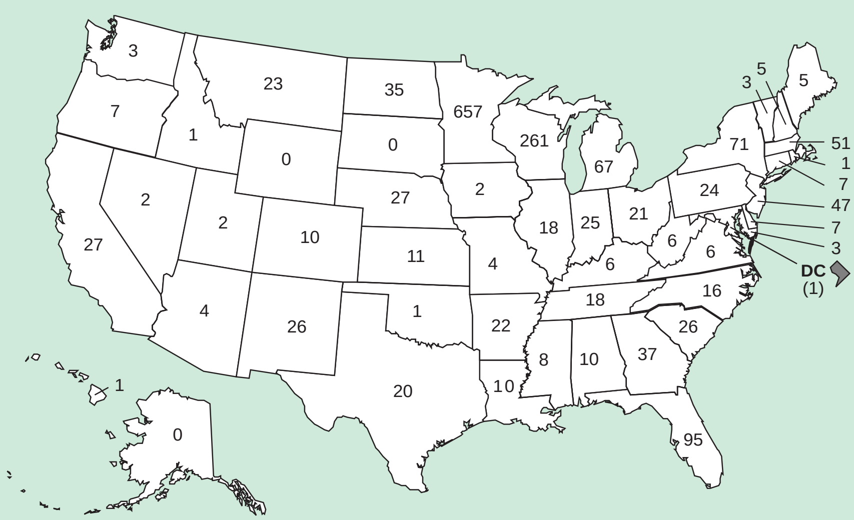
An analysis was conducted of sediment toxicity data collected during the NOAA Coastal Ocean Program's Toxic Chemical Contaminants Program from 20 bays and estuaries, encompassing over 2,200 square kilometers, in order to estimate the spatial extent of environmental degradation in U.S. coastal regions. The toxicity tests included bioassay for acute toxicity, measures of impaired fertilization or larval development, and observations of physiological responses upon exposure to contaminants.

Based on acute toxicity measurements, about 10 percent of the nation's coastal regions are estimated to be environmentally degraded. The extent of environmental degradation ranges from none in generally pristine environments such as Apalachicola Bay in Florida to 85 percent in the relatively small but heavily contaminated Newark Bay. Measurements of impaired fertilization and physiological stress indicate that approximately 50 percent of coastal regions show adverse biological responses to environmental contaminants—a figure that could be indicative of impending problems.

Trends in Fish Advisories

The number of waterbodies with fish contamination advisories reported to EPA in 1995 (1,740 advisories) represents a 14 percent increase from the number reported in 1994 (1,532 advisories) and a 36 percent increase from the number of advisories issued since 1993 (1,278 advisories). As noted in Chapter 13, "Water," the increase in advisories reflects an increase in the number of assessments of the levels of chemical contaminants in fish and wildlife tissues. A substantial number of advisories were issued in coastal states (Figure 14.9).

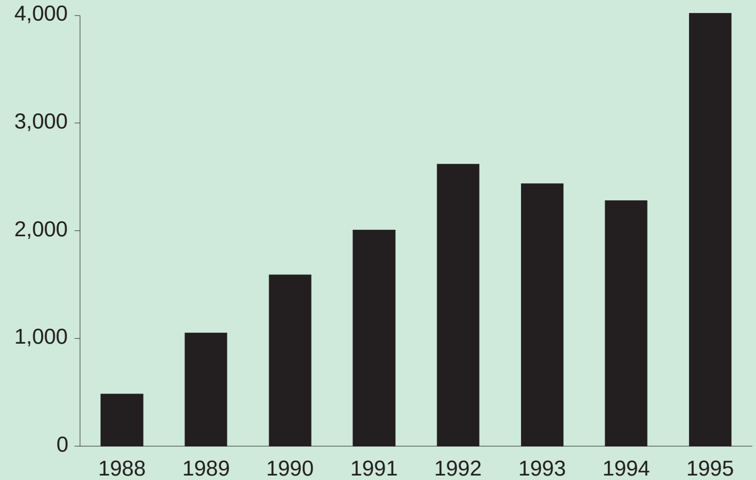
Figure 14.9 Number of Fish Consumption Advisories Issued by State, 1995



Source: U.S. Environmental Protection Agency (EPA), Office of Water (OW), *Update: National Listing of Fish and Wildlife Consumption Advisories*, Fact Sheet (EPA, OW, Washington, DC, 1996).

Note: The numbers depicted here do not necessarily reflect the geographic extent of chemical contamination in each state nor the extent of state monitoring efforts.

Figure 14.10 Number of U.S. Coastal Beach Closings and Advisories, 1988-1995



Source: Natural Resources Defense Council (NRDC), *Testing the Waters, Volume VI, Who Know What You're Getting Into* (NRDC, New York, NY, 1996).
Note: A beach closure/advisory is a single beach for which a closure/advisory has been issued for a single day. Numbers do not include permanent or extended closures/advisories. Data for 1995 include information received by NRDC after the source document was published.

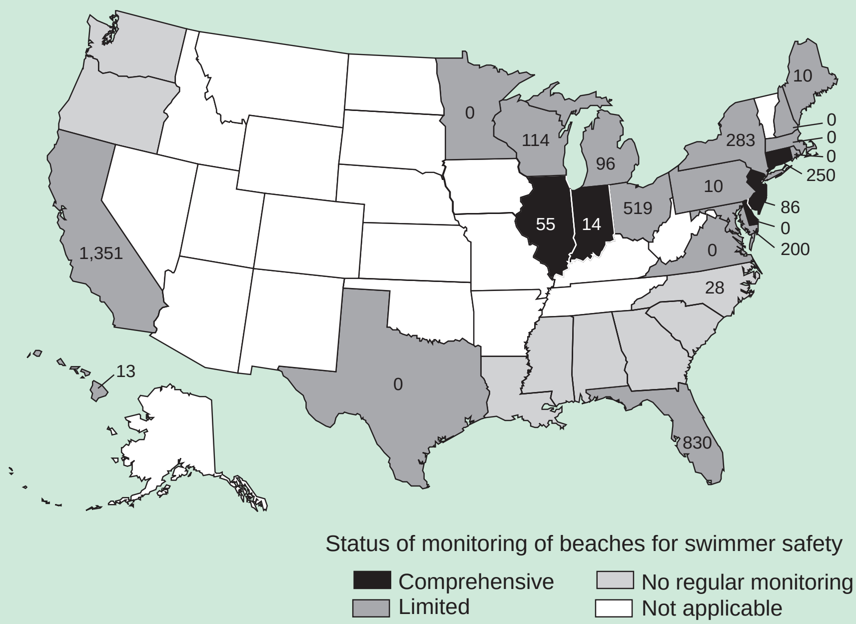
Trends in Beach Closings

Disease-carrying organisms, primarily from stormwater runoff and sewage overflows, prompted at least 4,020 closings and advisories at ocean, bay, and Great Lakes beaches in 1995, according to a study released by the Natural Resources Defense Council. This number is 76 percent higher than the 1994 tally, reversing what had been a declining trend since 1992. Since 1988, there have been over 16,492 closings and advisories (Figure 14.10). This figure could actually be higher because no standard monitoring, testing, or closure practices control beach safety and because eight states do not regularly monitor beach water for swimmer safety (Figure 14.11).

The primary sources of pollution that caused beach closings and advisories in 1995 included sewage overflows (842 closings), stormwater runoff (823), sewage treatment plant malfunctions (236), and polluted runoff (143). High levels of bacteria—indicating the presence of pathogens from human or animal waste—caused another 510 closings/advisories. The 1995 increase in closings and advisories was due in part to major storms in California and Florida that flushed pollutants into coastal waters.

Because of a wide range of diseases that can be carried by pathogens in sewage-contaminated waters, including gastroenteritis, dysentery, and hepatitis, beachwater pollution threatens the pub-

Figure 14.11 U.S. Coastal Beach Closings and Advisories by State, 1995



Source: Natural Resources Defense Council, *Testing the Waters, Vol VI, Who Knows What You're Getting Into* (NRDC, New York, NY, 1996.

Note: Numbers refer to the number of coastal beach closings and advisories.

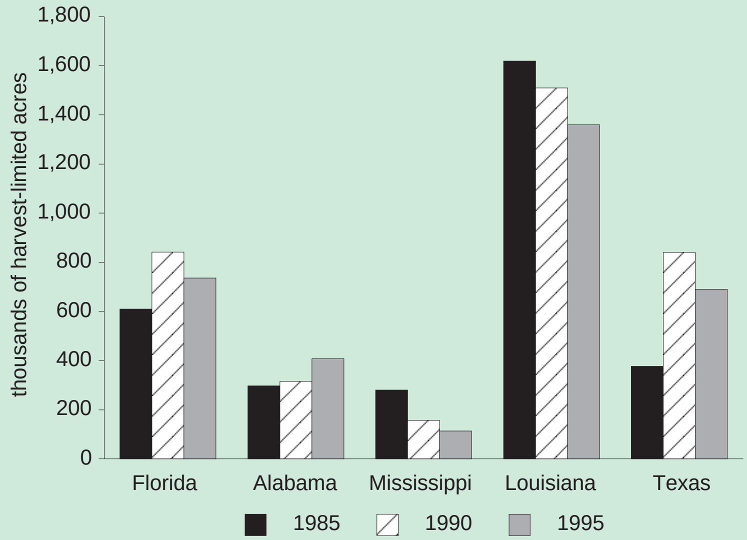
lic's health. The risk can be greater for children, elderly people, and those with weakened immune systems. A recent large-scale epidemiological study conducted in California by the Santa Monica Bay Restoration Project found that people swimming in ocean waters contaminated by urban runoff from storm drains were at greater risk of developing fever, chills, ear discharge, vomiting and other health problems than those swimming in cleaner waters. This study underscores the importance of monitoring beachwater quality and of reducing pollution sources.

Trends in Shellfish Growing Waters

NOAA's National Shellfish Register collects data on the number of shellfish-rearing areas with harvest restrictions. Harvest-limited areas (areas not available for direct marketing at all times) may be restricted for a variety of reasons, including water quality problems, lack of funding for complete surveying and monitoring, conservation measures, and other management actions.

Results from the 1995 Register are only available for the Gulf of Mexico, the largest oyster-producing region in the

Figure 14.12 Harvest-Limited Shellfish Waters in the Gulf of Mexico, 1985-1995



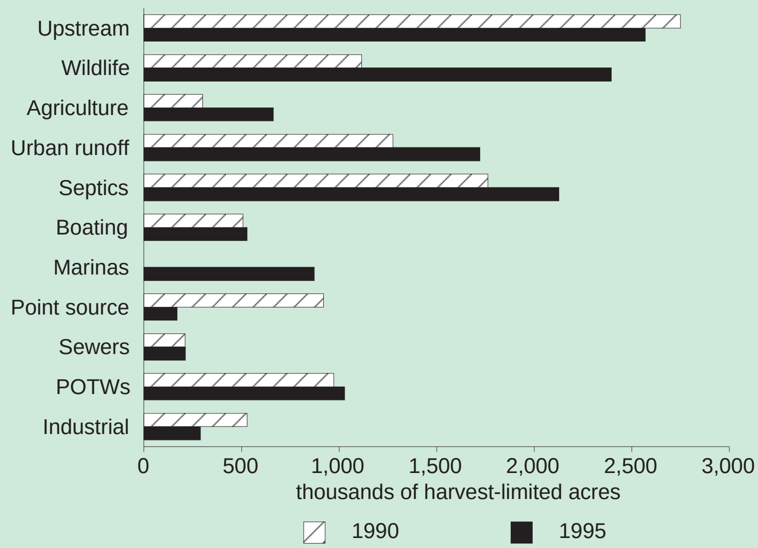
Source: See Part III, Table 43.

country. Of the 9.3 million acres of classified waters reported in 1995, 3.3 million (or 35 percent) of these waters were classified as harvest-limited. This represents a decline in the amount of harvest-limited waters from 1990, when 3.7 million acres or 52 percent of the then total classified waters (7.1 million), were classified as harvest-limited. From 1990 to 1995 there was an increase in harvest-limited acreage in Alabama; Florida, Mississippi, Louisiana, and Texas experienced decreases in harvest-limited acreages (Figure 14.12).

The top five sources of pollution most frequently cited as contributing to a harvest-limited classification in the 1995 Register for the Gulf of Mexico region were upstream sources (78 percent), wildlife (72 percent), septic systems (64 percent), urban runoff (52 percent) and wastewater treatment plants (31 percent). In contrast, the top five sources cited in the 1990 Register for this region were upstream sources (74 percent), septic systems (48 percent), urban runoff (35 percent), wildlife (30 percent), and wastewater treatment plants (27 percent).

Between 1990 and 1995 the amount of harvest-limited acreage in the Gulf of Mexico affected by wastewater treatment plants, boating, septic systems, urban runoff, agricultural runoff and wildlife increased, while that affected by industrial facilities, direct discharges and upstream sources decreased (Figure 14.13).

Figure 14.13 Sources of Pollution Affecting Harvest-Limited Shellfish Waters in the Gulf of Mexico, 1990-1995



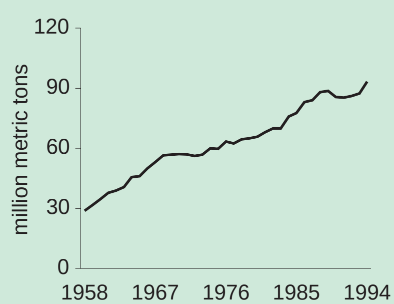
Source: See Source for Part III, Table 43.
Note: 1990 data for marinas not available.

Trends in Coastal and Marine Fishery Resources

At the global and national level, there are many troubling signs that fishery resources are imperiled. After a long period of expansion, the global fish catch (excluding aquaculture) peaked in 1989 at about 89 million metric tons and then declined to 87 million metric tons in 1993. In 1994, global fish catch rebounded to surpass the 1989 peak, primarily because of increased catch of Peruvian anchovy (Figure 14.14). The Food and Agriculture Organization of the United Nations estimates that, of 200 stocks fished worldwide, more than 25 percent are overexploited, depleted, or recovering, while 38 percent are fully exploited.

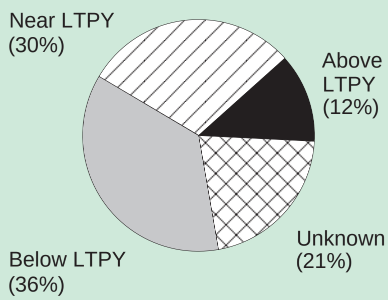
In the United States, which accounted for an estimated 6 percent of the global catch in 1994, the situation is similarly

Figure 14.14 World Commercial Fish Catches, 1958-1994



Source: Food and Agricultural Organization of the United Nations (FAO), *Yearbook of Fishery Statistics* (FAO, Rome, annual).

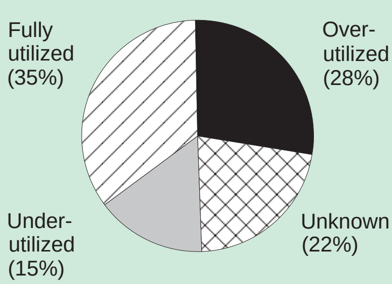
Figure 14.15 Abundance of U.S. Fishery Resources, 1994



Source: See Part III, Table 44.
Note: LTPY=Long-Term Potential Yield for 158 stocks.

alarming. Of the 158 stock groups whose biological status is known and monitored by NOAA, 36 percent (73 groups) are currently below estimated optimum long-term levels (i.e., productivity is below the estimated long-term potential yield) (Figure 14.15). As measured in terms of fishery utilization of the resource, NOAA estimates that 28 percent (56 of 157 known stock groups) are overutilized (Figure 14.16).

Figure 14.16 Utilization of U.S. Fishery Resources, 1994



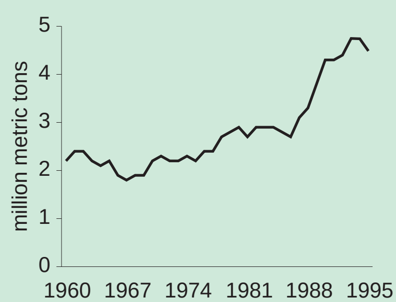
Source: See Part III, Table 44.
Note: Based on 157 "known" stocks.

Of the 56 overutilized stocks, fully one third (18 stocks) occur among the demersal fisheries (groundfish and flounder) in the Northeast. In addition, 10 stocks or stock groups of Atlantic and Gulf of Mexico reef fish are overutilized at dockside.

In 1994, U.S. fishermen landed a total of 4.7 million metric tons, valued at a record $3.81 billion. In 1995, total landings declined to 4.5 million metric tons, valued at $3.77 billion (Figure 14.17). The total catch has more than doubled since 1970, but catch reductions from 1994 were evident for many of the major species such as Pacific hake, Atlantic mackerel, tuna, American lobster, blue crab, oysters, and Atlantic squid. Finfish accounted for 87 percent of total landings, but only 52 percent of total value.

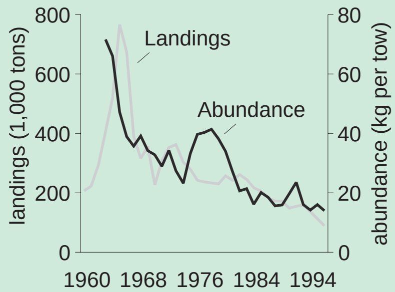
Groundfish and flounder in the Northeast—particularly cod, haddock, and yellowtail flounder—have been severely overfished. Their overall abundance in 1994 was the lowest on record (Figure 14.18). Dogfish and skate, which increased in abundance as more com-

Figure 14.17 U.S. Commercial Fish Catches, 1960-1995



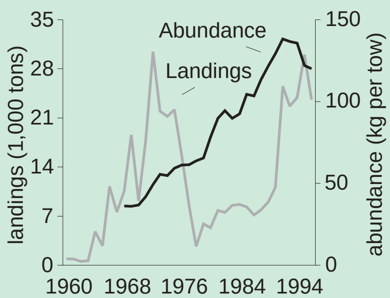
Source: National Marine Fisheries Service (NMFS), *Fisheries of the United States* (NMFS, Washington, DC, annual).

Figure 14.18 Northeast Groundfish and Flounder, 1960-1994



Source: National Marine Fisheries Service (NMFS), *Our Living Oceans* (NMFS, Washington, DC, 1996).

Figure 14.19 Northeast Skate and Dogfish, 1960-1994



Source: National Marine Fisheries Service (NMFS), *Our Living Oceans* (NMFS, Washington, DC, 1996).

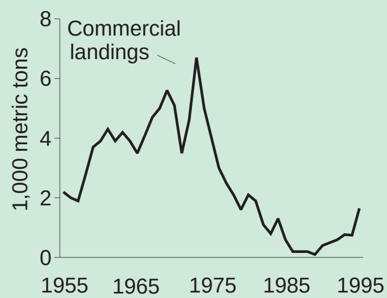
mercial groundfish species were declining, now make up about 75 percent of the total fish biomass in the region and have supported increased catches until relatively recently (Figure 14.19). Beginning in 1990, their abundance also declined.

Most of the Northeast region's fisheries are included in fishery management plans, but few of these plans have been successful in preventing overexploitation. An amendment to the Northeast Multispecies Plan, which was debated for several years and finally implemented early in 1994, was intended to limit commercial fishing of groundfish in New England and prevent the issuance of new vessel permits in this overcapitalized fishery. By early 1994, however, stocks had collapsed so severely that NMFS imposed an emergency closure of portions of Georges Bank and a moratorium on fishing for haddock. In 1995, another amendment to the Northeast Multispecies Plan was developed to reduce fishing mortality on critically overfished groundfish while avoiding increased exploitation on stocks in the Gulf of Maine and Middle Atlantic that could result if effort were transferred from one area to another. Canada continues to maintain severe restrictions on its own groundfish fishery on Georges Bank to promote stock rebuilding. Recovery of these stocks is expected to take 6 to 9 years.

Among other national stocks, trends are mixed:

- Off the Atlantic coast, the anadromous striped bass, driven to very low levels of abundance in the early 1980s and subjected to severe catch restrictions beginning in the mid-1980s, was declared fully restored in early 1995 (Figure 14.20). The Northeast's valuable crustaceans and bivalve molluscs, both offshore (e.g., American lobster, sea scallop, surfclam, ocean quahog) and inshore (e.g., blue crab, oyster, blue mussel, hard and softshell clam), are fully or overexploited.
- In the Southeast, the three major shrimp species (brown, white, and pink) are considered fully utilized in

Figure 14.20 Chesapeake Bay Striped Bass, 1955-1995



Source: National Marine Fisheries Service (NMFS), *Fisheries of the United States* (NMFS, Washington, DC, annual).

both the Gulf of Mexico and the Atlantic.

- Among pelagic species in the Northeast and Southeast, bluefin tuna is well below the biomass level required for maximizing long-term yield. The marlins (white and blue) are below optimum levels as well, although blue marlin appears to be increasing. Swordfish has recently declined to a level below its maximum long-term yield. Yellowfin tuna is currently fully exploited and near its maximum long-term yield. Bigeye tuna exploitation has increased recently, but current yields are not expected to be maintained.

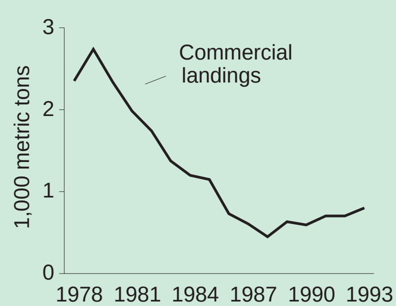
- Large coastal sharks (as a group) may be overutilized, but the status of each species is currently unknown. Because they grow and mature slowly, large sharks may be particularly vulnerable to overfishing.

- Spanish mackerel appears to be fully utilized in both the Gulf of Mexico and the Atlantic. King mackerel has been overfished in the Gulf, and a stringent rebuilding program has been in place for the last several years. King mackerel in the Atlantic may have some additional yield potential. The status of other coastal migratory pelagic species in the region is unknown.

- Most reef fishes are either fully utilized or overutilized. In the Gulf of Mexico, red snapper is overfished, and rebuilding the fishery hinges on the reduction of bycatch of juveniles in the Gulf shrimp fishery. In the Atlantic, many of the key reef fish species are considered overutilized (e.g., vermilion and other snapper, red porgy, several kinds of grouper, amberjack, jewfish). In the Caribbean, where Nassau grouper and jewfish are considered overutilized, landings of traditional reef fish have declined (Figure 14.21).

- The status of drum and croaker stocks is largely unknown. Many of the smaller species could also be heavily impacted from bycatch of the

Figure 14.21 Reef Fish in U.S. Caribbean Waters, 1978-1993



Source: National Marine Fisheries Service (NMFS), *Our Living Oceans* (NMFS, Washington, DC, 1996).

shrimp fleet. Red drum harvests in the Gulf and South Atlantic EEZ have been prohibited (the popularity of “blackened redfish” in the 1980s stimulated a significant demand for red drum so that in a few years the stock became seriously depleted), and harvests in state waters have been reduced for several years because of low spawning levels. Recovery is expected.

• Weakfish bycatch in the Atlantic is becoming a major management issue. On November 22, 1995, NMFS announced a ban on fishing for Atlantic coast weakfish in federal waters from Maine to Florida. The ban will remain in effect until the stock recovers. State waters will remain open for weakfish fishing under the guidelines of the Atlantic States Marine Fisheries Commission’s weakfish management plan.

• In Alaska, salmon stocks have produced bumper harvests in recent years. Five species of Pacific salmon (chinook, coho, sockeye, pink, and chum) contribute to the catch.

• In the Bering Sea and Aleutian Islands, the major species groups harvested are walleye pollock, Pacific cod, flatfish, Atka mackerel, rockfish, and sablefish. Except for Greenland turbot, all flatfish species are high in abundance and in excellent condition. Walleye pollock and Pacific cod abundances are much lower than their recent high levels, but are still close to long-term sustainable levels. Overall abundance of groundfish in the Gulf of Alaska has been relatively stable, except for walleye pollock, which is down. Shrimp resources are down throughout Alaska. King crab resources are depressed, but Tanner crab stocks are still relatively high.

• On the Pacific coast, the major fisheries are salmon, coastal pelagics, groundfish, Pacific halibut, and nearshore resources. Most stocks, including all five species of Pacific salmon, are fully utilized or overutilized. Depressed production is partly due to ocean conditions that have been generally unfavorable for salmon off the Pacific coast since the late 1970s. Coastal pelagic fishes are low in abundance, and all, except jack mackerel, are fully utilized. Jack mackerel is one of the few underutilized Pacific coast species. The Pacific sardine population has been increasing after decades at low abundance levels. Most shellfish species are fully utilized.

• In the Western Pacific region (the Hawaiian Islands and the U.S. territories of American Samoa, Guam, and the Northern Marianas), fishery resources include highly migratory pelagic fish, bottomfish, nearshore reef fish, and invertebrates. Of the 15 stock groups of highly migratory pelagics (tuna, swordfish, and so forth), 12 stocks are near their long-term sustainable levels. Among Western Pacific bottomfish (snapper, jack, grouper, emperor), which are harvested from a variety of rock and coral habitats (mainly around Hawaii), stock assessments indicate that some important species are only at 10 to 30 percent of original stock levels, and overutilization is a concern. Spiny and slipper lobsters, which are primarily fished in the northwestern Hawaiian Islands, peaked during the mid-1980s, but have since declined. The primary cause of the decline is thought to be a general reduction in lobster productivity and recruitment since 1989, stemming from oceanographic changes. Since 1991, emergency closures, a limited entry regime, and a closed season were adopted to rebuild the stocks, which are now recovering.

Trends in Nonindigenous Coastal and Marine Species

The number of nonindigenous species in Long Island Sound, San Francisco Bay, Los Angeles Harbor, and most other estuaries, ports, and harbors around the country is increasing steadily, in large part as a result of travel by ocean-going ships to and from foreign countries. Ships take on ballast water in their home ports; when they reach their destination, they discharge their ballast, including any aquatic species in the water. Foreign organisms then may become established in U.S. waters and threaten the sustainable populations of native species either by being predatory or by competing for food and habitat. Examples include:

- a half-dozen species of Chinese and Japanese copepods are now found from the Columbia River in Washington to the San Francisco Bay in California;
- the Japanese shore crab *Hermigrapsus sanguineus* is well established and spreading rapidly along the Atlantic coast from the Chesapeake Bay to Cape Cod;
- three species of Eurasian fish, one species of waterflea, and two species of zebra mussels have invaded the Great Lakes; and
- the South American mussel *Perna perna* has become established on the Texas Gulf coast, and the Indo-Pacific mussel *Perna viridis* has invaded the lower Caribbean.

These non-native species disturb the natural ecosystem and can cause direct adverse economic impact. Zebra mussels in the Great Lakes, for example, have caused hundreds of millions of dollars in damages and required maintenance actions to remove them from boat hulls, navigation buoys, and municipal and industrial water-intake pipes (see also Chapter 8, “Biodiversity”).

RECENT DEVELOPMENTS

The difficulties in protecting coastal and marine resources include overlapping political jurisdictions, a multitude of stakeholders, and a lack of knowledge of cause-and-effect linkages involving natural and social systems. The complexity of these efforts is illustrated by current initiatives to restore shellfish beds in Puget Sound, to restore the Florida Everglades, and to rebuild groundfish stocks in the Northeast.

Cooperation in the Puget Sound

Restoring the health of the shellfish beds in the Puget Sound has required a number of measures. Since the mid-1980s, the state of Washington has prohibited or restricted oyster harvesting on nearly 45,000 acres of shellfish beds—one quarter of all available grounds in Puget Sound.

Because sources of pollution into the Sound included agricultural runoff and private septic systems, a major campaign was launched to identify and upgrade failing septic systems in the watershed. About 100 farmers teamed with a local conservation district to cover manure piles, construct fences along steams to keep animals out, and rotate grazing areas to reduce erosion runoff.

These and other steps have helped reduce contamination in the sound. More than 20,000 acres of shellfish beds remain closed, but clam and oyster harvesting has recently opened again in at least four areas.

Everglades Restoration

The Florida Everglades, with its vast area and long history of engineered alterations, presents a massive and complex restoration challenge. In response to intense flooding in south Florida and pressures to create more agricultural acreage, a complex system of public canals, levees, pumping stations, and other structures was built (largely in the 1920s and 1930s) to control the water and make the land more suitable for farming and urban development. As a result, about half of the Everglades wetland area was drained and converted to agriculture or urban development. Over time, these alterations contributed to the near collapse of the Everglades ecosystem. Ninety percent of the wading birds are gone, the estuarine fisheries have declined, and dozens of species are listed as threatened or endangered.

In recent years, a variety of public and private efforts have begun to restore the hydrologic functions of the Everglades, including the following:

- In January 1996, the Clinton Administration announced a comprehensive restoration program, including $1.5 billion in federal assistance. Among other things, the funding is to be used to acquire, in partnership with the state, enough land to make restoration a reality, including the purchase and reconversion of farmlands in the Everglades agricultural area and lands threatened by development along the eastern portion of the Everglades. The funding will also be used to continue work on the Kissimmee River, to initiate a number of restoration projects in Central and South Florida, to establish wetlands to serve as natural filters for phosphorus and other pollutants, and develop a multispecies recovery plan.

- In April 1996, Congress passed and the President signed the 1996 Federal Agricultural Improvement and Reform Act (otherwise known as the 1996 Farm Bill), which made available $200 million for land acquisition and other activities useful for Everglades restoration.

- A federal interagency research program was initiated in 1994 to quantify the health of the Florida Bay and to develop specifically tailored information products to assist with understanding potential effects of proposed Everglades restoration activities on the water quality and living resources of the Florida Bay and Keys.

- In 1993, Florida and the Army Corps of Engineers began the task of converting the Kissimmee River from an "engineered" channel back into its more natural, riverine form. In addition, a special federal task force on south Florida ecosystem restoration was created to improve coordination among the federal, state, and tribal interests in the area.

- The state and the sugar industry agreed to work together to reduce phosphorus loadings by 75 percent.

- A "Save Our Everglades" campaign has helped to acquire and protect over 326,000 acres of land.

These efforts are beginning to pay off, although much work remains to be done. Hydrologic improvements have helped rid the ecosystem of exotic species that invade and disrupt the area's natural vegetation and habitat. In the past 3 years, phosphorus levels in waters discharged from farmland north of the Everglades have been cut by about 30 percent.

Rebuilding Groundfish Stocks in the Northeast

In the Northeast groundfish crisis, a critical part of the problem is overcapacity in the fishing industry. Simply allowing the industry to shrink, however, could have a drastic economic impact on fishing-dependent communities.

To help cushion the blow, the Clinton Administration provided $25 million in disaster relief funds in August 1995. The money is for a vessel and permit buyout program that retires fishing vessels and buys back existing permits.

The buyout effort began with a $2 million demonstration program that attracted 114 vessel owners with vessels worth $52 million. Had the program been funded enough to accept all 114 applications, more than 31 percent of all fleet capacity could have been eliminated in the Northeast.

Thirteen applicants were chosen in October 1995 for inclusion in the demonstration program. Collectively, they produce about 2.6 percent of all revenues from the regulated groundfish species. They were chosen through a scoring formula that ranked offers according to the least scrapping cost per dollar of previous groundfish production. With the success of the demonstration, the remaining $23 million will be available for an expanded buyout program.

Complementing the vessel buyout program is a research project, the U.S. Global Ecosystems Dynamic Program, which is funded jointly by NOAA's Coastal Ocean Program and the National Science Foundation. Its primary objective is to understand how climate variability affects the distribution, abundance, production, and population dynamics of zooplankton and fish populations in the sea in order to improve resource management. Recovery of the fisheries on Georges Bank is a central theme of the program. Management plans have been initiated to limit fishing and to rebuild the groundfish stocks. Knowledge of current and historical physical and biological processes will contribute to improved understanding of changes in the fish stocks during recovery.

These are just a few examples of how the federal government works with communities to address environmental problems that have critical implications for the local, regional, or national economy. Other major efforts to protect coastal and estuarine resources include the National Estuary Program (NEP) and the federal interagency partnership Coastal America.

The National Estuary Program was established by Congress in the 1987 amendments to the Clean Water Act and is administered by the EPA (see also Chapter 7, "Ecosystems"). The goal of the NEP is to help communities protect and restore the health of their estuaries while supporting economic and recreational opportunities. This is achieved by forming a partnership involving all levels of government, businesses, environmental organizations, citizens, and academia. Through the partnership process, the community defines the estuary's priority problems and the actions that can be taken to protect and restore the estuary's health. The program now includes 28 estuaries. These serve as models for effectively integrating federal, state, and local environmental activities in ways that avoid duplication of effort while ensuring that problems get addressed. A major benefit of the program is that it provides a way to apply the lessons learned more broadly in other communities.

Similarly, Coastal America joins the forces of federal agencies with State, local, and private alliances to address collaboratively environmental problems along the nation's coasts. The federal partners in this effort include those agencies with principal responsibility for the stewardship of coastal resources, those with responsibilities for infrastructure development and maintenance, and those whose activities can impact coastal environments. Specifically, it includes the Executive Office of the President and the following agencies: Department of Agriculture, Department of Defense, Department of the Army, Department of Commerce, Department of Energy, Department of Housing and Urban Development, Department of the Air Force, Department of the Interior, Department of the Navy, Department of Transportation, and the Environment Protection Agency.

Coastal America's collaborative, interagency structure enables national policy issues to be identified and resolved, regional plans to be developed, and local restoration projects to be implemented. Since 1992, 150 restoration and protection projects in 26 states, two territories, and the District of Columbia have been undertaken in collaboration with over 300 nonfederal organizations. Through these partnerships, thousands of acres of wetlands are being restored, hundreds of miles of streams for anadromous fish are being reestablished, and habitat for endangered species of fish, birds, and mammals is being protected.

FUTURE CHALLENGES

As population and economic growth continue, coastal and marine resources face increasing stress from environmental pollution and overexploitation. Improving coastal waters will require improving habitat protection and enhancement, controlling pathogens from sewer system overflows, further reducing toxic pollution and eutrophication, and preventing marine debris. These actions will be particularly important in rapidly growing states such as Florida, where the need for careful management and protection will only grow stronger.

Because fish and shellfish are valuable and self-perpetuating, there are strong incentives for careful management and protection. In cases where resources are threatened by overutilization, careful management will be required and managers may have little choice but to impose moratoria or reduce utilization. Clearly, the preferred choice is to manage such resources on a long-term sustainable basis and avoid future crises. Avoiding such crises will require close monitoring and a willingness to respond quickly to early signs of trouble.

Other coastal resources, such as coral reefs and seagrass beds, have direct and indirect economic value for commercially valuable species and for tourism and recreation. These resources may be at greater

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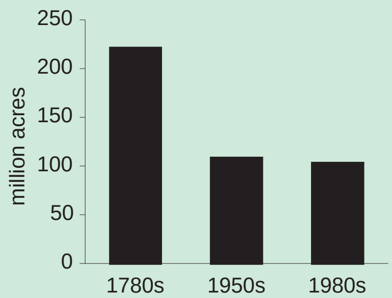
CHAPTER FIFTEEN

Wetlands

When the Declaration of Independence was signed in 1776, there were an estimated 221 million acres of wetlands in what is now the contiguous 48 states. By the late 1980s, slightly more than 104 million acres of that original wetlands area were left (Figure 15.1), and 10 states had lost over 70 percent of their original wetlands acreage (Figure 15.2). Although the rate of wetlands losses has slowed, wetlands continue to be lost in the 1990s.

Historically, wetlands were regarded as swampy lands that bred diseases, restricted overland travel, and impeded the production of food and fiber. Most settlers, commercial interests, and governments agreed that wetlands should be eliminated and the land reclaimed for other purposes.

Figure 15.1 U.S. Wetlands Area, 1780s-1980s



Source: See Part III, Tables 46 and 47.
Note: Data exclude wetlands in Alaska and Hawaii.

In the 18th century, wetlands drainage was widespread in the South. Parts of the Great Dismal Swamp in Virginia and North Carolina were surveyed in 1763 so that land could be reclaimed for water transportation routes. In Washington County, North Carolina, large-scale drainage began as early as 1788 with the construction of a canal and a system of ditches; today, only about one third of the county's original wetlands acreage remains.

In 1849, 1850, and 1860, Congress granted 65 million acres of swamp and overflow lands to 13 states for reclamation, setting a clear policy favoring wetlands drainage and reclamation for development that pervaded policy and land use trends for the next century. In the 1930s, the U.S. government in essence provided free engineering services to farmers to drain wetlands. By the 1940s, the government was sharing the cost of drainage projects. Methods such as tile and open-ditch drainage were considered conservation practices under the Agriculture Conservation Program.

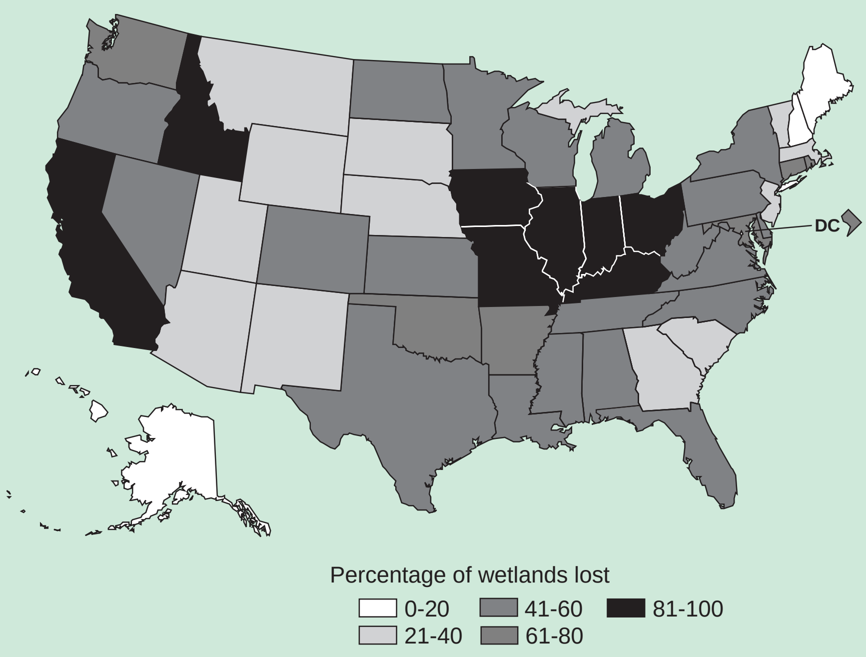
By the mid-1970s, the direction of environmental policy began to change. The principal driving force behind this change was a rapidly growing appreciation of the value of wetlands. Since passage of the Migratory Bird Hunting Stamp Act in 1934, there was some acknowledgment of the value of wetlands as duck habitat. For example, one half to two thirds of America's wild ducks hatch in the marshes of the prairie pothole region in the Dakotas, Minnesota, and Iowa. Drastic reductions in prairie pothole habitat had direct implications for duck populations. And it was known that ducks and other migratory birds depend on wetlands for specific habitat and nutritional needs during migration.

Since the 1970s, we have come to appreciate wetlands for values much broader than bird habitat. For example:

- Wetlands in the United States support about 5,000 plant species, 190 amphibian species, and one third of all bird species. In addition, they provide habitat for nearly one half of the fish, one third of the birds, one fourth of the plants, and one sixth of the mammals on the threatened and endangered species list.

- Coastal wetlands play a valuable role in the protection of shorelines and an important role in the life cycles of fish and shellfish. In 1994, the dockside value of fish landed in the United States was $3.8 billion. The fish processing and sales industry generates nearly $38 billion per year and employs hundreds of thousands of people. An estimated 71 percent of

Figure 15.2 Wetland Losses by State, 1780s to 1980s



Source: See Part III, Table 47.

Mallard Ducks. One of the great variety of wild ducks which depend on northern wetlands habitats.

Photo Credit: Gene Whitaker
U.S. Fish and Wildlife Service

this value is derived from fish species that depend directly or indirectly on coastal wetlands during their life cycles. Louisiana's marshes and coastal waters alone produce an annual commercial fish and shellfish harvest of 1.1 billion pounds, which was valued at $291 million in 1995.

- Wetlands help improve water quality by removing excess nutrients, sediments, and pesticides from surface waters.

- Many wetlands slow the overland flow of water and thus reduce flooding and soil erosion downstream. Wetlands are reservoirs for rainwater and runoff. They recharge groundwater supplies and extend streamflow during periods of drought or low rainfall.

RECENT TRENDS IN WETLANDS LOSSES

Until the mid-1980s, conversions to cropland accounted for most wetlands losses. In the 1954–74 period, 87 percent of the 690,000 acres lost annually were converted to cropland (see Part III, Table 48). In the 1974–84 period, estimated annual losses dropped to an average of 423,000 acres, with agriculture still accounting for over half of the total.

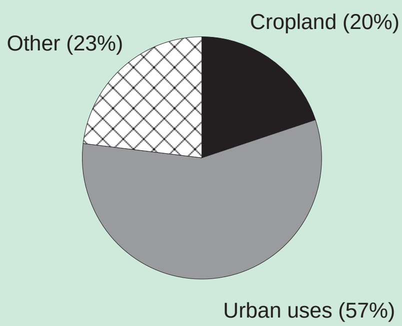
The picture changed dramatically in the 1982–92 period, with total gross losses on nonfederal lands dropping to an estimated 156,100 acres per year (Figure 15.3) and losses due to agriculture dropping to just 20 percent (30,900 acres). Urban development accounted for nearly 57 percent of the total losses (88,600 acres), and transition to deepwater habitat about 13

Natural water purification system: Bottomland hardwood wetlands in South Carolina.

Photo Credit: Craig Rieben
U.S. Fish and Wildlife Service

percent. For every 60 acres of wetlands converted to cropland annually from 1954 to 1974, only 3 acres were being converted annually from 1982 to 1992.

Figure 15.3 U.S. Wetlands Converted to Other Uses, 1982-1992

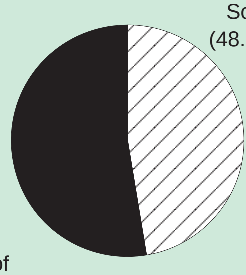


Source: See Part III, Tables 48.
Note: Data refer to annual losses of 156,100 acres of nonfederal wetlands; excludes Alaska.

Of the 1.56 million acres lost over the 1982–92 period, about 1.4 million acres became uplands and about 200,000 acres became deepwater habitat. During the same period, about 769,000 acres of deepwater or upland habitat became wetlands. Thus, though gross losses were estimated at 156,100 acres annually, the net loss of wetlands averaged 70,000 to 90,000 acres annually.

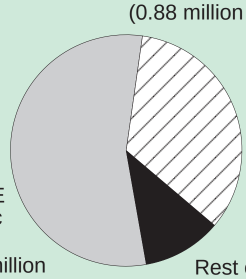
Among regions, there are a variety of different threats to wetlands. In the Southeast, which has more wetlands area (Figure 15.4) and has lost more wetlands acres (Figure 15.5) than any other region, remaining wetlands are declining in quality because of nutrient loading, altered hydrology, and urban encroachment. According to the Fish and Wildlife Service's *Status and Trends* reports, there have been significant losses and declin-

Figure 15.4 U.S. Wetlands Coverage, Mid-1980s



Source: Hefner et al., *Southeast Wetlands: Status and Trends, Mid-1970s to Mid-1980s* (FWS, Atlanta, GA, 1994).

Figure 15.5 U.S. Wetlands Losses, Mid-1970s to Mid-1980s



Source: Hefner et al., *Southeast Wetlands: Status and Trends, Mid-1970s to Mid-1980s* (FWS, Atlanta, GA, 1994).

ing quality in the South Central region in areas such as playas or seasonal depression wetlands and in Gulf Coast estuaries, which are threatened by saltwater intrusion from canal construction, geologic subsidence, and development pressures along the coastal regions. In the Northern Plains, nearly half of the original wetlands in the prairie pothole region have been drained; of those remaining, many are cropped when the weather permits. (See also Part III, Table 47.)

TRENDS IN WETLANDS PROTECTION

The changes in wetlands status represent a number of complex factors playing out on our nation's landscape. Changes in demographics, movement of population to the coasts, both human-induced and natural ecological succession, and shifts in land use patterns are all part of the picture. Another factor was the uncertain economic climate for agriculture in the 1980s, which saw a decline in the profitability of converting wetlands for agricultural production, although profitability has increased in subsequent years and will continue to do so as commodity prices rise. In addition, there is now much greater public interest and support for wetlands protection and restoration.

The key factor driving the dramatic change in wetlands losses, however, has been the enactment of laws and implementation of federal, state, and local programs that protect and restore wetlands.

Federal Programs

Clean Water Act. The 1972 Clean Water Act, in recognition of the importance of wetlands in maintaining water quality, established the federal government's role in wetlands protection. Section 404 of the act provides the govern-

Oil well spillover into wetland. Greater public interest, enactment of Federal law and implementation of Federal, State and Local programs protect against loss of valuable wetlands.

Photo Credit:
U.S. Fish and Wildlife Service

ment's main tool for that task. It regulates the discharge of dredged or fill material into waters of the United States, including most wetlands.

The permitting process for these activities is managed by the Corps of Engineers. An individual permit is required to discharge dredged or fill material, unless the activity is exempt or authorized under a general permit. For example, many normal farming, forestry, and ranching activities that involve discharges of dredged or fill material into U.S. waters are exempted from section 404. General permits are issued to authorize specific activities that have minimal environmental impacts, such as bank stabilization, minor road crossings, and certain wetlands restoration activities.

Because over half of the wetlands in the conterminous United States are found on private land and wetlands are the only ecosystem type to be comprehensively regulated by the federal government, section 404 has been the subject of some controversy. One aspect of the debate has been the matter of wetlands delineation. The Corps uses a delineation manual that it released in 1987 and which is generally considered to be in need of revision. Attempted revisions have met with disapproval for being either too inclusive in delineating wetlands or too exclusive. Delineation of wetlands is likely to be a central issue in future congressional debates on the Clean Water Act. Opposition to section 404 has focused on concerns over the financial impacts of federal regulation of private lands.

Following passage of the Clean Water Act, President Carter issued Executive Order 11990 in 1978, which modified government involvement in activities that could lead to the destruction of wetlands.

Swampbuster Provisions. Passage of the "swampbuster" provision in the 1985 Farm Bill was a major development in wetlands protection. Under the original provision, farmers who converted wetlands to cropland after December 23, 1985, jeopardized their eligibility for certain federal farm subsidy programs. The trigger for swampbuster violations was the planting of an annual crop on a newly converted wetland.

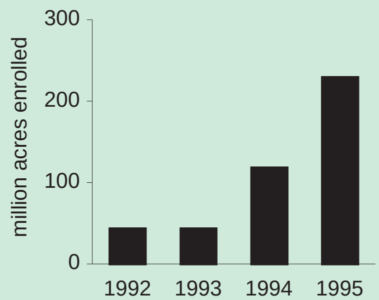
The 1990 swampbuster amendment changed the trigger for violation to include those activities that drain, fill, level, or otherwise alter wetlands to make possible the production of an agricultural commodity. The 1990 law allows producers to convert frequently cropped wetlands, but only if they mitigate the loss by restoring a converted wetland with equivalent wetlands functions.

The 1996 swampbuster amendments provide additional flexibility for mitigation of wetlands conversions, allowing the functions and values of converted wetlands to be mitigated by restoration, creation, or enhancement. The new amendments strive for balance between the protection of the functions and values of wetlands and the promotion of a more viable agricultural community. The current program allows farmers to manipulate wetlands in order to make farming operations more efficient and at the same time protects and enhances wetlands val-

Restoring Wetlands.

Photo Credit:
U.S. Fish and Wildlife Service

Figure 15.6 U.S. Wetlands Reserve Program, 1992-1995



Source: Natural Resources Conservation Service, unpublished, USDA, Washington, DC, 1996.
Note: Data are cumulative year-end totals.

ues. For example, in southeastern Missouri six farmers worked with federal and county officials to create a 38-acre wetland in exchange for converting several small, degraded wetlands in their fields to cropland. The 38-acre site includes open water, emergent marsh, and well-developed stands of bottomland hardwoods. It was purchased by the Butler County Soil and Water Conservation District and serves as a "mitigation bank," that is, a wetlands area that has been restored, created, or enhanced to compensate for conversions of other wetlands.

Wetlands Reserve Program. The 1990 Farm Bill established the Wetlands Reserve Program, which allows farmers to voluntarily sell easements to the government for wetlands restoration purposes as an alternative to agricultural production. The program was originally designed to provide permanent and 30-year voluntary restoration easements on cropland. The act set an enrollment limit of just under 1 million acres over 5 years.

The program started as a pilot program in 8 states in 1992 and was expanded to 20 states in 1994, before becoming a nationwide program in 1995. As of 1995, almost 230,000 acres of restorable wetlands and adjacent existing wetlands had been enrolled in the program (Figure 15.6). It is expected that just over 96,000 acres will be added to the enrollment in 1996.

In response to the devastating floods in the Midwest, an emergency supplemental appropriation (PL-103-75, signed August 13, 1993) authorized the Emergency Wetlands Reserve Program, which offered landowners an alternative to agriculture on their floodprone lands. In 1994 and 1995, over 86,000 acres were enrolled in this program, and an additional 5,800 acres are expected in 1996.

The 1996 Farm Bill changed the Wetlands Reserve Program by requiring that, effective October 1, 1996, one third of the acres be enrolled through use of permanent easements, one third through 30-year easements, and one third through restoration cost-share agreements (with no easements), to the extent practicable. Restoration cost-share agreements provide financial and technical assistance for restoration practices without a land payment. The 1996 bill set the enrollment limit at 975,000 acres. Landowner interest in both programs has greatly exceeded the available funds.

Partnership Programs

Aside from the programs mentioned above, the federal government is actively supporting partnerships with other government agencies, tribes, and private organizations to help landowners restore and conserve wetlands. Partners for Wildlife, which is managed by the Fish and Wildlife Service, is a stewardship program for the restoration and protection of wetlands and other wildlife habitat on privately owned lands. The Forest Service's Forest Stewardship Program provides landowners with cost-share and technical assistance for riparian and wetlands protection and improvement.

There are many examples of creative new wetlands protection and restoration partnerships, including the following:

- In North Dakota, a coalition of state and federal agencies has been cooperating in the development and implementation of the North Dakota State Water Bank Program. To date, about 175 acres of wetlands have been restored, and more than 1,000 additional acres of wetlands are being protected. Nearly 2,500 additional acres of uplands were placed in the program to provide wildlife habitat and wetlands protection.
- Lake Lafayette, a 2,000-acre forested wetlands complex adjacent to Steele Bayou in northern Mississippi, has been partially drained, and most of the historical floodwaters have been diverted by major flood-control projects. The Lake Lafayette Wetland Restoration Project plans to build 5 miles of levees and install 21 water control structures to allow the area to

Riverine wetland. Intermittently flooded streambed.

Photo Credit:
U.S. Fish and Wildlife Service

flood up to 3 feet deep during the winter, thus approximating historical flood flows. The project's partners include two federal agencies, the local soil and water conservation district, six landowners, the Mississippi Partners for Wildlife Program, and the Mississippi River Levee Board.

- The National Wetlands Conservation Alliance is a partnership of government and nongovernmental organizations that funnels assistance directly to landowners. More than 2.5 million landowners are reached annually through publications, workshops, and demonstration projects.

RECENT DEVELOPMENTS

In response to growing debate over conflicts between protection of private property rights and protection of wetlands values, the Clinton Administration released a plan on August 24, 1993, entitled *Protecting America's Wetlands: A Fair, Flexible, and Effective Approach*. The plan seeks to address legitimate landowner concerns through actions that increase flexibility and fairness in implementing wetlands regulations.

In the 3 years since it was developed, a number of proposals from the plan have been implemented, including streamlining the wetlands permitting program, responding to the concerns of farmers and small landowners, improving cooperation with private landowners to protect and restore wetlands, and increasing the role of state, local, and tribal governments in wetlands protection.

Key actions under the plan are as follows:

- The Agriculture Department's Natural Resources Conservation Service is now the lead federal agency responsible for identifying wetlands on agricultural lands under both the Clean Water Act and the Farm Bill. This action reduces duplication and increases consistency across the two programs.
- The Army Corps of Engineers is establishing an administrative appeals process so that landowners can seek recourse on permitting decisions without costly and time-consuming court battles.
- The Corps and EPA agreed to final regulations ensuring that approximately 53 million acres of previously converted wetlands will not be subject to wetlands regulation.
- The Natural Resources Conservation Service, Corps, EPA, and Fish and Wildlife Service have agreed to use a common definition of wetlands and will use the same procedures to identify wetlands. In addition, the agencies have issued new guidelines for establishing mitigation banks to offset unavoidable wetlands losses.

FUTURE CHALLENGES

Prior administrations supported a policy of "no net loss" of wetlands. President Clinton has endorsed the goal of no net loss but has gone further and also called for a long-term increase in the quality and quantity of the nation's wetlands. Although we have probably not yet achieved the no-net-loss goal, progress is being made. Achieving no net loss and moving into a net gain in wetlands may be possible if restoration programs such as the Wetlands Reserve Program are fully funded and there is no reduction in the protection of wetlands provided by existing programs.

Notwithstanding the controversy over private property rights, public support for wetlands protection remains strong. The Gallup Organization in 1995 surveyed a nationally representative sample of 1,250 people, asking if they thought laws and regulations protecting agricultural wetlands had gone too far, have not gone far enough, or were about right. Of those surveyed, 42 percent said the laws have "not gone far enough," 38 percent said they were "about right," 15 percent said they had "gone too far," and 5 percent said they "didn't know."

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CHAPTER SIXTEEN

Agriculture

The 1970 CEQ annual report included this observation about agriculture:

> *Monoculture has increased production efficiency but has reduced the plant and wildlife diversity essential to a stable ecosystem. These less complex ecosystems are highly susceptible to attack by insects and diseases which can devastate a standing crop or single species regionwide. Moreover, monoculture has forced a heavy dependence on pesticides and fertilizers.*

In the 25 years since the first edition of *Environmental Quality*, the nation has come to value "plant and wildlife diversity" as biodiversity and to adopt "stable" ecosystems as a goal of the federal government. Continued agricultural productivity goes hand-in-hand with a public awareness that the way the nation grows its food and fiber affects all aspects of the environment and impacts all types of ecosystems. In response, federal farm policy has begun to include initiatives to address public concerns for natural resources and environmental quality.

Since about 60 percent of U.S. land is in private ownership (70 percent if Alaska is excluded), according to the Department of Agriculture, agriculture's environmental agenda must target the practicing farmer and rancher. About 2 percent of the U.S. population grows much of the nation's food and fiber, with enough excess to export quantities to other countries. How agricultural land is managed has far-reaching impacts on the state of the environment, from air and water pollution to biodiversity and stable ecosystems.

Conditions and Trends

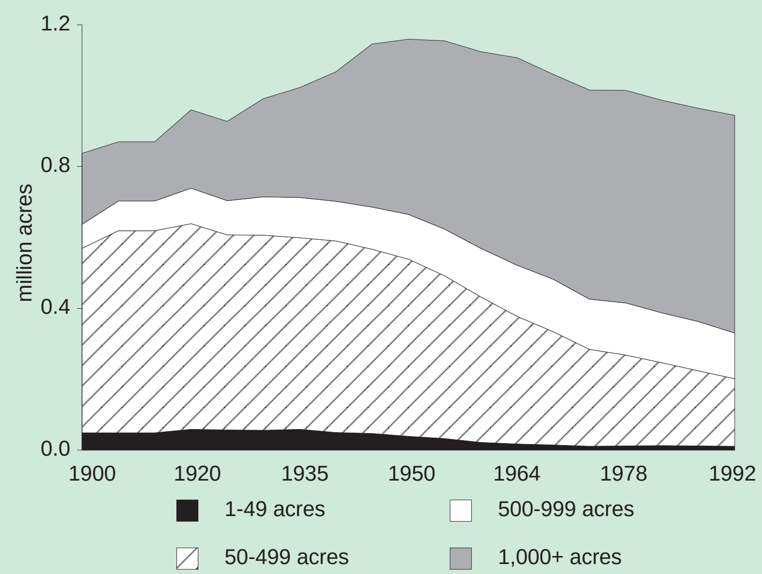
Since 1950, the total amount of land in U.S. farms—including cropland, forestland, and grazing land—has declined from 1.16 billion acres to 950 million acres in 1992 (Figure 16.1 and Part III, Table 51). Over this same period, the amount of cropland has remained fairly stable, staying within the 460-470 million-acre range (Part III, Table 49).

Since 1970, the trend in the United States has been toward fewer and larger farms (Figures 16.2 and 16.3) that are increasingly specialized, mechanized, labor-efficient, and capital-intensive. In the past decade, U.S. farm output per unit of input has increased by 26 percent. The factors responsible for this growth include increased use of fertilizers and pesticides, plus improvements in hybrid plant varieties and animal breeding practices.

In the 1970s, high worldwide demand for U.S. farm commodities, fueled by crop shortages abroad, encouraged a federal farm policy that emphasized increased production. Farmers began plowing land that had not recently or ever been cropped. In addition to fewer, larger grain farms, the trend was toward more specialized livestock, dairy, and poultry operations and toward regional concentrations of livestock production.

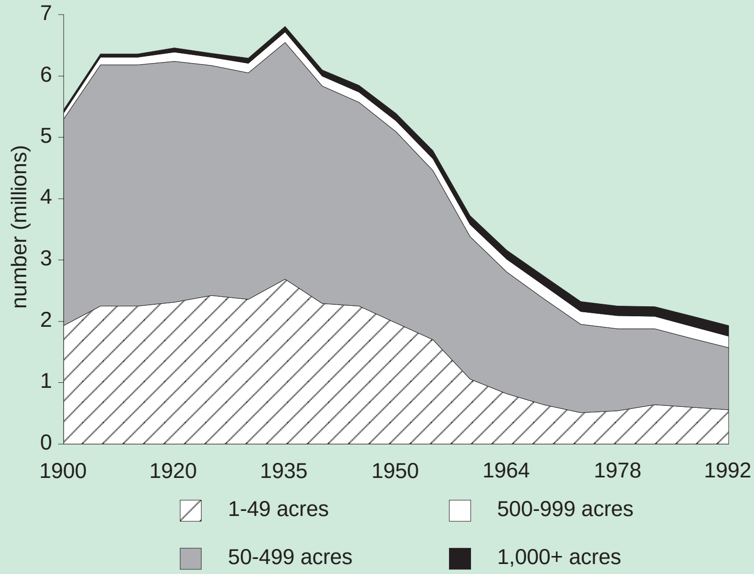
Agricultural programs and policies developed in the 1980s and 1990s have encouraged the use of more sustainable agricultural practices. Provisions of the Food Security Act of 1985 were intended to discourage land use on new-to-farm lands (Sodbuster), highly erodible lands, and wetlands (Swampbuster). The 1985 Farm Bill also established the Conservation Reserve Program (CRP), which offered farmers subsidies to temporarily retire highly erodible lands and other environmentally sensitive croplands from production and plant them to grasses or trees. By targeting highly erodible lands and wetlands, these provisions were designed to deal with commodity surpluses and resource protection. The Food, Agriculture, Conservation, and Trade Act of 1990 strengthened the links between farm production and natural resource conservation. It also introduced the Wetland Reserve Program to reduce wetlands conversions. The new provisions of the 1996 Federal Agricultural Improvement and Reform Act (otherwise known as the 1996 Farm Bill) build on the conservation gains of the past decade, improving performance and efficiency, simplifying existing programs, and creating new programs to address high priority environmental protection goals (see Recent Developments).

Figure 16.1 Land in U.S. Farms by Farm Size, 1900-1992



Source: See Part III, Table 51.

Figure 16.2 U.S. Farms by Farm Size, 1900-1992

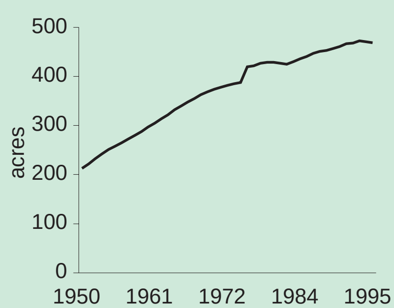


Source: See Part III, Table 51.

Cropland

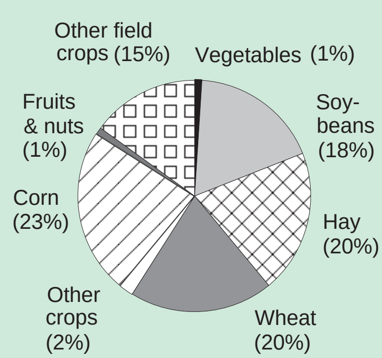
The most intensively used and most valuable agricultural land is generally that planted to crops and known as cropland. Four out of every five cropland acres produce one of four crops: corn, wheat, hay, or soybeans (Figure 16.4). Most of the corn and virtually all of the hay is fed to livestock. Corn, wheat, and soybeans also are major export commodities.

Figure 16.3 Average U.S. Farm Size, 1950-1995



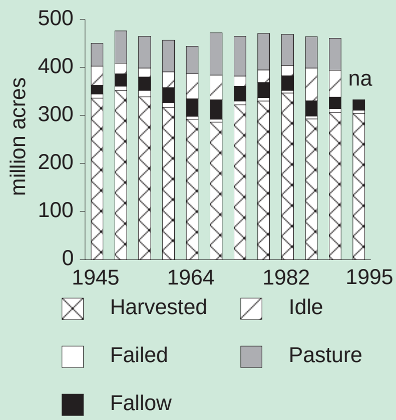
Source: USDA, National Agricultural Statistics Service.

Figure 16.4 Crops Harvested From U.S. Cropland, 1993



Source: USDA, Economic Research Service.
Note: Total cropland harvested=299 million acres.

Figure 16.5 Major Uses of U.S. Cropland, 1945-1995



Source: See Part III, Table 52.
Note: na=not available until next Agricultural Census.

Variations in cropland use (Figure 16.5) have occurred largely as a result of acreage diverted from production by government programs (Figure 16.6).

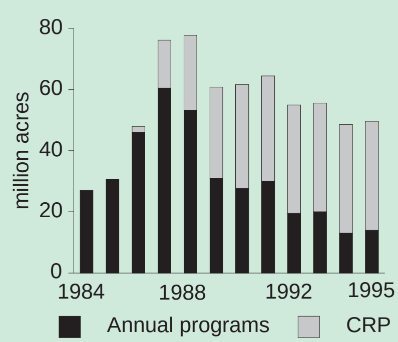
Grazing Lands

According to the Department of Agriculture, the nation has 803 million acres of grazing lands. About 55 percent of grazing lands are privately owned, with the rest on federal lands in 11 western states and Alaska (36 percent), on state and local government land (5 percent), and on land managed by the Bureau of Indian Affairs held in trust for Indian tribes and individuals (4 percent). Of the public-private total, 67 million acres are cropland used for pasture, 591 million acres are grassland pasture and range, and 145 million acres are grazed forest-land. The federal agencies that assess the condition of grazing lands—Natural Resources Conservation Service (NRCS), Bureau of Land Management (BLM), Forest Service, and U.S. Environmental Protection Agency (EPA)—have used different approaches but are developing a uniform method to incorporate indicators of more than vegetative species composition.

Bureau of Land Management Rangeland. Through a Rangeland Reform '94 initiative, BLM is making rangeland management more compatible with ecosystem management. The key is restoration and improvement of the public range. Regulations issued in 1995, known as the Healthy Rangeland Initiative, require establishment of new standards of rangeland health and guidelines for grazing management.

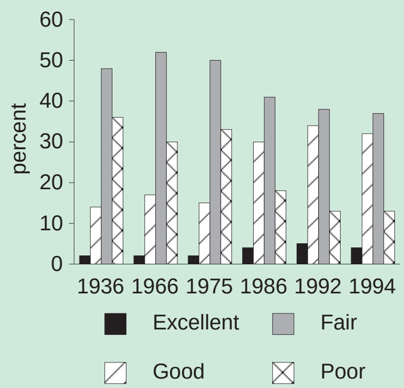
- According to BLM *Public Land Statistics*, the BLM administers 268 million acres of land, of which 164 million acres are managed for grazing under the Taylor Grazing Act, the Public Rangeland Improvement Act,

Figure 16.6 Cropland Idled by USDA Programs, 1984-1995



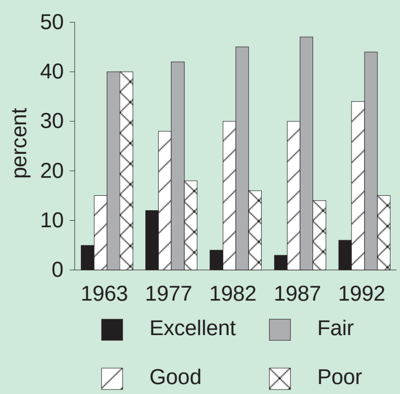
Source: See Part III, Table 52.
Note: CRP=Conservation Reserve Program.

Figure 16.7 BLM Rangeland Condition, 1936-1994



Source: See Part III, Table 60.

Figure 16.8 U.S. Nonfederal Rangeland Condition, 1963-1992



Source: See Part III, Table 60.

and the Federal Land Policy and Management Act. In 1994 the Bureau managed 22,000 grazing allotments in 16 states, collecting a grazing fee of $1.98 per animal unit month from 91,000 operators. In 1995, the number of grazing allotments and operators generally remained the same at the cost of $1.61 per animal unit month.

- The 1994 assessment, as reported in *Public Land Statistics*, reports 5 percent of BLM rangeland in excellent condition, 31 percent in good condition, and 13 percent in poor condition (Figure 16.7). Improved rangeland is attributable to a decrease in livestock numbers from excessive grazing in the past and to better livestock management resulting from cooperative efforts of BLM, livestock operators, other rangeland users, and interest groups.

National Forest System Grazing Lands. According to the USDA Forest Service, half of the 191 million acres in the National Forest System are available for grazing by livestock. Rangeland management on the national forests and grasslands emphasizes restoration and long-term health of rangeland ecosystems. In 1994, the Forest Service administered 9,413 grazing allotments in 32 states and collected $11.1 million in grazing fees. The agency has set management objectives for 75 million acres of its rangeland and in 1994 met or moved toward them on 50 million acres, up 4 million acres from the previous year.

Nonfederal Rangeland. The 1992 National Resources Inventory found an increase of nonfederal rangeland in excellent and good condition (Figure 16.8). As its condition improves, rangeland becomes more resistant to change from natural forces (drought, fire, and flood), but—as with federal rangeland—

more than half of nonfederal rangeland remains in the fair and poor categories.

Conservation Compliance

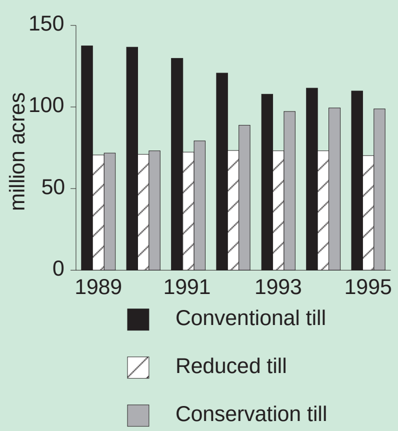
The conservation compliance provision of the 1985 Farm Bill stipulated that farmers with highly erodible lands (HEL) who did not implement approved conservation plans by 1995 would lose eligibility for USDA farm program benefits. Approved conservation plans specify the use of conservation management systems, such as conservation (crop-residue) tillage, on 75 percent of HEL planted to crops. Other conservation practices include contour plowing and stripcropping, vegetative buffer strips, windrows, vegetative covers, and crop rotations.

Conservation tillage systems leave a protective cover of residue on the field from the previous crop, which serves not only as a primary defense against sediment loss, water runoff, and chemical leaching, but also improves soil structure, organic content, and moisture retention. Conservation tillage allows chemicals to break down into harmless components through the action of microorganisms in the organic matter of the residue or in the top layer of soil in the presence of air and sunlight. Used on less than 5 percent of planted acreage prior to 1970, crop residue tillage exceeded 35 percent in 1994 (Figure 16.9) on HEL and on other cropland devoted to corn, cotton, soybeans, and wheat. A greater share of highly erodible cropland (43 percent) was planted with conservation tillage compared to other cropland (33 percent). Use of conservation tillage and crop-residue management is increasing along with related improvements in soil quality.

For corn and soybeans, use of conservation tillage systems, especially no-till or ridge till, has increased much faster than for wheat on highly erodible cropland. Conversely, conservation tillage has not been widely used on cotton acreage.

Many farmers are adopting conservation tillage and other crop-residue management systems for cost savings as well as soil conservation. They cite fuel and labor savings, lower machinery investments, and long-term benefits to soil quality as advantages over conventional tillage systems.

Figure 16.9 U.S. Cropland Tillage Practices, 1989-1995

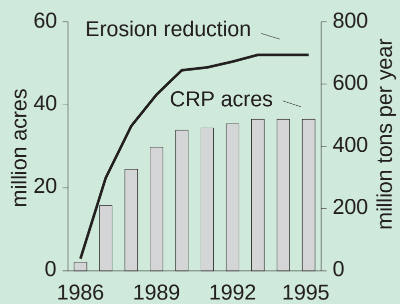


Source: See Part III, Table 53.

Conservation Reserve Program

CRP is a voluntary program under which farmers temporarily convert highly erodible and other environmentally sensitive cropland to soil-conserving uses,

Figure 16.10 CRP Acres and Erosion Reduction, 1986-1995



Source: USDA, Economic Research Service.
Note: Erosion reduction refers to amount of soil prevented from eroding by CRP. Data are cumulative.

such as grass or trees. Since the first CRP signup in 1986, farmers have enrolled more than 36 million acres in the program.

Farmers with land that qualified for CRP bid their land into the program by offering it at an annual per-acre rental rate for 10-15 years. Of the 13 CRP signups to date, the first 5 focused on highly erodible cropland. In 1988, the program expanded to include vegetative filter strips along water bodies to trap sediment, nutrients, and pesticides; and, beginning in 1989, CRP temporarily accepted restoration of previously cropped wetlands.

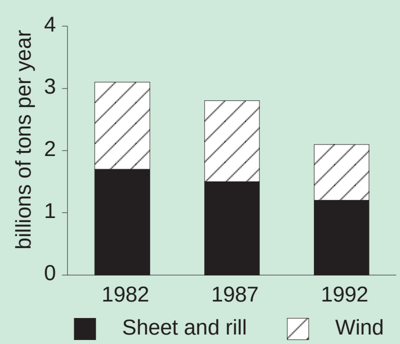
Although farmers and ranchers have planted most CRP acres to grass, 2 million acres are in trees, and another 2 million acres represent special wildlife practices. Nearly half a million acres are restored wetlands, and 8,900 miles of CRP filter strips protect waterways.

Erosion reduction credited to CRP may be as high as 700 million tons annually or 19 tons per acre per year (Figure 16.10). CRP also provides benefits in terms of wildlife habitat and populations, water quality, and restored wetlands and forestlands. The program has reduced federal outlays for farm deficiency payments, strengthened farm income, and helped balance supply and demand for agricultural commodities.

Wetlands Conservation

Wetlands losses attributed to agricultural practices are showing a downward trend. In 1994, NRCS, EPA, the U.S. Fish and Wildlife Service, and the U.S. Army Corps of Engineers signed a memorandum of agreement for delineating wetlands under Section 404 of the Clean Water Act and the wetlands conservation provision of the Food Security Act. Land users will now be able to rely on wetlands determinations made on agricultural land by one agency for all federal programs.

Figure 16.11 U.S. Cropland Erosion by Type, 1982-1992



Source: See Part III, Table 54.

Box 16.1
Natural Resources Conservation Service: Reading the Land

In 1994, Congress renamed the Soil Conservation Service—born in the Dust Bowl days of the 1930s—as the Natural Resources Conservation Service (NRCS) to recognize agriculture's environmental importance. The NRCS provides a variety of services, including:

National Resources Inventory

NRCS constantly "reads the land" to maintain a National Resources Inventory (NRI) and to produce a 5-year report card on trends in soil erosion by water and wind, wetland losses, prime farmland acreage, irrigation, and conservation treatments. Data and analytic software for the most recent NRI (1992) are available to the public on CD-ROM.

The agency links digitized soil surveys with resource data from other agencies in geographic information system (GIS) technology. By layering information from various data sources, GIS shows how pieces of the environment interact and helps landowners, resource managers, and policymakers visualize effects of land-use options.

National Conservation Partnership

NRCS has formed a National Conservation Partnership of federal, state, and nonprofit agricultural groups. Members pledge to provide leadership for "a productive nation in harmony with a quality environment." The partners are NRCS, the National Association of Conservation Districts (NACD), representing 3,000 local conservation districts that promote voluntary conservation practices by farmers and ranchers, and the National Association of State Conservation Agencies (NASCA), a coalition of state conservation agencies that funds conservation districts and programs for sediment control and soil erosion prevention. Partnership efforts include the following:

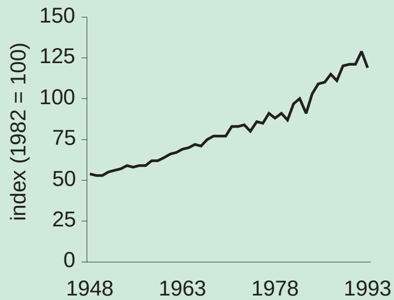
- In Santa Cruz, California, the Partnership developed stabilization practices and revegetation techniques to prevent erosion, landslides, spread of wildfire, and poor water quality.
- The Partnership also developed a community plan for Holly Grove, Arkansas, to help that community deal with creek flooding.

In Louisiana, which has 40 percent of remaining U.S. coastal wetlands and 80 percent of coastal wetlands losses, NRCS is helping landowners with a watershed management approach to conserve wetlands while meeting landowner objectives for fisheries, wildlife habitat, wildlife management, and grazing. An NRCS plant materials center in Louisiana conducts studies on wetlands plant species to use in wetlands restoration (see also Chapter 15, "Wetlands").

Soil Erosion

In the past decade, the USDA has administered conservation programs responsible for saving a billion tons of soil—a remarkable soil conservation success story. Soil erosion is a universal problem. In the East, Southeast, Midwest,

Figure 16.12 U.S. Agricultural Productivity, 1948-1993



Source: See Part III, Table 55.

Northwest, and other humid regions of the United States, sheet-and-rill erosion occurs as water removes soil in thin layers (sheets) and tiny channels (rills). In many parts of the Great Plains and West, wind erosion is the more serious problem. The average annual rate of sheet-and-rill erosion on cropland was 3.1 tons per acre in 1992, down 25 percent in a decade (Figure 16.11). Cropland wind erosion also declined from 3.3 to 2.5 tons per acre, due in large part to the HEL provisions. Preliminary results of a 1995 erosion study suggest a continuation of this downward trend, but 135 million acres continue to erode at rates above T (the soil-loss tolerance rate, at which erosion does not reduce the long-term productivity of soil). NRCS provides a variety of programs to promote soil conservation (Box 16.1).

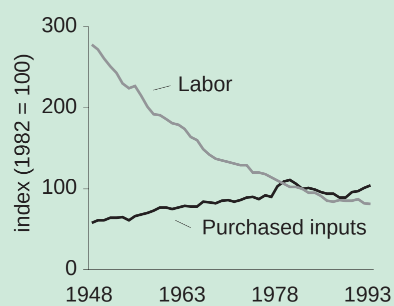
Agricultural Productivity

Productivity—the difference in rates of growth in output and aggregate input—of U.S. agriculture has increased each year since World War II (Figure 16.12). Excluding 1993 when extensive flooding in the upper Mississippi and lower Missouri River basins severely curtailed output, the average annual rate of increase is 1.84 percent. Stable aggregate inputs disguise shifts in intermediate (purchased) inputs that have increased 1.3 percent per year (Figure 16.13). Underlying this increase are energy inputs that increased 1 percent per year and chemicals that increased at 2.5 percent annually, while labor input decreased 2.75 percent per year.

Fertilizer Use

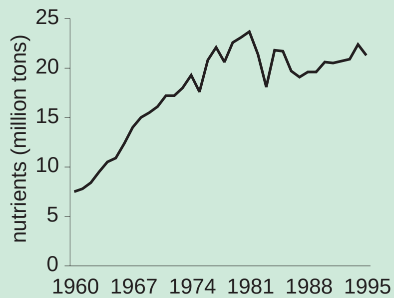
When rain or irrigation water flushes fertilizers past the reach of crop roots, it means not only a waste of expensive inputs but a threat to the environment. Agricultural runoff, rich in nitrogen and phosphorus, can pollute surface waters and groundwater. For this reason, nutrient management practices that help adjust fertilizer applications to crop

Figure 16.13 U.S. Agricultural Inputs, 1948-1993



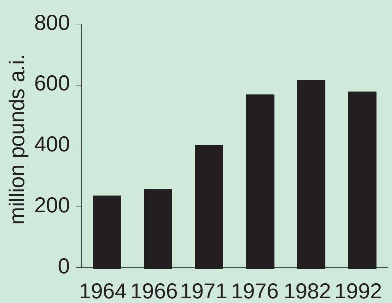
Source: See Part III, Table 55.
Note: Purchased inputs=energy, chemicals, feed, etc.

Figure 16.14 U.S. Commercial Fertilizer Use, 1960-1995



Source: See Part III, Table 57.

Figure 16.15 U.S. Farm Pesticide Use, 1964-1992



Source: USDA, Economic Research Service.
Note: a.i.=active ingredients.

needs and reduce losses to the environment are seeing increased use.

The total amount of nitrogen, phosphate, and potash used for all purposes (farms, lawns, golf courses, home gardens, and other nonfarm lands) tripled in the United States between the 1960s and 1980s, peaking at 23.7 million tons in 1981 (Part III, Table 57). The total volume used in 1995 was 21.3 million tons, in step with total crop acreage declines (Figure 16.14). Nitrogen use also has tripled and equaled 11.7 million tons or 55 percent of all commercial fertilizers used in 1995. In contrast, phosphate's share declined to 21 percent, and potash now exceeds phosphate at 24 percent. According to Department of Agriculture estimates, agriculture accounts for greater than 80 percent of total U.S. fertilizer use.

Pesticide Use

Farmers began widespread use of pesticides—herbicides, insecticides, fungicides, and others—in the late 1950s, and today agriculture accounts for about three fourths of all pesticide use in the United States, according to EPA. The industrial, commercial, and government sector uses 18 percent, with the remainder used by the home and garden sector.

Pesticides promote reliable harvests, quality crops, and stable farm income. Many pesticides have adverse environmental and health impacts, but most environmentally damaging pesticides have been or are being taken off the market, and farmers have refined pesticide management to reduce farm worker exposure and environmental damage (Box 16.2).

After peaking in 1980, pesticide use declined through 1993 (Figure 16.15). Preliminary EPA figures suggest that the total volume of active ingredients may have rebounded in 1994 and 1995.

Corn, with the largest acreage of all U.S. crops, also exceeds other commodities in pesticide use. In 1995, corn accounted for 35 percent of major crop acres and 47 percent of all pesticide use (including 63 percent of all herbicide use and 35 percent of all insecticide use).

Box 16.2
Integrated Pest Management

Integrated Pest Management (IPM), which coordinates natural pest controls with pesticide use, gained attention in the 1970s as a strategy for responding to the adverse environmental effects of DDT and other insecticides. IPM techniques include prevention, monitoring, mechanical trapping devices, natural predators, biological pesticides, and, if appropriate, chemical pesticides.

Biological pesticides, which target specific pests, are considered to pose little or no risk to human beings, other species, or the environment. They include insect growth regulators, which halt or interfere with the development of an insect before it matures; pheromones, which disrupt normal mating behavior by stimulating breeding pests and luring them into traps; and microbial pesticides, which infect specific pests.

IPM Studies

Government and university studies that track IPM have found greater use of biocontrol techniques in fruit, vegetable, and cotton production, where insects are the major pest problem, than in corn, soybeans, and wheat, where weeds are the major pest. Insecticide use on 11 major agricultural crops declined by more than half between 1971 and 1990 (measured by pounds of active ingredients). In contrast, herbicide use on the same crops almost doubled before peaking in the early 1980s and leveling off by 1990.

IPM surveys made in the 1990s found that although monitoring and thresholds for insect pests were common in fruit, vegetable, and cotton production, only crop rotation and a few other nonchemical control techniques were widely used, except in certified organic production systems. Half of the fruit and nut acreage and three-fourths of the vegetable acres in surveyed states were scouted for insects; and economic thresholds were used to make pesticide treatment decisions on scouted acres. On fruit and nut acreage, producers used the following IPM techniques in varying amounts: traps to lure harmful insects, beneficial insects, resistant varieties, and pheromones. Vegetable crop producers used purchased beneficial insects, pheromones, and adjusted planting dates. Surveyors found such techniques in common use on certified organic vegetable acreage.

IPM techniques used for corn included scouting and thresholds for insect pests, banded applications of herbicides, and a shift to post-emergence herbicides. Only 10 percent of corn and soybean growers alternated herbicides to slow development of resistance. Producers who practiced banding reduced herbicide use significantly. Half of the corn and soybeans were grown in rotation with each other, while monoculture was practiced on two-thirds of cotton acreage. Farmers rotating corn with other crops used insecticides less frequently than did those planting corn two years in succession (11 percent versus 46 percent).

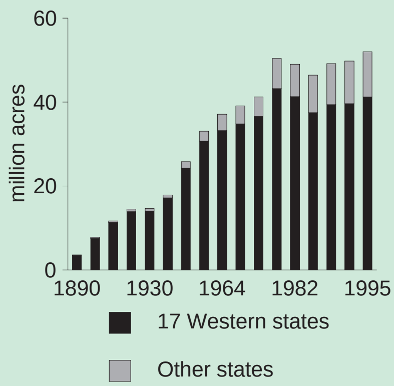
Pesticide Environmental Stewardship Program

This effort by EPA, USDA, and the U.S. Food and Drug Administration to reduce pesticide use and risk in agricultural and other settings relies on public/private partnerships. When the agencies announced PESP partnerships in 1994, more than 20 private organizations signed on as charter members to help attain the following goals:

- To develop use/risk reduction strategies including reliance on biological pesticides and other controls thought to be safer than traditional chemical methods.
- By 2000, to have 75 percent of U.S. agricultural acreage in integrated pest management programs.

More than 50 major groups are now either PESP partners or supporters. Partners are groups that use pesticides or represent pesticide users and agree to adopt strategies to reduce the use and risk of pesticides; and supporters are groups, such as food processors, that do not use pesticides but do influence pest management practices and agree to promote environmental stewardship programs.

Figure 16.16 Irrigated U.S. Farmland, 1890-1995



Source: See Part III, Table 59.

Irrigation

Farmland irrigation, which today is practiced in all 50 states, developed in three waves (Figure 16.16). The initial wave, a western phenomenon that lasted into World War I, was characterized by private or local district development of surface water sources relying primarily on gravity to convey water to nearby farms and distribute it over fields.

World War II triggered a second wave of development, also in the West, that used efficient, high capacity pumps and electric power. A third wave of development followed the export-led agriculture boom of the 1970s and built on new deep-well pumping technology, center-pivot sprinklers, and other labor-saving technologies. All regions participated in this last growth phase.

In 1890, when questions relating to irrigation were first included in the Census of Agriculture, the nation already had 3.6 million acres under irrigation, with a million irrigated acres in California. In 1995, the Department of Agriculture estimates that some 52 million acres of irrigated land produced 40 percent of total crop value—on only 15 percent of total harvested cropland. Economic value and total production output from irrigated lands continues to increase, even as irrigated cropland has begun to decrease.

RECENT DEVELOPMENTS

The 1996 Farm Bill

In 1996, Congress completed action on a new farm bill—the Federal Agriculture Improvement and Reform Act of 1996—that was designed to, among other things, further integrate environmental values into U.S. agricultural policy.

President Clinton signed the 1996 Farm Bill on April 4, 1996 (PL 104-127). Briefly, the new law includes the following conservation provisions :

- A major change in federal farm policy that would almost completely eliminate production-based payments. Farmers would receive income-support payments for 7 years as long as they comply with existing conservation plans for the farm, wetland provisions, and planting flexibility provisions, as well as to keep the land in agricultural uses.

- Extension of the Wetlands Reserve Program and Conservation Reserve Program through 2002. Landowners would have more options for protecting wetlands and highly erodible lands. In the WRP, landowners would be able to choose either permanent or

30-year easements or restoration cost-share agreements.

• Modification of swampbuster and wetlands provisions to provide farmers with more flexibility to meet wetlands conservation compliance requirements. Changes would expand areas where mitigation could be used, allowing mitigation by restoration, enhancement, or creation, and changing the abandonment clause.

• Changes in conservation compliance, directing USDA employees who provide on-site technical assistance to notify landowners of potential compliance problems. Landowners would be allowed time for corrective action and, in cases of economic hardship, would be eligible for relief.

• A new Environmental Quality Incentives Program would consolidate conservation programs, focusing assistance on locally identified conservation priority areas or areas where agricultural improvements would help meet water quality goals or other natural resource concerns, such as wildlife and wetlands. The program would provide technical assistance, costsharing, or incentive payments for conservation practices. Half of the funds would be targeted to conservation on livestock operations.

• A new farmland protection program that would help farmers preserve their land in agriculture. A federal program would assist states, tribes, and local governments with existing farmland protection programs and the purchase of conservation easements.

• A new Wildlife Habitat Incentives Program would help landowners improve wildlife habitat on private lands.

• A flood risk reduction program that would allow farmers to contract for a lump-sum payment of remaining income support on lands with high flood potential, if they forego some USDA benefits. The program would create incentives to switch to less vulnerable cropping practices such as pasture or to move farming operations entirely from frequently flooded land.

• An emergency watershed protection program that would allow purchase by the federal government of floodplain easements.

• A conservation of private grazing land initiative that would offer landowners technical, educational, and related assistance on private grazing lands.

• Membership in State Technical Committees, groups which provide guidance on technical standards for conservation programs, would be broadened to include agricultural producers and others knowledgeable about conservation.

• A new conservation farm option would be created for producers of wheat, feed grains, upland cotton, and rice who are eligible for Agriculture Market Transition Contracts. Under a pilot program, landowners would be able to consolidate their payments from the Conservation Reserve Program, Wetlands Reserve Program, and proposed environmental quality incentive program into one annual payment. Participants would enter into a multi-year contract and agree to adopt a conservation farm plan.

- Expansion of the definition of agricultural land to include not only cropland and pastureland but also rangeland, native pastureland, other land used to support livestock production, and tree farms.

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CHAPTER SEVENTEEN

Forestry

Responsible management of forests has been a challenging and controversial issue throughout this country's development. From George Perkins Marsh's observation in 1864 in the landmark work *Man and Nature* that, "the too general felling of the woods has been recognized as the most destructive among the many causes of the physical deterioration of the Earth" to protests in 1996 over continued logging of old growth trees, debate over how to balance commercial harvest of trees with other uses and values associated with America's forests continues.

Federal involvement in managing forests began in the 1870s, with a Congressionally-mandated report to address the issues of preservation of forests and importance of cultivating timber and the (unsuccessful) introduction of legislation to preserve forests adjacent to navigable waters. Federal involvement and interest in forest matters increased steadily during the rest of the century, culminating in creation of the Forest Service in the Department of Agriculture in 1905. After creating a cadre of professional foresters in the United States, Gifford Pinchot became the first Chief of the Forest Service. He strongly believed in use of forest resources for timber, but insisted on professional standards, based on the best science available, not, in his words, "forest butchery." He also sought to achieve federal unity of purposes among the various government agencies having some authority over natural resources, rather than seeing them act "like loose horses in a field, each one following his own nose." The impact of the Forest Service was evident in the significant downturn in U.S. forestland burned by wildfire (Box 17.1).

The forest reserves, the precursor to the national forests, were created for two purposes: first, the need to secure favorable water flow conditions and avoid further damage to watersheds, and second, to provide for a reliable supply of timber for future generations. Throughout the first half of the 1900s, the Forest Service developed various planning methods to achieve these goals, adding, along the way, provisions to address recreation, including wilderness areas, as well as protection of archaeological sites and other noncommodity features of national forests. The national forests were also faced with accommodating other resource use and development, such as mining and grazing. Controversy over these multiple uses increased sharply after World War II, when increasing housing demands in turn stimulated pressure for higher timber harvest levels.

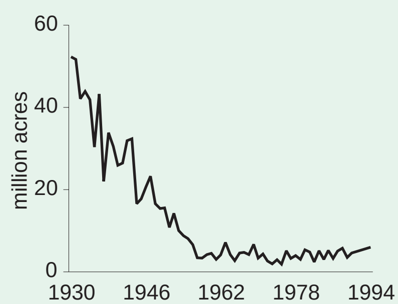
Box 17.1
Forests and Fire

Some 7 million acres of forests were lost to wildfire in 1995. This is far less than the 50 million acres lost yearly in the early part of the century, but up from the 3.3 million acres lost in 1970 (Box Figure 17.1).

While fire management strategies need to be adopted to the characteristics of particular ecosystems, increased use of prescribed burns to decrease the fuel load, along with thinning and other fuels management techniques, are often recommended by forest ecologists and fire specialists. The recent findings of a Congressionally chartered scientific assessment of the status of the Sierra Nevada Mountains in California bear noting, although they are specific to the Sierra Nevada ecosystem:

- **Ecological Functions of Fire.** Fire is a natural evolutionary force that has influenced Sierran ecosystems for millennia, affecting biodiversity, plant reproduction, vegetation development, insect outbreak and disease cycles, wildlife habitat relationships, soil functions and nutrient cycling, gene flow, selection, and, ultimately, sustainability.
- **Effects of Climate.** Climatic variation plays an important role in influencing fire patterns and severity; fires have been most extensive in periods of dry years.
- **Presettlement Fire Regimes.** In most lower-elevation oak woodland and conifer forest types of the Sierra Nevada, presettlement fires were frequent, collectively covered large areas, burned for months at a time, and, although primarily low to moderate in intensity, exhibited complex patterns of severity.
- **Effects of Suppression.** Fire suppression in concert with changing land-use practice has dramatically changed the fire regimes of the Sierra Nevada and thereby altered ecological structures and functions in Sierra plant communities.
- **Fuel Conditions.** Live and dead fuels in today's conifer forests are more abundant and continuous than in the past.
- **Effects of logging.** Timber harvest, through its effects on forest structure, local microclimate, and fuel accumulation, has increased fire severity more than any other recent human activity.
- **Fire Size Trends.** The commonly expected consequence of decades of fire suppression—that large infrequent fires are becoming larger and small frequent fires smaller—is generally not confirmed by records for twentieth-century Sierran forests.
- **Fire Surrogates**. Although silviculture treatments can mimic the effects of fire on structural patterns of woody vegetation, virtually no data exist on the ability to mimic ecologic functions of natural fire.

Box Figure 17.1 U.S. Forest Land Burned by Wildfire, 1930-1994



Source: See Part III, Table 65.

The growing understanding of the essential role fire plays in forest ecology has led to the incorporation of prescribed burns, such as this one in Florida, into forest management strategies.

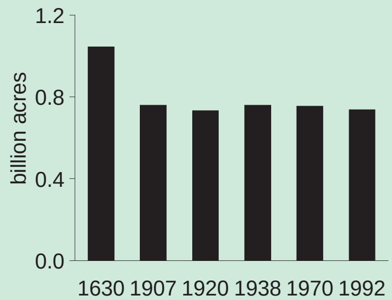
Photo Credit: John and Karen Hollingsworth
U.S. Fish and Wildlife Service

Beginning in the 1960s, Congress addressed the increasing conflict between uses of the national forests with legislation aimed at confirming the multiple use nature of the federal forests (the Multiple-Use Sustained-Yield Act of 1960), and coordination and planning requirements to addresses those uses: the Forest and Rangelands Resources Planning Act of 1974 and the National Forest Management Act of 1976 (NFMA). Passage of the National Environmental Policy Act (NEPA) in 1970 opened up forest planning to public involvement and scrutiny, while other protection or management statutes passed during the 1970s (such as the Endangered Species Act and the Clean Water Act) provided specific management direction for particular resources.

CONDITIONS AND TRENDS

During the past 25 years, the United States has maintained a relatively stable area of forestland (Figure 17.1). Today, forests cover 732 million acres in the United States. This area, however, is significantly reduced from earlier eras. In the precolonial era, forests covered about one billion acres, but declined by a fourth in the 19th century because of cropland clearing, fuelwood cutting, and logging for railroads and mines.

Figure 17.1 U.S. Forest Land Area, 1630-1992



Source: See Source for Part III, Table 61.

Timber growth currently exceeds removals, although the gap is narrowing (Figure 17.2). There have been notable improvements in technologies and efficiency. Recycled paper now accounts for more than one third of the fiber used in the pulp and paper industry, and sawmills produce more usable lumber and other products per log input than they did in 1970. Engineering standards reduce the wood volume used per square foot of building space, and preservative treatments extend the service life of wood. Over the 1970–90 period, U.S. production of lumber increased by 25 percent, plywood and veneer by 60 percent, pulp products by about 33 percent, and fuelwood production more than quintupled (Figure 17.3).

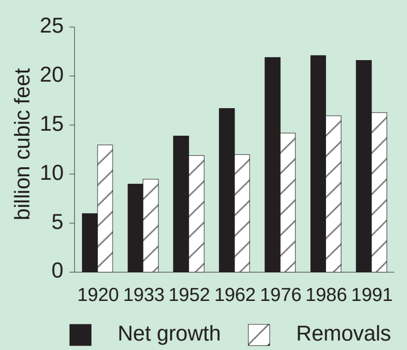
In 1995, the United States planted 2.4 million acres of trees, up 1 million acres from 1970. The Conservation Reserve Program (CRP) offers financial incentives to farmers willing to plant highly erodible cropland to forests (Figure 17.4). Of the new CRP forests, 90 percent are in the South.

Roughly two thirds of all public and private U.S. forests (490 million acres) are classified as timberland—forests capable of producing 20 cubic feet per acre of industrial wood annually and not reserved from timber harvest. Another 36 million acres that could qualify as timberland are reserved from harvesting and managed as parks or wilderness.

The Southeast and South Central states have most of this resource, with 199 million acres of public and private timberland. The Northeast and Midwest together have a total of 157 million acres; followed by the Pacific Coast (69 million acres, of which 15 million acres are in Alaska); and the Rocky Mountain states (62 million acres) (Figure 17.5).

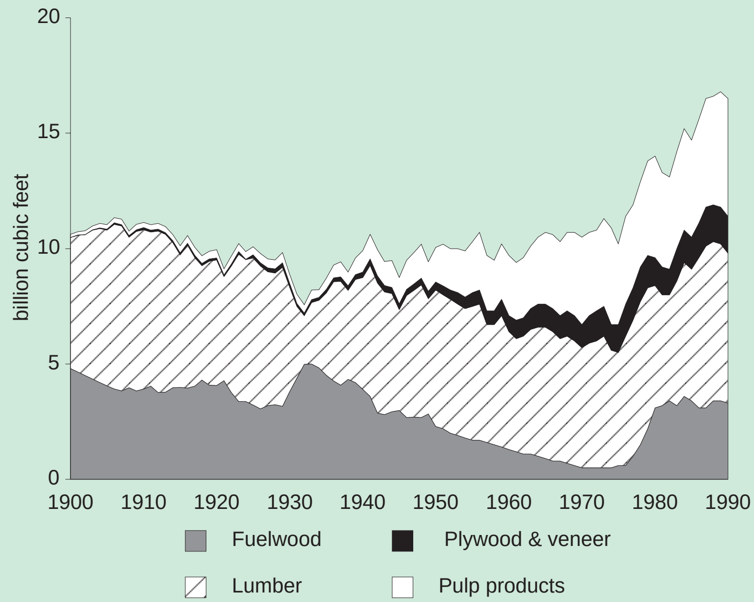
Just over one fourth of timberlands (26 percent) are publicly owned—131 million acres, including 85 million acres in national forests. The forest industry owns 70 million acres (of which 40 million acres are in the South), and nonindustrial private timberlands total 287 million

Figure 17.2 Net Growth and Removals of U.S. Timber, 1920-1991



Source: See Part III, Table 62.

Figure 17.3 U.S. Production of Forest Products, 1900-1990

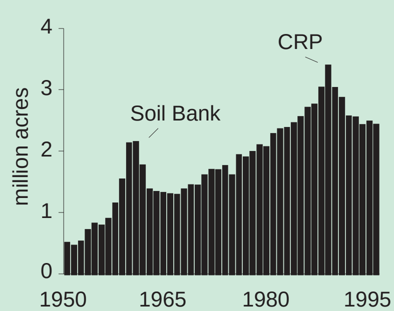


Source: See Part III, Table 63.

acres (Figure 17.6). Among the 6 million nonindustrial private forestland owners, 10 percent hold three fourths of the nonindustrial forest base.

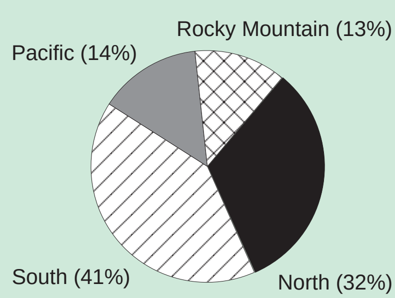
Public and private U.S. timberlands together contain an estimated 858 billion cubic feet of timber, of which 92 percent is in growing stock. Softwood growing

Figure 17.4 U.S. Tree Planting, 1950-1995



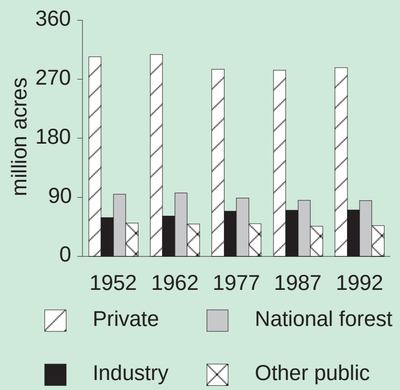
Source: See Part III, Table 65.
Note: CRP=Conservation Reserve Program.

Figure 17.5 U.S. Timberland by Region, 1992



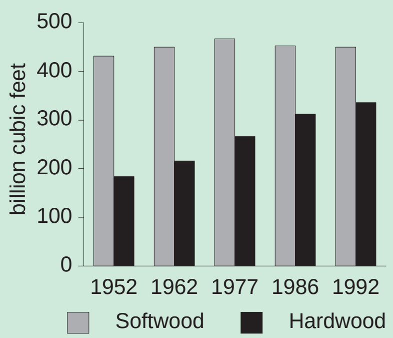
Source: See Source for Part III, Table 61.
Note: Total timberland=489.56 million acres.

Figure 17.6 U.S. Timberland Area by Ownership, 1952-1992



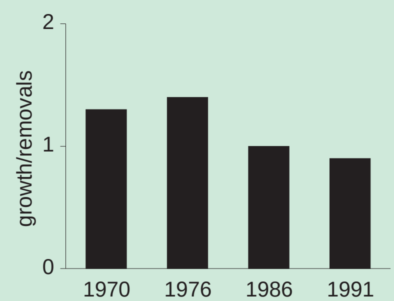
Source: See Part III, Table 61.

Figure 17.7 U.S. Timber Volume by Type, 1952-1992



Source: See Part III, Table 62.

Figure 17.8 Softwood Growth/Removals Ratio in the Southern United States, 1970-1991



Source: See Part III, Table 62.

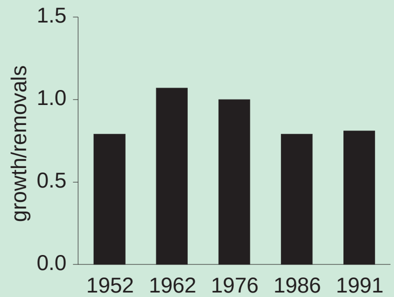
stock volume totals 450 billion cubic feet; the hardwood volume is 336 billion cubic feet (Figure 17.7). The most abundant softwood species, Douglas fir, has 93 billion cubic feet of volume; and oak, the most common hardwood species, accounts for 113 billion cubic feet.

Although the gap between growth and removals has narrowed, the national ratio of growth to removals remains positive. In the South, however, the softwood ratio is down to 0.9; that is, removals now exceed growth (Figure 17.8). For the forest industry, the ratio is 0.8 (Figure 17.9).

When foreign demand for U.S. forest products is added to growing domestic demand, pressure on pulp and paper supplies will likely result. Forest Service projections show federal timber acreages remaining steady or declining. Any increase will likely come in the form of carbon-sink forests managed for nontimber uses. Even after accounting for the effects of recycling on roundwood prices, the Forest Service projects that, over the next several decades, stumpage prices could double in the South and rise by one third in the Pacific Northwest.

Declining federal timber sales and increasing state and local regulations will increase pressure on industrial and private forestlands. As wood prices rise, timber harvests on forest industry lands could increase as much as 39 percent over the next several decades, with har-

Figure 17.9 Growth/Removals Ratio for U.S. Industry-Owned Growing Stocks, 1952-1991



Source: See Part III, Table 62.

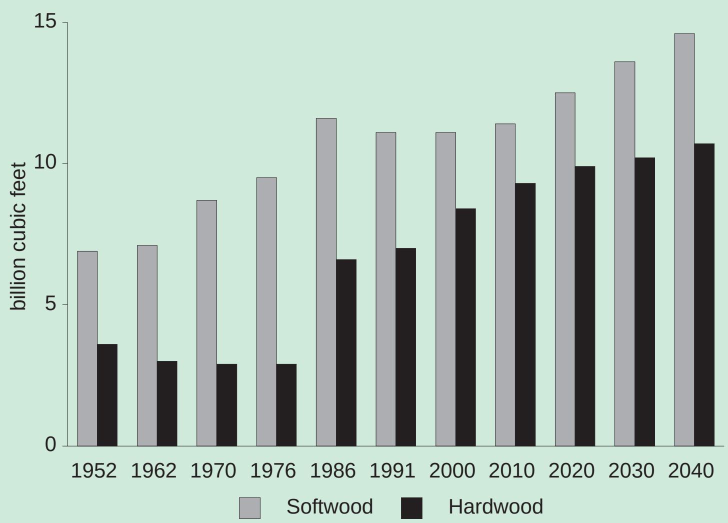
vests on other private lands increasing as much as 64 percent. Both softwood and hardwood harvests are likely to increase in coming decades (Figure 17.10). The biggest response is expected on private timberlands in the South, with the area of pine plantations possibly doubling from the current 23 million acres, and timber harvests escalating several times from the current 831 million cubic feet per year.

Multiple Uses of the National Forest System

In the 1930s, the pioneer land manager Aldo Leopold cautioned natural resource managers to "save all the pieces." That was wise, because all of the pieces are needed as the Forest Service strives to meet the following mandated objectives.

Watershed Management. From the earlier days of the U.S. forestry movement in the 19th century, the nation rec-

Figure 17.10 U.S. Timber Harvests by Type, 1952-1991, with Projections to 2040



Source: R.W. Haynes, D.M. Adams and J.R. Mills, *The 1993 RPA Timber Assessment Update*, General Technical Report RM-GTR-259 (USDA, Forest Service, Washington, DC, 1995).

ognized the value of forests in protecting watersheds. The foresight that the Forest Service's founders had in making watershed protection a preeminent rationale for the establishment of our national forests is underscored by the need to ensure safe drinking water for ourselves and future generations. Flood protection is another critical role that forests play in protecting our land and settlements.

Wildlife Habitat and Biodiversity. Forests are a rich source of biodiversity, at the genetic, species and community level. Over the years, forestland conversions and timber management have reduced that diversity. Today, national forests provide habitats for more than 3,000 species of animals and another 3,000 species of rare plants. The ecosystem focus on the Forest Service seeks to protect the viability of resident species, minimize exotic introductions, and promote biodiversity. For example, in a partnership called "Bring Back the Natives," the Forest Service, the Bureau of Land Range Management, and the National Fish and Wildlife Foundation are improving the status of 28 threatened and endangered native aquatic species on public lands. The agencies are rehabilitating riparian areas, restoring watersheds, and reintroducing species. Since its creation in 1992, the partnership has completed 86 projects in 15 states (see also Chapter 7, "Ecosystems" and Chapter 8, "Biodiversity").

Outdoor Recreation. In 1995, national forests and grasslands recorded a total of 829 million recreation visits. With studies suggesting that outdoor recreationists will increasingly be older, from urban areas, and from more diverse racial and ethnic backgrounds, the Forest Service is changing the design and management of recreation settings. Among recreation uses of national forests, fishing leads in popularity, followed by nonconsumptive uses (hiking, camping, photography, bird watching, viewing scenery) and then by hunting. The most significant increase occurred in mechanized travel and viewing scenery.

Wilderness and Wild and Scenic Rivers. The National Wilderness Preservation System, with more than 103 million acres in 36 states, protects fragile ecosystems and preserves natural resources for scientific, educational, and historical values. The National Wild and Scenic Rivers System, with 10,734 river miles, assures a heritage of protected waterways. The Forest Service manages 4,385 miles of Wild and Scenic Rivers and 34.6 million acres of wilderness. In 1995, the agency recorded 13.9 million recreational visits to roadless wilderness areas.

Carbon-sink Forests. The 1970 CEQ annual report listed as a forest value, "local climatic moderation." Since then, scientists have identified the value of forests in counteracting global climate change. Projected global warming may well affect forest growth and distribution, but forests, in turn, can affect climate change by storing or releasing carbon. When forests are harvested, burned, or decaying, they emit carbon dioxide, the greenhouse gas that accounts for half the projected warming. Conversely, living forests serve as a carbon sink, removing carbon dioxide from the atmosphere and storing it. Carbon uptake by forests can be increased by increasing forestland area, restricting some commercial harvests, and increasing the efficiency of forest product manufacturing. Forests are considered part of the U.S. strategy to meet international obligations under the 1992 Framework Convention on Global Climate Change (see also Chapter 12, “Climate Change”).

Range Management. In fiscal year 1995, approximately 53.9 million acres of rangeland vegetation were managed in partial or full compliance with forest plan standards and guidelines. The range acreage accommodates 9.9 million animal “head months” of permitted grazing by cattle, sheep, goats, horses and burros. Riparian area restoration, watershed protection, maintenance of soil productivity, and improvement of rangeland conditions are management priorities.

Timber Management. In FY 1994, 3.4 billion board feet (bbf) were offered, 3.1 bbf were sold, and 4.8 bbf were harvested. For FY 1995, the numbers are 4. bbf offered, 2.9 bbf sold, and 3.9 bbf harvested. The reduction in volume sold in FY 1995 is partly attributable to a large amount of timber not offered until late in the year. For both FY 1994 and FY 1995, the most timber offered, sold, and harvested came from the Southern region, except that for FY 1994, the highest harvest was in the Pacific Northwest. The lowest offer, sold and harvest rates for both fiscal years were in the Southwest, except for the number of sales sold in FY 1994, which occurred in Alaska. The total acres clearcut declined from 100,796 in FY 1994 to 67,889 acres in FY 1995. A total of 441,000 acres were reforested in FY 1994, compared to 387,000 acres in FY 1995.

RECENT DEVELOPMENTS

Meeting Commitments in the President’s Forest Plan

In July, 1993, President Clinton convened a Forest Conference in Portland, Oregon, to address the human and environmental needs served by the federal forests of the Pacific northwest and northern California. Following the conference, the President directed his cabinet to craft a comprehensive, balanced, long-term policy for the management of over 14 million acres of public land. An interagency, interdisciplinary team of expert scientists, economists, sociologists and others was assembled—the Forest Ecosystem Management Assessment Team, led by Dr. Jack Ward Thomas. The team produced a report analyzing ten options and their effects. On July 1, President Clinton announced his proposed “Forest Plan for a Sustainable Economy and a Sustainable Environment.” A draft environmental impact statement (EIS) for the proposed plan was issued in July 1993, and, after extensive public comment, a final EIS was issued in February 1994. The Record of Decision for the plan was signed by the Secretary of Agriculture and Secretary of Interior on April 13, 1994. The plan withstood all federal court challenges (see Chapter 3, “National Environmental Policy Act” and case law appendix). An Interagency Office of Forestry and Economic Development

The President's Northwest Forest Plan has sought to preserve key areas of old growth timber while reestablishing a stable and predictable timber sale program.

was established in Portland, Oregon, to assist in coordinating implementation of the plan in the region and between regional and headquarters offices.

Progress made to date in meeting commitments set forth in the forest plan includes the following:

Watershed Analysis. The area covered by the President's plan includes 143 key watersheds designed to ensure that high-quality habitat is widely distributed across the landscape to conserve and restore at-risk fish stocks. Another 21 key watersheds are designed to maintain sources of high-quality water.

In 1994 and 1995, agencies completed watershed analyses on more than 8 million acres of federal lands covered by the President's forest plan. Federal agencies plan to complete analyses on about 3.2 million acres more in fiscal year 1996, and an additional 2.5 million acres in fiscal year 1997.

Watershed Restoration. In fiscal year 1994, federal agencies involved in implementation of the forest plan published the "Interagency Watershed Restoration Strategy for Fiscal Year 1994" to guide and design and select watershed restoration projects for that year. The strategy was revised in October 1994, for use in fiscal year 1995. The Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, and Environmental Protection Agency contributed $19.8 million of restoration work to the forest plan area in fiscal year 1994 and more than $32 million in fiscal year 1995, completing more than 1,299 contracts or projects.

Research and Monitoring. An interagency Research and Monitoring Committee comprised of representatives from the Forest Service, Environmental Protection Agency and the National Biological Service is developing a monitoring program to review agency implementation of the forest plan standards and guidelines and the effectiveness and validity of those guidelines. The agencies have initiated a pilot effort to conduct reviews of a statistically valid sample of fiscal year 1994 and 1995 timber sales to determine compliance with the standards and guidelines. In August 1994, the interagency committee released a draft effectiveness-monitoring plan, focusing on five emphasis areas that are high priority for the agencies (late-successional and old-growth forests, northern spotted owl, marbled murrelet, survey-and-manage species, and riparian and aquatic habitat). The agencies intend to complete the draft plan by the end of fiscal year 1996, for use in the fiscal year 1997 field season.

Timber Harvest. Reestablishing a stable and predictable timber-sale program that was halted for three years by injunctions has been taken longer than some expected, due to reductions in staff, start-up times, a severe fire season in the summer of 1994, government furloughs, and implementation of the so-called "timber rider" passed in the 1995 Rescissions Act (see below). On the plus side, there were no court injunctions directed toward any management activities under the plan during fiscal years 1994 and 1995.

Despite some obstacles, the land management agencies got back on track to meet the timber commitments under the forest plan. The agencies offered 241 million board feet during fiscal year 1994, and increased their offerings to 620 million board feet in fiscal year 1995. As anticipated under the plan, restoring the federal timber-sale pipeline is expected to take until 1997.

The Northwest Economic Adjustment Initiative. The Northwest Economic Adjustment Initiative was designed to directly help those workers, businesses, tribes and communities in Washington, Oregon and northern California affected by reductions in federal timber harvests. It was not intended to directly employ people, but rather to provide workers and their families with the skills and support to find long-lasting, family-wage jobs, and to assist businesses and communities in providing the economic basis to sustain those jobs.

The federal financial commitment announced as a part of the forest plan is to make $1.2 billion available to the region over 5 years, beginning in fiscal year 1994. Nine federal agencies with 16 different programs are participating financially, along with additional agency participation by way of technical assistance.

Not all the goals for funding the initiative have been met, due to lack of funding by Congress. For example, the proposed Northwest Economic Adjustment Fund of $13 million was never implemented because Congress did not pass the legislation. Thus, funding has largely come from agency appropriations, including significant monies from the

Department of Labor and the Rural Development Agency in the Department of Agriculture, as well funds from Department of the Interior agencies for watershed restoration and the Jobs in the Woods program, earmarked ecosystem investment funds from the Environmental Protection Agency, and funds passed through to state agencies through the Community Development Block Grant program administered by the Department of Housing and Urban Development.

In fiscal year 1994, more than $126 million dollars in federal assistance was delivered to more than 100 communities in grants (46 percent), contracts (21 percent), and loans and loan guarantees (33 percent). Forty-six percent of the assistance was spent in Oregon, 29 percent in Washington, and 21 percent in northern California. Additionally, $164 million in loans were guaranteed by the Small Business Administration in the region. By category of assistance, the distribution was assistance to workers and families (7 percent), business and industry (31 percent), communities and infrastructure (37 percent), and watershed restoration (25 percent).

In fiscal year 1995, federal spending increased dramatically and more than $217 million was delivered to the region. Forty-three percent were awarded as loans or loan guarantees, 42 percent was awarded as grants and 14 percent was awarded in contracts or agreements. Small Business Administration loans amounted to almost $163 million in loans. Again, the biggest percentage of assistance was spent in Oregon (44 percent), followed by Washington (31 percent), and California (25 percent). Workers and families received 9 percent, business and industry received 23 percent, assistance to communities and infrastructure amounted to 53 percent, and watershed restoration accounted for 15 percent.

Interagency Coordination and Streamlining: The Administration has placed a high priority on interagency coordination and cooperation in all of its efforts associated with the forest plan, from data sharing to policy formulation, and with natural resources management in general. Along with that, the agencies have sought to develop concurrent, rather than sequential, environmental review processes. For example, a new interagency Geographic Information System data base is being developed to provide standardized information for federal, state and local government representatives and the public. The Interorganization Resources Information Coordinating Council working on this effort has developed common standards for defining vegetation and is now seeking to standardize natural resource data bases. An Interagency Executive Committee of 11 federal agency directors and an Intergovernment Advisory Committee consisting of state, county, and tribal representatives from Oregon, Washington, and California were established. These committees meet monthly and provide advice about and oversight of implementation of the forest plan.

Considerable progress has been made in streamlining consultation and review processes between land management and wildlife management agencies. In March 1995, the Forest Service, Bureau of Land

Management, U.S. Fish and Wildlife Service and National Marine Fisheries Service entered into an agreement to utilize interagency teams and complete consultation under the Endangered Species Act in a timeframe needed to meet the requirements of the National Environmental Policy Act. This process shortened project planning timeframes from 220-475 days down to 160-350 days. In addition, the agreement allowed consultation to occur simultaneously with project development. This agreement was followed by a second interagency agreement in May 1995, on further streamlining consultation procedures under the Endangered Species Act. The agreement provides for progressive elevation to the forest, regional, or national arena if disagreements among the agencies cannot be resolved within a specific time period. As a result of these interagency agreements, consultation time has been reduced by 70 percent, averaging 34 days compared to 114 days in the past.

Among the benefits of interagency cooperation most often cited are creating common data bases and thus improving the availability of information, coordinating resources for meetings, field trips and discussions, understanding and respecting each agency's missions, building working relations and trust with other agencies, and maximizing limited agency resources. The significant changes in the way agencies now do business in the Pacific Northwest in the forestry context are serving as a model for headquarters' offices and other regions.

The 1995 Rescissions Act "Timber Rider"

In July 1995, after vetoing an earlier version of the bill partly because of the so-called "timber rider," President Clinton reluctantly signed into law certain provisions of the 1995 "Emergency Supplemental Appropriations and Rescissions Legislation" (PL 104-19) that related to timber sales on both Forest Service and Bureau of Land Management (BLM) lands. Those provisions, commonly referred to as the "timber rider," contained requirements for three different types of sales:

(1) "Salvage timber sales" were defined as a sale for which an important reason for entry includes the removal of disease or insect-infested trees, dead, damaged, or down trees, or trees affected by fire or imminently susceptible to fire or insect attack (Box 17.2). The definition also encompassed the removal of associated trees or "trees lacking the characteristics of a healthy and viable ecosystem for the purpose of ecosystem improvement or rehabilitation," although each sale was to include an identifiable salvage component of trees. The act required the land management agencies "to achieve, to the maximum extent feasible," a salvage timber sale volume level above the programmed level to reduce the backlogged volume of salvage timber. The salvage program established under the act was shielded from litigation concerning compliance with federal environmental laws, forest management laws, and international agreements and treaties until December 31, 1996. During this

Box 17.2
Forest Health

Indicators of forests in difficulty include increased mortality, species shifts in mixed conifer stands, overstocked stands of small trees, and excessive levels of burnable biomass. Timber mortality—-loss of commercial-grade trees to insects, disease, and fire—-is on the rise (Box Figure 17.2). In 1991, mortality estimates were 5.5 billion cubic feet per year; this was up a billion cubic feet from 1970. Although these estimates represent fewer than 1 percent of total growing stock volume, any upward trend in mortality merits scrutiny.

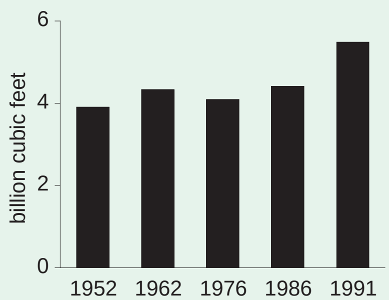
Contributing factors, in addition to natural aging, may include air pollution and climate change effects. Neither insects nor disease appears to be the culprit. Over the past 25 years, insect outbreaks have shown no clear trend, with the most severe damage caused by the southern pine beetle (Box Figure 17.3). In the 1991—93 period, this beetle damaged 35 million acres, mostly in monocrop forests on forest industry and nonindustrial private lands, which were salvage-logged soon thereafter.

In the intermountain West, many pine and mixed conifer stands are in an unhealthy condition from decades of overgrazing and heavy harvesting. In addition, fire suppression during the past 75 years may have weakened fire-dependent forests, and recent episodes of drought have aggravated the situation.

Forest management tools include precommercial thinning—removing trees too small to have commercial value—pruning to eliminate low-growing branches, prescribed fire to reduce biomass, and fertilization to accelerate growth. Foresters can use these tools in a coordinated approach to improve forest health.

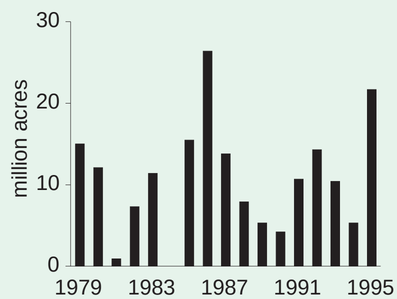
In 1995, in response to public concerns about mortality and wildfire, the Forest Service implemented a Western Forest Health Initiative, composed of 300 projects on national forests in the West. The projects are designed to make forests less susceptible to drought, insects, disease, and wildfire; and to restore forests destroyed by the 1994 wildfires. The agency named a Forest Health Technology Enterprise Team to develop technologies for protecting forests; a Forest Health Monitoring Program provides data on long-term trends.

Box Figure 17.2 Annual Mortality of U.S. Timber, 1952-1991



Source: See Source for Part III, Table 62.
Note: Data refer to the net volume of timber dying from natural causes (e.g., insects, disease, fire, windthrow).

Box Figure 17.3 U.S. Southern Pine Beetle Damage, 1979-1995



Source: See Part III, Table 66.
Note: Data for 1984 not available.

period, the land management agencies were directed to implement an expedited and integrated process that was deemed sufficient for compliance with the National Environmental Policy Act and the Endangered Species Act. The land management agencies were also exempt from competitive contracting laws and regulations and the Small Business Act. Congress stated that timber sales "shall not be precluded because the costs of such activities are likely to exceed the revenues."

(2) "Option 9" Sales. Another section of the timber rider required the land management agencies to "expeditiously prepare, offer, and award" timber sale contracts described in the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planing Documents Within the Range of the Northern Spotted Owl, more commonly referred to as the Pacific Northwest Forest Plan or the President's Forest Plan (see discussion at pp. 210-212, Twenty-Fourth Annual Environmental Quality Report). The rider shielded these sales from judicial review under environmental and forest management laws until December 31, 1996. The rider also included sufficiency language for the proposed "4-d" rule to reduce restrictions on non-federal lands within the range of the northern spotted owl under the Endangered Species Act by shielding it from review under the National Environmental Policy Act until December 31, 1996.

(3) "Previously Offered and Unawarded Timber Sale Contracts." Although the timber rider was largely cast as a "salvage law" during Congressional debate, this section, pertaining to previously offered green timber sales, immediately proved to be the most controversial of the provisions. The provision required the land management agencies to award, release, and permit to be completed, with no change in originally advertised terms, volumes, and bid prices, all timber sale contracts offered or awarded before 45 days after enactment of the timber rider in any unit of the National Forest System or Bureau of Land Management districts subject to Section 318 of PL 101-121, an earlier timber rider on an appropriations bill in 1989. The only exception to the requirement to release these sales was a determination that a threatened or endangered bird species was "known to be nesting" within the acreage that was the subject of the sale unit, in which case, the purchaser was entitled to replacement timber of an equal volume, kind and value. This section of the timber rider was set to expire on September 30, 1996.

Shortly after signing the bill, the President directed the Departments of the Interior, Agriculture, Commerce and the Environmental Protection Agency to "move forward expeditiously to implement this timber-related provisions in an environmentally sound manner, in accordance with my Pacific Northwest Forest Plan, other existing forest and land management policies and plans, and existing environmental laws, except those procedural actions expressly prohibited by Public Law 104-19." To implement that direction, the departments and agencies executed a Memorandum of Agreement on the timber salvage program mandated by the law, reaffirming their commitment to carry out requirements of existing environmental law to the extent authorized.

Litigation regarding the interpretation of the provision mandating the release of previously offered and awarded sales followed quickly after the rider became law, and expanded considerably the number of sales subject to that provision. Numerous cases were also filed challenging salvage sales under the rider, confirming the President's stated concern that "the timber salvage provisions could slow down our forest management program." Demonstrators in Oregon and Washington protested the likely release of sales previously found to jeopardize threatened or endangered species. By the end of 1995, it was clear that the release of timber sales previously withheld for environmental reasons and the lack of a meaningful administrative or judicial remedy in the salvage and option 9 sales provisions had stimulated renewed controversy over timber harvest on federal lands.

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CHAPTER EIGHTEEN

Energy

Energy is the lifeblood of an industrial economy. It heats and lights our homes and powers our vehicles and factories.

Energy also is a major source of pollution. The combined effects of the production, distribution, and consumption of fossil fuel energy are the nation's largest source of pollution. Driven by population growth and economic growth, the demand for energy will continue to increase, thus posing a continuing environmental protection challenge, both domestically and internationally.

The ongoing challenge is to find ways to accommodate population and economic growth through improved energy efficiency; to use more efficient technologies and different kinds of energy to prevent or reduce energy-based pollution; and to take advantage of market-based incentives to make energy as cost-effective, reliable, and environmentally benign as possible.

BACKGROUND

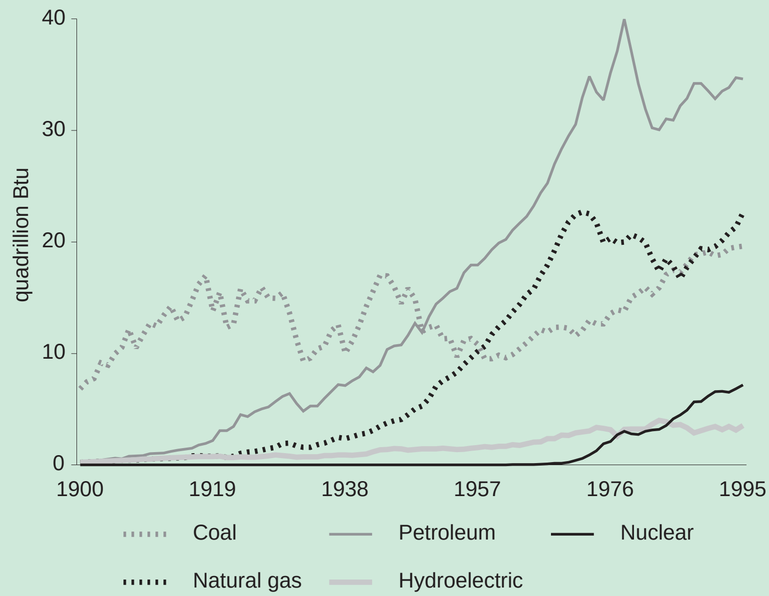
Inexpensive and abundant energy has been a vital cog in the expansion of the U.S. economy.

At the turn of the century, coal was the dominant source of energy in the United States, providing 90 percent of all energy consumed in 1900 (Figure 18.1). But the demands of World War I, mining labor shortages, and other factors combined to create a severe coal shortage. Soon the price of coal more than doubled. The general coal strike of 1919 caused a second fuel price shock. In response, petroleum became the dominant source of energy supply. New technologies such as ships, planes, and trucks created rapidly growing new sources of demand for oil.

Domestic oil continued to support U.S. economic growth through the 1930s and 1940s. Sparked by economic growth in the 1960s, demand for oil in Europe and Japan grew rapidly. Industrial countries' dependence on oil produced by the Organization of Petroleum Exporting Countries (OPEC) continued to grow. By 1971, OPEC was able to influence oil production and prices. The 1973 Arab oil embargo caused every nation to reassess its energy policies.

In the 1960s, nuclear energy began to play a role in the nation's energy picture. A 1962 Atomic Energy Commission report projected that electricity from nuclear power would provide about 30 percent of the nation's total projected energy supply in the year 2000. By 1995, nuclear power plants generated about one

Figure 18.1 U.S. Energy Consumption by Source, 1900-1995



Source: Energy Information Administration (EIA), *Annual Energy Review1996* (EIA, Washington, DC, 1996).
Note: Petroleum includes natural gas plant liquids. Hydroelectric includes geothermal after 1948.

fifth of the electricity in the U.S. But prospects for nuclear energy have diminished severely over the past few decades. Factors contributing to the decline included the rapid rise in the capital construction costs of new nuclear plants, ongoing concerns about safety and environmental problems such as the disposal of high-level nuclear waste, and the 1979 accident at the Three Mile Island Nuclear Power Plant in Pennsylvania.

In the 1970s, high energy prices, high dependence on foreign sources, and assumptions that energy demand would continue to grow led to an increased focus on energy efficiency as a goal.

The Energy Policy and Conservation Act of 1975 was enacted to promote energy efficiency improvements and diversification of supply and sources. The act required states to prepare energy conservation plans in order to receive financial assistance for eligible programs. It also set energy efficiency standards for appliances and light-duty vehicles and authorized federal grants for energy inspections and audits of schools and hospitals. Energy prices fell in the late 1980s, which tended to undermine efficiency incentives somewhat. Since then, consumers' interest in the energy efficiency of cars has declined. More recently, many states have relaxed the fuel-saving 55-mph speed limit on their highways.

In other respects, the policy context has changed. According to a report by the

National Academy of Engineering, the key energy policy assumptions of the 1990s differ substantially from those of the 1970s (Table 18.1).

The high prices of the 1970s spurred an investment boom that led to increased oil production by non-OPEC countries and a much greater understanding of the opportunities to make energy use more efficient through demand-side management, conservation, and new technologies. Some of these gains were based on improved design of automobiles, buildings, appliances, and factories. The 1975 Energy Policy and Conservation Act helped this process along.

In the mid-1970s, according to the National Academy of Engineering report, most experts were predicting that annual energy demand would rise to around 115 quads by 1985, yet in 1986 the United States used only 74 quads, the same as in 1973 (1 quad equals 1 quadrillion Btu, the energy equivalent of 171.5 million barrels of crude oil). From 1973 to 1995, total energy consumption increased by 22 percent, while GDP increased by 73 percent (Figure 18.2).

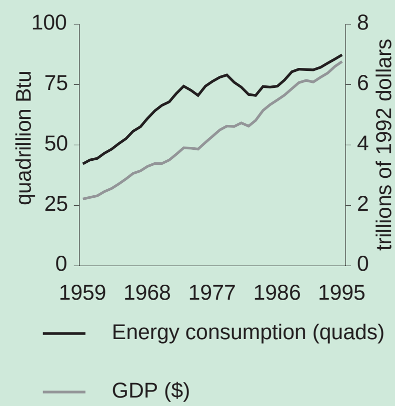
By the 1990s, the environmental implications of energy use were much more widely recognized. The major impacts include the following:

- On a global level, increased use of fossil fuels will mean an increase in greenhouse gas emissions, which contribute to global climate change.
- On a regional and local level, burning of fossil fuels releases smog-related emissions and may increase acid precipitation, affect human health, and degrade downwind habitats; mining can lead to land degradation and water pollution; and nuclear energy, though not a source of air pollution or greenhouse gas emissions, nevertheless has serious environmental impacts associated with both production risks and radioactive waste disposal.

CONDITIONS AND TRENDS

The United States has one of the most energy-intensive economies among advanced industrialized nations, according to a recent report by the Organisation for Economic Co-operation and Development (OECD) (Figure 18.3; see also section on energy intensity below). In addition, a relatively high proportion of U.S. energy consumption is related to transportation (Figure 18.4), in part because of the nation's relatively low energy prices, large land area, and comparatively low population density. Cana-

Figure 18.2 U.S. Energy Consumption and GDP, 1959-1995



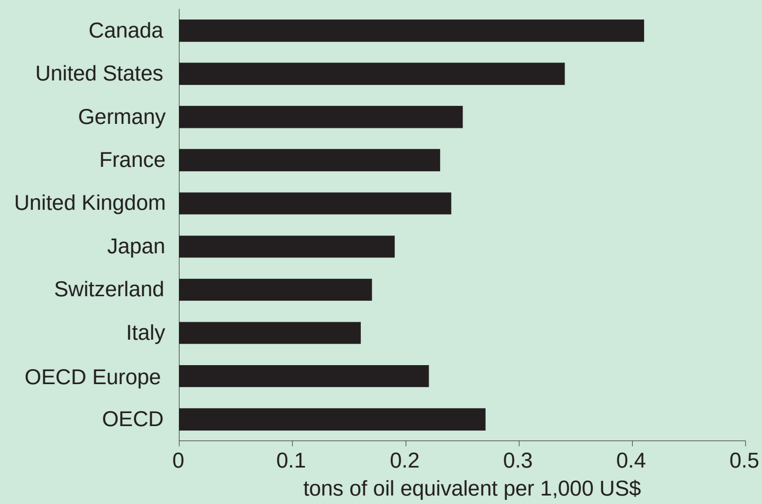
Source: See Part III, Tables 9 and 85.

Table 18.1
Key Energy Policy Assumptions

1970s	1990s
• Rapidly rising prices	• Volatile prices oscillating around a gradually changing average price, probably rising in real terms
• Widely held beliefs that both prices and consumption would continue to rise without moderation	• Increased recognition of price elasticities in free markets, and the realization that these elasticities are constructive and tend to moderate emergencies
• Perceived episodic shortages leading to real episodic shortages; rising consumption exacerbated by panic purchases; government interventions to allocate scarce supplies	• Shifts from supply shortages to supply excess and rising consumption
• Major emphasis on supply management; belief that all viable energy sources should be mobilized and alternative energy sources should be developed for the future	• More sophisticated understanding of demand management and how demand can be mitigated by efficiency measures and how price influences supply growth and incentives for development of alternative fuels; federal deregulation of supply sectors such as the electric power distribution grid and natural gas pipelines
• Strong market and government incentives for investment in long-term energy supply	• Disincentives for long- range energy investments, such as energy commodity price volatility and short time horizons for competing capital investment opportunities
• Tacit assumptions that environmental problems would remain local in scope and that their solution would be straightforward	• Mounting concerns about energy system impacts on the environment at the local, regional, and global scales
• Acute concern over economic and strategic vulnerabilities due to high petroleum prices and dependence on foreign supplies	• Growing concern that the U.S. energy system will eventually be vulnerable again to price shocks, given increasing consumption and diminishing development of new energy sources because of currently lower energy prices

Source: National Academy of Engineering (1990).

Figure 18.3 Energy Intensity per Unit of GDP for Selected Industrialized Nations, 1993



Source: *OECD Environmental Data, Compendium 1995* (OECD, Paris, 1995).
Note: GDP at 1991 prices and purchasing power parities.

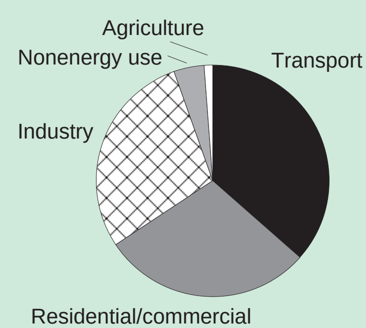
da, with similar geographical characteristics, also has a relatively high energy intensity.

As in most other industrialized nations, the general trend in the United States has been a steep decline in energy intensity per unit of GDP from 1970 until the early 1980s, followed by a period of leveling off and a period of relatively slow decline (see Part III, Table 87).

U.S. energy prices are among the lowest in the OECD, mainly because of the low level of energy taxation. According to the OECD report, for example, the average price of premium unleaded gas in the United States in 1993 was only about 43 percent of the price in Europe, while the average cost of electricity was only about three fifths that in Europe.

According to the *Annual Energy Review 1995*, a report by DOE's Energy Information Administration (EIA), U.S. energy consumption grew by a little over one third, from 66.43 to 90.62 quads,

Figure 18.4 U.S. Total Final Energy Use by Sector, 1993



Source: International Energy Administration.

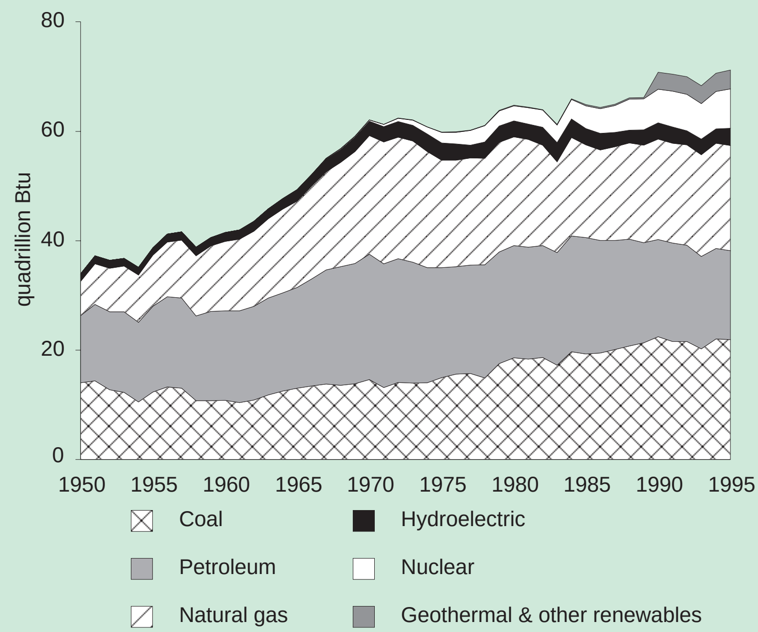
over the 1970–95 period, though this trend was interrupted several times by declines following sustained increases in oil prices. Domestic energy production grew by 15 percent, from 62.07 to 71.16 quads (Figure 18.5). The production of coal and nuclear energy rose dramatically: coal from 14.61 to 21.91 quads and nuclear from 0.24 quad to 7.19 quads, while various forms of renewable energy (other than conventional hydroelectric energy) grew from 0.01 quad to 3.40 quads. Gas production, however, declined by 10 percent (from 21.67 to 19.23 quads), while oil production dropped significantly, from 20.40 to 13.82 quads. (For more information on these trends, see Part III, Table 78.)

The growth in the role of electricity continued. Net generation by electric utilities nearly doubled, rising from 1,532 billion kilowatt-hours in 1970 to 2,995 billion kilowatt-hours in 1995 (Figure 18.6). Nearly half of that growth was provided by nuclear generating units.

The transportation sector continued to be the main generator of new demand, rising nearly 50 percent to 24.06 quads in 1995 (Figure 18.7). Consumption in the industrial and residential/commercial sectors rose by 5.84 quads and 10.36 quads, respectively.

During this time frame, net imports of primary energy sources more than tripled, rising from 5.72 to 17.86 quads; increased imports of petroleum account-

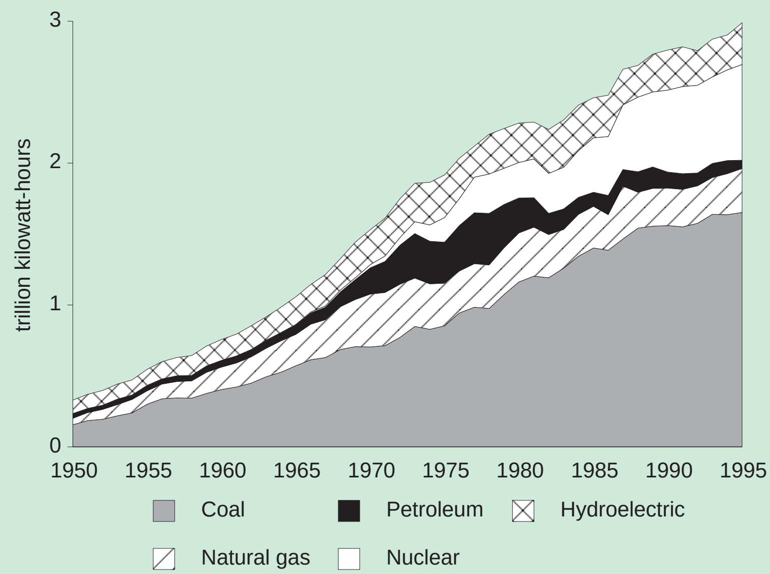
Figure 18.5 U.S. Energy Production by Source, 1950-1995



Source: See Part III, Table 78.

Note: Coverage of nonutlity use of renewable energy was expanded in 1990.

Figure 18.6 U.S. Electricity Generation by Source, 1950-1995



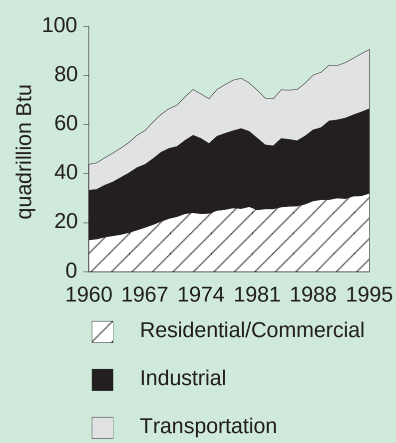
Source: See Part III, Table 82.

ed for nearly all the increase (Figure 18.8; see also Part III, Table 84).

Trends in Energy Supply and Production

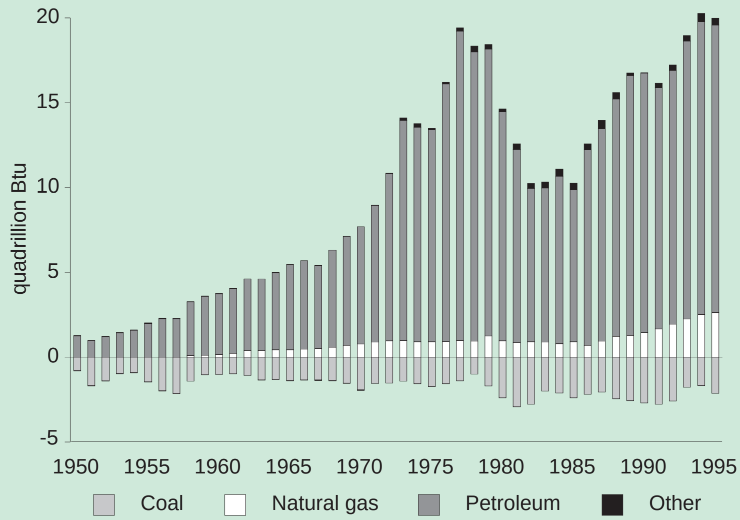
According to data in the DOE/EIA *Annual Energy Review 1995*, U.S. energy production from 1970 to 1995 has been characterized by a rapid increase in coal production, especially in production of low-sulfur western coal; a continuing decline in domestic oil production, accompanied by a rise in imports approaching the record level of 1977; and a recent 9-year rise in gas production. Electricity output continues to increase; coal fuels 55.1 percent of the output, oil 2.0 percent, gas 10.3 percent, nuclear power 22.5 percent, hydropower 9.9 percent, and other renewable energy sources 0.2 percent.

Figure 18.7 U.S. Energy Use by Sector, 1960-1995



Source: See Part III, Table 85.

Figure 18.8 Net U.S. Imports of Energy Sources, 1950-1995



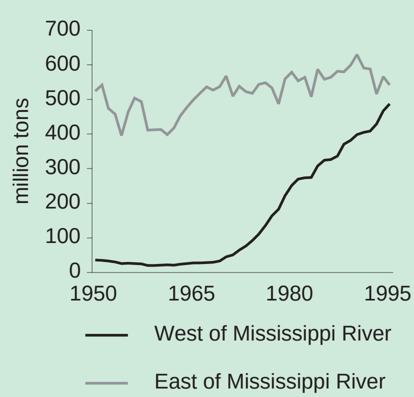
Source: See Part III, Table 84.

Coal. In 1995, according to EIA, estimated production of all types of coal totaled 1,030 million tons, the highest total ever. The West's share of total U.S. production has increased almost every year since 1965 (Figure 18.9). Production in the West grew from 45 million to 487.5 million tons (47 percent of the total) between 1970 and 1995. The growth in western coal production was due in part to environmental concerns that led to increased demand for low-sulfur coal, which is concentrated in the West. In addition, surface mining, with its higher average productivity, is much more prevalent in the West.

Coal production is forecast by EIA to increase to 1,240 million tons per year by 2015, with western production growing to 623 million tons.

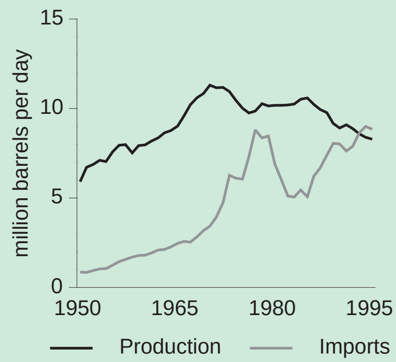
Petroleum. By the 1970s, the average productivity of domestic wells began to decline, and domestic oil production leveled off. Increases in Alaskan production at the end of the 1970s and through 1988 partially offset production declines in the lower 48 states. In 1989, Alaskan

Figure 18.9 U.S. Coal Production by Location, 1950-1995



Source: See Part III, Table 79.

Figure 18.10 U.S. Oil Production and Imports, 1950-1995



Source: See Part III, Table 80.
Note: Data include natural gas plant liquids.

production declined. In 1995, U.S. oil production totaled 6.5 million barrels per day. Of total U.S. production, 79 percent came from onshore wells and 21 percent from offshore.

In 1994, petroleum imports reached a 17-year high of 45 percent, nearly returning to the 1977 peak level of 47 percent (Figure 18.10). Saudi Arabia, Venezuela, Canada, Mexico, and Nigeria were the primary foreign suppliers.

Domestic oil production is projected by EIA to decline through 2005. After 2005, production is projected to increase as drilling is stimulated by rising prices and as the cumulative effects of improved technology reduce the costs of finding, developing, and producing oil resources.

Natural Gas. According to EIA, gross withdrawals of natural gas from wells totaled 24 trillion cubic feet in 1995, up for the ninth consecutive year. Texas, Louisiana, and Oklahoma accounted for 61 percent of the U.S. total. The total gross withdrawals yielded 20 trillion cubic feet of marketed production (Figure 18.11).

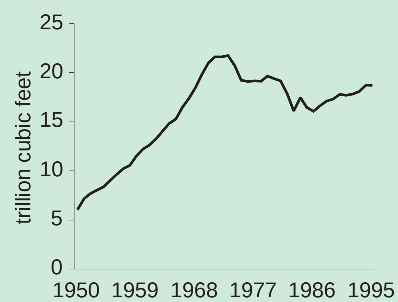
The total includes a small but rapidly growing amount of methane produced from coalbeds. In 1993, gross withdrawals of coalbed methane totaled about 732 million cubic feet, accounting for about 4 percent of total production.

After peaking at 435,000 cubic feet per day in 1971, average gas well productivity has trended downward to 164,000 cubic feet per day in 1995, or just 38 percent of the 1971 level.

Gas production is projected by EIA to increase, reflecting the combined impact of rising prices, relatively abundant resources, and improvements in technologies, which reduce costs and provide methods for economic recovery of unconventional and offshore gas resources.

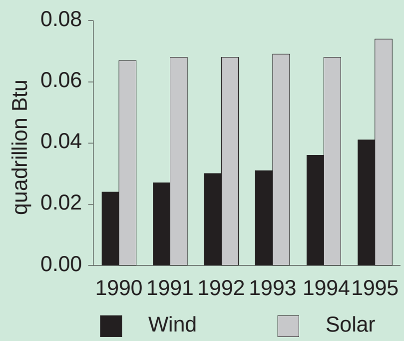
Nuclear Energy. In 1995, there were 109 licensed nuclear generating units operating in the United States, 1 unit was licensed for start-up, and construction had been canceled or halted on 6 other

Figure 18.11 U.S. Natural Gas Production, 1950-1995



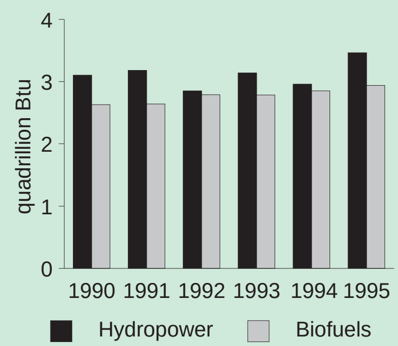
Source: See Part III, Table 81.

Figure 18.12 U.S. Wind and Solar Energy, 1990-1995



Source: See Part III, Table 88.

Figure 18.13 U.S. Hydropower and Biofuels Energy, 1990-1995



Source: See Part III, Table 88.

planned units. In comparison, 48 units were operating in 1974, but the total number of units in all stages of planning, construction, or operation at that time was 226, well above the 1995 total (see Part III, Table 83). Environmental, safety, and health concerns have contributed to the decline in the number of planned units. In addition, costs of plant construction have increased, growth in electricity demand has been slower than expected, and the uncertain economic environment has made electric utilities less willing to invest in new units.

Nuclear power's contribution to U.S. electricity net generation increased almost every year from the late 1950s through 1995. Production rose to 673.4 billion kilowatt-hours in 1995, up 5.2 percent from the year before.

Renewable Energy. EIA estimates that renewable energy—solar, biomass, wind, geothermal, and hydropower technologies—supplied 7 percent of total U.S. energy consumption in 1994. Of the amount provided by renewables, 48 percent was from conventional hydroelectric facilities and 45 percent was from biomass resources. Wind-generated electricity showed the greatest percentage increase (71 percent) over the 1990–95 period (Figure 18.12).

During the last 15 years, intensive work by industry and the Department of Energy's national laboratories has steadily increased the reliability of renewable energy systems while dramatically lowering their costs. Some of these systems are becoming commercially competitive with conventional power sources.

Today, the United States has regained its lead in world photovoltaic shipments, and the bioenergy industry is working to become a major new source of electric power (Figure 18.13). However, at present, total electricity generation from geothermal, solar, and wind resources makes up less than 1 percent of U.S. electricity generation.

Patterns of Energy Consumption

After the 1973 oil price shock, energy consumption fluctuated, influenced by dramatic changes in oil prices, changes in the rate of growth of the domestic economy, and such factors as concerns about the effect of energy use on the environment. The post-1973 low point of energy consumption, 71 quads, occurred in 1983, during a period of economic recession and very high oil prices. The highest level of energy consumption, 91 quads, occurred in 1995, when oil prices were low and the U.S. economy was growing (see Part III, Table 86).

Electricity Use. Before the 1970s, growth in electricity consumption surpassed economic growth by nearly a factor of 2. During the 1970s and 1980s, higher costs drove up the price of electricity production, and the growth in demand for electricity decelerated. In the 1990s, the rate of demand growth is continuing to lag behind economic growth.

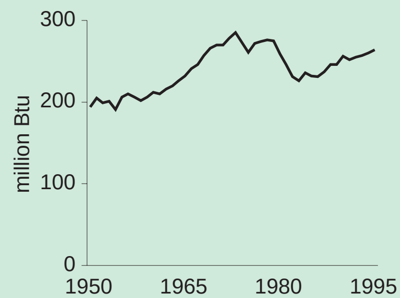
EIA estimates that 252 gigawatts of new generating capacity will be needed between 1994 and 2015 to satisfy electricity demand growth and to replace retiring units (Figure 18.14). Between 1994 and 2015, 84 gigawatts, or 12 percent, of current generating capacity is expected to be retired, including 36 gigawatts of nuclear capacity (mostly after 2010).

Energy Use per Capita. Energy use per capita, which generally declined from 1970 through the mid-1980s, increased in the mid-1980s as energy prices dropped (Figure 18.15).

It appears that energy use per capita may have begun to stabilize. In its *Annual Energy Outlook 1996*, EIA predicts that per capita energy use will remain nearly stable through 2015, as increasingly efficient technologies offset growing demands for energy services.

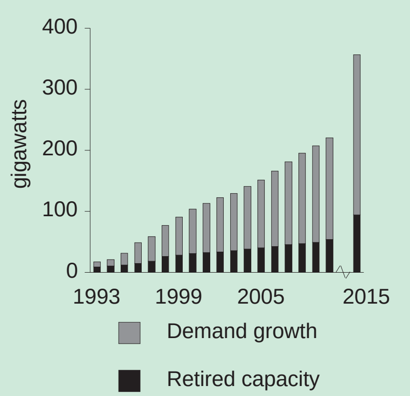
Per capita demand for electricity is expected to increase over the next decade, while per capita demand for

Figure 18.15 U.S. Energy Use per Capita, 1950-1995



Source: See Part III, Table 86.

Figure 18.14 Projected Need for New U.S. Electricity Generating Capacity, 1993-2015



Source: Energy Information Administration (EIA), *Annual Energy Outlook 1996* (EIA, Washington, DC, 1996).

Wind Turbines at Tehachapi, California. Government is working closely with industry to research and develop new, improved wind turbine technology.

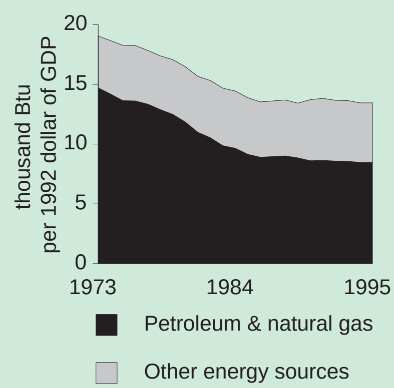
Photo Credit:
U.S. Environmental Protection Agency

other energy sources is expected to remain flat.

Energy Intensity. As technology has become more efficient and the U.S. economy has shifted away from energy-intensive industry, the amount of energy that we use to produce a dollar's worth of GDP—the energy intensity of the economy—has declined (Figure 18.16), as it has in most other industrialized countries.

The reduction in energy intensity that has occurred over the last two decades has been driven by energy efficiency advances on the demand side, high energy prices, and a shifting of the economy away from energy-intensive industry. People and companies often found that it was cheaper to save energy than to buy it. Investing in efficient technologies allows them to reduce wasteful energy use and

Figure 18.16 U.S. Energy Use per Dollar of GDP, 1973-1995



Source: See Part III, Table 87.

get the energy services they need at lower overall cost.

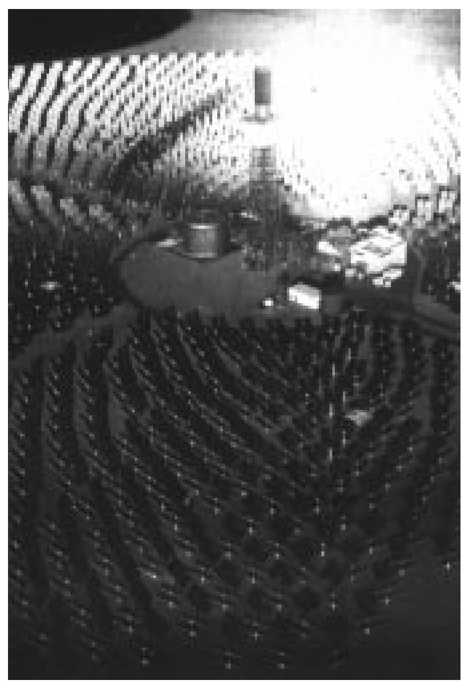
Many of the efficiency gains realized over the past 20 years were assisted by government policies to encourage, facilitate, and in some instances, require investment in cost-effective efficiency technologies. By continuing to address barriers to economically desirable investments in energy efficiency, energy efficiency policies and measures continue to produce significant economic payoffs for all Americans.

According to DOE estimates, U.S. energy efficiency and conservation efforts from 1973 through 1991 curbed the pre-1973 growth trend in primary energy use by about 31 quads—a 27 percent reduction. This saves the economy about $275 billion annually, which is equal to about half of the nation's $522 billion annual energy spending. Of the 31 quads in savings, it is estimated that about 56 percent comes from industry, 21 percent from residential buildings, 5 percent from commercial buildings, and 18 percent from transportation.

This has substantially reduced the environmental burdens associated with using energy. However, low expected energy prices could lead to a continued slowing of this trend. The gains in reducing environmental degradation through reductions in energy intensity could be lost if low prices lead to increasing energy use per dollar of GDP.

Industrial Energy Use. Of the three end-use sectors, the industrial sector proved initially to be the most responsive to the turmoil in energy markets after the 1973–74 embargo. In 1979, industrial consumption of energy reached the then-record level of 33 quads (gross consumption). In 1983, industrial consumption declined to a 16-year low of 26 quads. Despite slow economic growth in the early 1990s, industrial energy consumption trended upward and reached 34 quads in 1995, the highest level recorded to that date (see Part III, Table 85).

Industry uses about 38 percent of the nation's primary energy for fuel and feedstocks, for which the manufacturing sector alone spends about $100 billion per year.

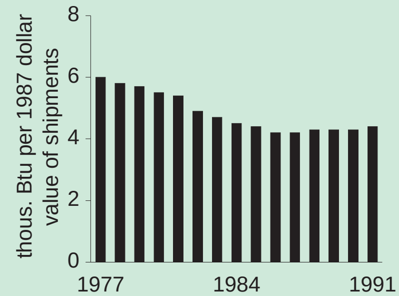


Solar Two, built in Barstow, California, is the most advanced solar thermal, central receiver power plant in the world. It will serve as a model for commercial solar power plants, generating as much as 200 megawatts of electricity.

Photo Credit:
U.S. Department of Energy

Between 1977 and 1991, industry reduced the amount of energy required for every dollar of output by 36 percent (Figure 18.17), with about two thirds of these savings coming from improvements in energy efficiency. When energy prices began to fall in the mid-1980s, the rate of efficiency improvement slowed. Between 1970 and 1980, energy intensity declined by 2.5 percent per year, but the rate of decline has dropped below 1 percent in recent years.

Figure 18.17 U.S. Industrial Energy Use, 1977-1991



Source: See Part III, Table 89.

Energy Use in Buildings. Energy use in buildings has changed substantially in both form and function during the past several decades. Total building energy use in the United States has increased, primarily because there are more people, more households, and more offices. Building energy use currently accounts for 35 percent of total primary energy demand, 42 percent of total energy costs, and 35 percent of all U.S. carbon emissions. Energy use per unit area (commercial) or per person (residential) has roughly stabilized over the past decade owing to a variety of efficiency improvements. About one half of the improvements were in space heating and cooling, one fifth in lighting, and one tenth in water heating.

Because utility bills are a substantial part of family budgets, residential building energy use affects what kind of housing people can afford. Energy use in the commercial sector represents a cost to business and can have a substantial bearing on employee productivity.

Energy Use in Transportation. Transportation energy use as a percentage of total energy use has remained relatively constant, accounting for just over one fourth of U.S. energy consumption. Cars and trucks alone account for about 20 percent of total U.S. energy use. Almost two thirds of total U.S. petroleum consumption is in the transportation sector.

Since 1949, transportation energy consumption has increased at an average annual rate of 2.4 percent, though growth has not been uniform. Energy use in transportation has risen slowly over the past 15 years. Corporate average fuel efficiency (CAFE) standards for light duty vehicles became effective in 1975, and the efficiency of the light-duty vehicle fleet improved significantly between 1975 and 1985.

According to data compiled by the Federal Highway Administration, both total vehicle-miles traveled in the United States (2.36 trillion vehicle miles in 1994) and average yearly miles traveled per vehicle (11,697 in 1994) are growing steadily. Fuel consumed, estimated at 140.5 billion gallons in 1994, also is rising, as is average annual fuel consumption per vehicle, which dropped from

830 gallons per vehicle in 1970 to 677 gallons in 1990, but has since risen to 705 gallons in 1994. Energy use in vehicles is expected to continue to rise throughout the beginning of the 21st century. (For more information on efforts to mitigate the impacts of transportation on the environment, see Chapter 19, "Transportation.")

RECENT DEVELOPMENTS

In the 1994–95 period, Congress and the Administration have addressed a number of energy-related issues, including changes in approach to the Strategic Petroleum Reserve, export of Alaskan North Slope oil, and regulatory changes in the electric utility industry.

Strategic Petroleum Reserve

Authorized in 1975 and intended to provide some protection in the event of another oil embargo, the Strategic Petroleum Reserve (SPR) holds (as of August 1996) about 584 million barrels.

During the 1990s, a number of developments have affected SPR policy, including the need to cut federal spending and the emergence of unregulated and relatively efficient oil markets. A defacto consensus emerged that the SPR was at an adequate level to fulfill its mission and that further filling was unneces-

This sanitation truck in New York City powered by compressed natural gas as part of a Department of Energy managed trial and evaluation project.

Photo Credit:
U.S. Department of Energy

sary. In early 1994, the Administration proposed, and Congress agreed, to suspend further purchases of oil for the SPR.

The priorities now are maintaining the reserve's readiness and upgrading an aging infrastructure. The President's FY 1996 budget request proposed using unspent oil acquisition funds, $25 million in new authority, and an additional $100 million from the sale of 7 million barrels of SPR oil to finance the transfer of 73 million barrels from the storage site at Weeks Island, Louisiana, where a sinkhole had developed. The sale proved controversial, with some members of Congress arguing that this was an inadvisable precedent. Owing to the higher price of crude oil, the sale of 5.1 million barrels was sufficient to generate $96.4 million in revenues.

In April 1996, Congress and the White House completed action on legislation (HR. 3019) that would authorize the sale of $227 million in SPR oil during FY 1996. The intent of the amendment was to provide an offset against the proposed restoration of cuts in education programs. The sale was largely completed by mid-1996.

Export of Alaska North Slope Oil

On November 28, 1995, the President signed legislation (S. 395, PL 104-58) that authorized the export of Alaska North Slope (ANS) crude oil subject to a national interest determination. Along with the National Economic Council (NEC), CEQ led the interagency environmental review associated with the lifting of the 23-year ANS crude oil export ban. A June 1994 report by the Department of Energy projects that lifting the ban will increase domestic production by as much as 110,000 barrels per day, raise significant revenue for the federal government and the states of Alaska and California, and expand net U.S. employment by up to 25,000 jobs.

On April 28, 1996, the President determined that ending the export ban was in the national interest, subject to four important environmental conditions:

- Tankers exporting ANS crude oil must remain outside of the 200-mile Exclusive Economic Zone, ensuring that tankers will remain far from environmentally sensitive areas along the Aleutian Islands.
- Tankers carrying ANS oil for export must be equipped with satellite communication systems to monitor their position.
- ANS export tankers must be inspected annually to ensure they are kept in safe working order.
- ANS export tankers are required to exchange their ballast water in deep ocean water prior to entering Prince William Sound.

In addition, all exports must be carried on U.S.-flagged tankers.

The interagency review group found no likelihood of adverse impacts from ANS exports on the state of Washington's consumers, refiners, or environment. However, the increasing volume of vessel traffic projected to occur as a result of other factors, such as the growing international trade between the state of Washington and Pacific Rim nations, has increased public concerns about existing vessel safety procedures and resources. As a result, at the same time that President Clinton made his national interest determination regarding ANS exports, he also requested that the Coast Guard study the private sector efforts for vessel assistance in Puget Sound and report to the Secretary of Transportation. In addition, the President directed the Secretary of Transportation to determine by December 31, 1996, the need for additional, cost-effective measures to protect the marine environment and prevent shipping accidents in Washington.

Electric Utility Restructuring

Regulation of the electric utility industry historically worked on the assumption that unified control of generation, transmission, and distribution was the most efficient means of providing service. About 75 percent of all Americans are still served by a vertically integrated, investor-owned utility.

The states and the federal government share in the regulation of the industry. State regulatory commissions have authority over intrastate activities, including wholesale and retail rate-making, and often over investment and debt. Federal regulation focuses on transmission and sales for resale of electric energy in interstate commerce.

Beginning in 1978, with the enactment of the Public Utility Regulatory Policy Act (PURPA), laws were passed to encourage energy efficiency and alternative sources of power. PURPA required utilities to buy all power produced by qualifying facilities at their "avoided cost," or the amount it would cost the utility to produce the power.

The 1992 Energy Policy Act removed regulatory barriers and promoted greater competition in the electricity supply industry. In March 1995, the Federal Energy Regulatory Commission (FERC) issued two proposed orders (No. 888 and No. 889) that are intended to promote competition in wholesale electricity markets by eliminating discriminatory pricing and access to transmission facilities and services. These orders were published in final form on April 19, 1996.

On May 13, 1996, the EPA Administrator referred Order No. 888 to CEQ for action under the National Environmental Policy Act (NEPA). The referral was based primarily on EPA's concerns that under certain circumstances the open access rule could lead to increases in air pollution in the future that could have impacts that are unsatisfactory from the standpoint of public health, welfare, or environmental quality.

(The CEQ regulations implementing the environmental impact statement assessment provisions of NEPA provide for a referral process for resolving federal agency disputes when there are "interagency disagreements concerning proposed major federal actions that might cause unsatisfactory environmental effects." The CEQ regulations implementing NEPA provide that rulemakings can be such "major federal actions.")

Because EPA determined that there was no immediate environmental threat from adoption of the rule, the agency proposed that the FERC rule be allowed to proceed without delay, but that a set of actions to address future potential emissions be undertaken by the states, EPA, and FERC.

In response to the EPA referral, FERC made important commitments to take future actions to protect clean air, if necessary. On June 14, 1996, CEQ notified the heads of both FERC and EPA of CEQ's conclusion that the referral process and subsequent responses had successfully resolved the disagreements between EPA and FERC.

FUTURE CHALLENGES

The Clinton Administration's national energy strategy emphasizes the importance of a competitive economy, the quality of the environment, and national security in addressing energy issues.

Central to the Administration's approach is the concept of sustainable development and three associated strategic goals. The first is the need to maximize energy productivity to strengthen our economy and improve living standards. The second goal is to prevent pollution and thereby reduce the adverse environmental impacts associated with energy production, delivery, and use, including emissions of pollutants and greenhouse gases. The third goal is to keep America secure by reducing our vulnerability to global energy market shocks. (Further discussion of these goals appears in *Sustainable Energy Strategy*, Executive Office of the President, 1995).

In keeping with these goals, the Administration is pursuing a wide range of programs that fall into several categories. These strategic components of a sustainable energy policy include increases in the efficiency of energy production and use; development of a balanced domestic energy portfolio, including renewables; investment in science and technology advances; reinvention of environmental protection; and development of international markets.

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CHAPTER NINETEEN

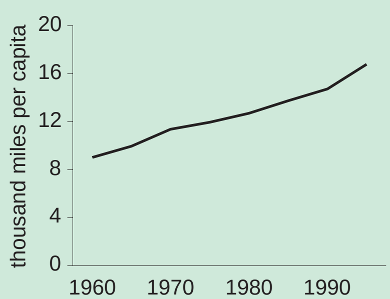
Transportation

The U.S. transportation system is a vast enterprise. Transportation-related goods and services account for approximately 11 percent of gross domestic product, and the economy relies heavily on the low-cost, highly flexible movement of goods and services. Most Americans enjoy a level of personal mobility that offers them a wide range of choices about where to live, work, shop, obtain health care, and vacation.

Yet, not all of the costs of mobility are paid directly by the individuals and businesses who are the beneficiaries. The U.S. transportation system has significant impacts on air and water quality, habitats and open space, and pollution levels.

Over the last 25 years important progress has been made, but more remains to be done. The need to improve the environmental performance of transportation while responding to rising demand for access to markets and services is a continuing challenge.

Figure 19.1 U.S. Passenger Transportation Growth, 1960-1994



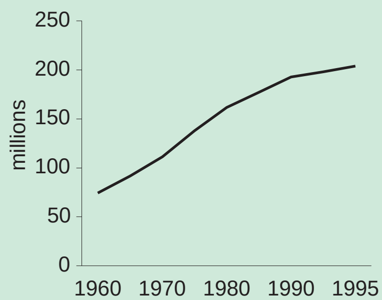
Source: U.S. Department of Transportation (DOT), Bureau of Tranportation Statistics (BTS), *Transportation Statistics Annual Report 1996* (Washington, DC, 1996).

BACKGROUND

Given its vast scope and scale, it is not surprising that the U.S. transportation system has environmental impacts. To meet the Nation's needs, the transportation system accommodates over 4 trillion passenger-miles of travel and 3 trillion ton-miles of domestic freight annually. Further, people in the United States travel much more today than in 1970—mainly by automobile and aircraft. In particular:

- Per capita travel on all modes increased from 11,400 miles to 16,800 miles (Figure 19.1).
- Highway passenger miles traveled in 1994 were nearly twice that of 1970.
- The number of registered motor vehicles increased from 111 million in 1970 to 205 million in 1995 (Figure 19.2).

Figure 19.2 U.S. Motor Vehicle Registrations, 1960-1995



Source: U.S. Department of Transportation (DOT), Federal Highway Administration (FHWA), *Highway Statistics 1994* (DOT, FHWA, Washington, DC, 1995).

- Total yearly air passenger miles in 1994 were more than three times the 1970 level.
- Ton-miles of freight grew 60 percent between 1970 and 1994, resulting in the domestic transport of 12,600 ton-miles of freight per capita (Figure 19.3).
- Ton-miles of freight moved by intercity trucks more than doubled between 1970 and 1994 (Figure 19.4).

CURRENT CONDITIONS

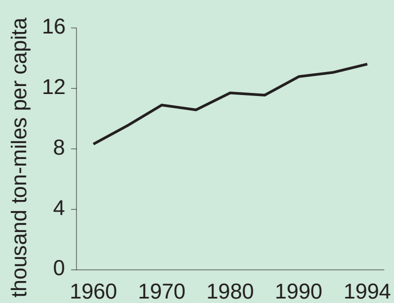
Transportation-related activities can adversely impact environmental quality and human health. Most of these impacts result from the widespread use of fossil fuels.

Transportation is the Nation's largest source of many air pollutants targeted under the Clean Air Act. In addition, transportation fuel use is a major U.S. source of greenhouse gas emissions, which have been strongly linked to potential changes in the earth's climate. (See Climate Change chapter.)

In addition, transportation infrastructure, vehicles, and fuels affect water quality and quantity, species diversity, and habitats. For example, oil and gasoline leaks and spills from tankers, motor vehicles, and above and below ground storage tanks pollute surface and ground water. Old vehicles, tires, and paving materials that are not recycled increase pressure on landfills, contaminate water systems, and contribute to air pollution emissions. Transportation infrastructure affects land use, flora and fauna habitats, and may cause changes in local water tables and drainage patterns.

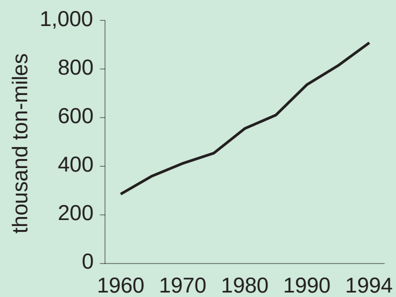
Traditionally, governments' roles have mainly been to build and maintain infrastructure, though the vast majority of transportation decisions are made by businesses and individuals. Whereas markets are relatively efficient at producing and allocating private goods and services, current pricing mechanisms seldom

Figure 19.3 U.S. Freight Transportation Growth, 1960-1994



Source: U.S. Department of Transportation (DOT), Bureau of Tranportation Statistics (BTS), *Transportation Statistics Annual Report 1996* (Washington, DC, 1996).

Figure 19.4 U.S. Freight Moved by Intercity Trucks, 1960-1994



Source: See Part III, Table 91.

reflect environmental costs. Due to public concern, laws have been enacted in the last 25 years that have made significant progress in reducing the environmental impacts of transportation.

Energy Use

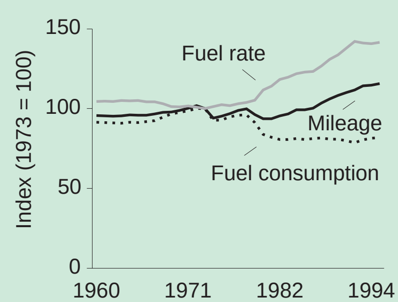
While overall transportation energy use has grown, major improvements in energy efficiency have occurred in the last 25 years (Figure 19.5). The increase in energy use would have been twice as great without these improvements, according to the Department of Transportation's Bureau of Transportation Statistics.

Most energy efficiency gains resulted from improvements to passenger cars and light trucks. In addition, improved use of available capacity and engine technologies have contributed to significant efficiency gains in rail freight and commercial air passenger traffic. However, for both light-duty vehicles and aircraft, a rapid surge in passenger miles traveled has offset a substantial increase in per-passenger or vehicle fuel economy.

The number of Americans traveling by transit, rail, and intercity bus has increased slightly since 1970, but by 1994 the share of total passenger miles of these modes was less than half the 1970 level. Air travel's share of passenger miles has increased by 180 percent over the same period. Further, the share of passenger miles by light trucks, sport utility and other vehicles has increased 220 percent since then.

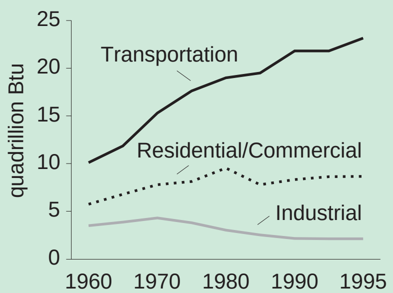
Highway vehicle energy improvements have tapered off in recent years as a result of several factors, including lower prices and stable supplies, which have greatly weakened market incentives for fuel efficiency, and declining vehicle occupancy rates. In addition, gains from the current corporate average fuel economy standards and other initiatives have nearly reached their full effects. Most recently, Congress prohibited the Department of Transportation from increasing car or truck standards in fiscal 1996.

Figure 19.5 U.S. Motor Vehicle Efficiency, 1960-1994



Source: See Part III, Table 85.
Note: Fuel rate = miles per gallon.

Figure 19.6 U.S. Petroleum Consumption by Sector, 1960-1995

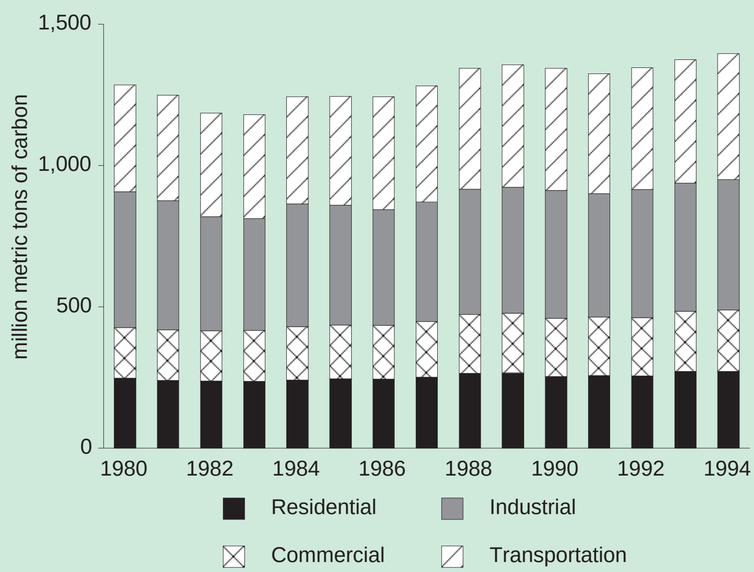


Source: See Part III, Table 85.

Nonetheless, government standards, technological change, and vehicle stock turnover continued the efficiency improvements well beyond the fall in oil prices and into the early 1990s.

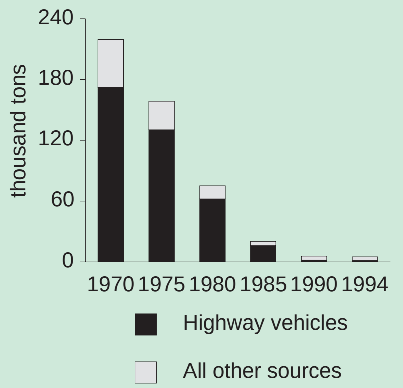
Transportation currently accounts for about two thirds of total U.S. oil consumption. While other sectors have shifted away from oil over the past two decades, transportation remains almost entirely dependent on petroleum (Figure 19.6). Due to growing transportation energy use and continued declining domestic oil production, U.S. reliance on oil imports is likely to continue in the future. The Energy Information Agency projected that imports are likely to supply about 60 percent of U.S. oil demand by 2005. Further, by 2010 two thirds of the oil traded in international markets will be from the Persian Gulf — an area of persistent political instability.

Figure 19.7 U.S. Carbon Dioxide Emissions by Sector, 1980-1994



Source: U.S. Department of Energy, Energy Information Administration.

Figure 19.8 U.S. Lead Emissions by Source, 1970-1994



Source: See Part III, Table 27.

Greenhouse Gas Emissions

The United States continues to be the world's largest emitter of greenhouse gases. Transportation's share of U.S. greenhouse gas emissions has grown over the last quarter century to 30 percent — the second largest source. Carbon dioxide — the most important greenhouse gas — is an inescapable by-product of fossil fuel combustion, and its emissions have been increasing with rising fossil-fueled energy use (Figure 19.7).

According to the U.S. Department of Energy, carbon dioxide emissions could increase by 1.3 percent per year through 2010, due to slow energy efficiency gains and rising vehicle travel. While several existing alternative fuels could lower carbon dioxide emissions, petroleum is expected to remain the dominant transportation fuel through 2010. Further, most alternative fuels either produce some carbon dioxide or other greenhouse gases (e.g., natural gas) or would likely depend on fossil fuels upstream (e.g., electric vehicles charged by fossil fueled electricity generation).

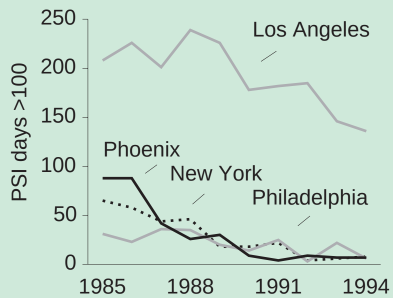
Air Quality

The total amount of air pollution from cars and other highway vehicles is far less today than in the early 1970s. This is largely due to cleaner new vehicles designed to meet increasingly stringent emission and new highway vehicle fuel economy standards developed in the late 1960s and early 1970s, and to improved fuels. Airborne lead emissions have been all but eliminated (Figure 19.8), and the sulfur content of diesel fuel has been lowered appreciably. Total emissions of carbon monoxide and volatile organic compounds from transportation sources have been cut significantly, though oxides of nitrogen emissions have remained level.

Progress also is evident at the metropolitan level. Mobile sources are a major contributor to unhealthy levels of carbon monoxide and urban ground-level ozone — or smog. However, of 42 areas exceeding the Clean Air Act standard for carbon monoxide in 1990, 34 areas were no longer reporting violations in 1994. In the nation's largest cities, the number of days when air quality was unhealthy or worse dropped from 778 in 1985 to 280 in 1994 (Figure 19.9; see also Part III, Table 33).

However, despite the success of air pollution control efforts, past trends will not necessarily continue in future years. Increases in some transportation emissions occurred between 1993 and 1994. Projections by the Transportation

Figure 19.9 Air Quality in Selected U.S. Cities, 1985-1994



Source: See Part III, Table 33.

Research Board of the National Academy of Science suggest that even modest growth in vehicle travel could reverse the downward trend in emissions that characterized the last 25 years.

Water Quality

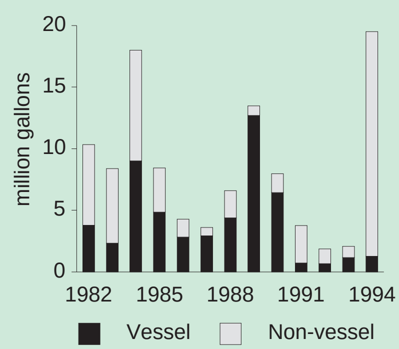
Oil spills and improper disposal of used motor oil and other chemicals from transportation vehicles and facilities are sources of both surface water and groundwater contamination. The most conspicuous are large tanker spills, such as the Exxon Valdez spill in Prince William Sound, Alaska, in 1989. The severity of environmental impacts of these spills depend on the extent of the spill and the natural resources affected. Large spills into U.S. waters accounted for only a little more than one-third of all reported oil spilled from 1982 to 1994 (Figure 19.10). The cumulative effect of smaller incidents, as well as unreported spills from many different sources such as the improper disposal of motor oil, can also have an impact on the environment and cleanup costs.

Although the unpredictable timing of large spills can complicate analyses, the data suggest that the volume of reported oil spilled in U.S. waters declined over the 1973 to 1993 period. This trend reflects, among other things, the success of initiatives such as the Oil Pollution Act of 1990, which increases liability and emphasizes prevention and quick response.

Leaking motor fuel storage tanks and pipelines present a continued challenge. In 1993, EPA estimated that 20 percent of the approximately 2 million underground fuel storage tanks in the U.S. that are subject to federal regulation were leaking. According to a 1993 American Petroleum Institute survey, 10 percent of petroleum transportation facilities with above ground storage tanks reported groundwater contamination.

In general, relatively little is known about the volume and impact of pollution from the numerous and widely dis-

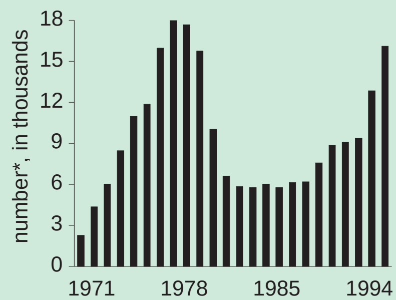
Figure 19.10 Oil Spills in U.S. Waters, 1982-1994



Source: See Part III, Table 45.

persed sources of water pollution affected by transportation. Substantial amounts of lubricants, antifreeze, fuel, deicing materials, and other contaminants enter the environment from millions of highway vehicles, aircraft, ships, pleasure boats and trains. Additional pollutants from pavement materials and non-transportation sources that settle on roads, runways, and other facilities are carried into rivers after rainfall.

Figure 19.11 U.S. Hazardous Materials Incidents, 1971-1994



Source: U.S. Department of Transportation (DOT), Bureau of Tranportation Statistics (BTS), *National Transportation Statistics 1996* (Washington, DC, 1995).
Note: *does not include oil spills in U.S. waters.

Transport of Hazardous Materials

Safely moving the millions of tons of hazardous materials and waste generated annually in the United States presents a difficult challenge. To minimize the risks to human health and the environment, federal agencies closely regulate the transport of hazardous materials through extensive requirements for container safety, labeling, and documentation, as well as through the monitoring of spills and coordinating quick responses.

In 1994, 16,092 hazardous material incidents (excluding oil spills in U.S. waters) caused 11 deaths, 577 injuries, and an estimated $44 million in damages (Figure 19.11). In addition, hazardous material incidents resulted in 316 evacuations, in which 18,392 people were evacuated. Ten of the incidents involved radioactive materials.

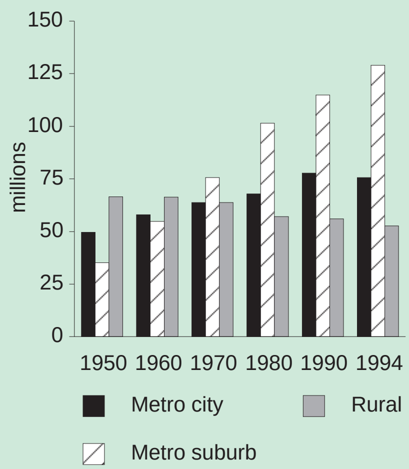
Over the past two decades the number of incidents has risen steadily. The increase in the absolute numbers is likely due at least in part to improved incident reporting. Despite the increase in the total number of incidents, the number of serious incidents has remained fairly constant. (“Serious” is defined as an incident that involves a fatality, major injury, closure of a major transportation artery or facility, evacuation of six or more persons, or a vehicle accident or derailment.)

Land Use and Habitat

The transportation system has both direct and indirect impacts on land use and wildlife habitat. While highways and rail lines do not occupy large expanses of land, they often fragment wildlife habitat into smaller, more isolated units of land or create barriers between functional areas. Transportation routes can also create new pathways allowing species to be introduced into previously isolated areas, disrupting local ecosystems.

Wildlife can be affected by traffic, harmful emissions, noise, and lighting. Habitat can be affected by infrastructure projects that cause changes in hydrology, soil, and water levels — such as those

Figure 19.12 U.S. Metropolitan and Rural Population, 1950-1994



Source: See Part III, Table 4.

that result in the loss of wetlands. Careful planning can avoid or minimize many of these impacts.

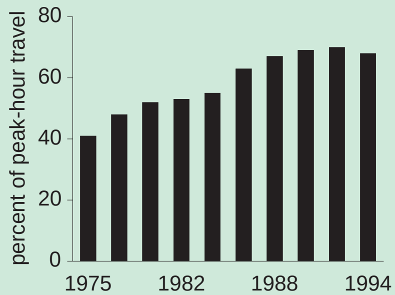
Transportation systems also can have indirect impacts by influencing how land is subsequently developed and used. Transportation infrastructure built in response to growth can encourage relatively rapid changes in travel behavior. Traffic congestion as well as road construction or expansion in turn stimulate new patterns of industrial, commercial and residential growth that can result in the significant loss of open space and habitat. Businesses may re-locate or open new premises, and households may move to new residential areas made more accessible to a region's employment, retail, recreational and institutional centers of activity. Over time, these changes in land use can generate new travel demands, possibly accompanied by greater traffic congestion, which in turn encourage additional transportation capacity.

The post World War II era has been characterized by increased concentration of the U.S. population in metropolitan areas. The portion of the population living in urban or suburban areas increased from 69 to 79.5 percent from 1970 to 1994, a result of net migration of people to metropolitan areas as well as overall population growth (Figure 19.12; see also Part III, Table 4). However, growth has been strongest in the suburbs. Over the 1970–94 period, the total urban population rose from 63.8 million to 75.6 million (29 percent of the total), while the total suburban population increased from 75.6 million to 129 million (50 percent of the total). With this suburbanization comes a decentralization of the economic base. More than two thirds of the employment growth (8 million of 11.8 million jobs) has occurred outside city centers. These demographic and other changes have had profound impacts on communities and the transportation system.

As populations and economic development relocate to lower-density areas, more people need to travel farther to reach these important destinations. Consequently, transportation in many metropolitan areas is characterized by increasing suburb-to-suburb commutes to work and other activities, and aging inner city infrastructure. The result: increased traffic congestion, continued (though reduced) air quality problems, and wasted fuel and time (Figure 19.13).

In part to address concerns about these trends, the Intermodal Surface Trans-

Figure 19.13 U.S. Urban Interstate Congestion, 1975-1994



Source: See Part III, Table 95.

portation Efficiency Act (ISTEA) requires states and metropolitan areas to consider land use and the environment in transportation planning.

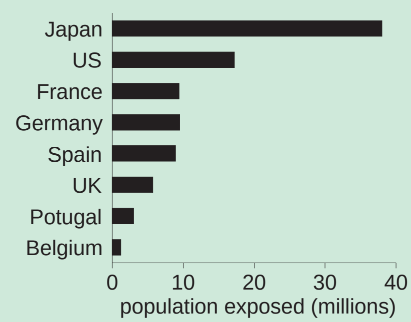
Future development patterns will depend in part on societal choices about highways, public transit, other transportation options, and the costs of constructing and maintaining these systems. Innovative community design at the local level can conveniently locate homes, employment, markets, and recreation to reduce the need for passenger car use.

Technological and other changes will also affect transportation choices. For example, the revolution in telecommunications technology can enable people to share ideas as well as produce goods and services with less travel. The actual impact, however, is difficult to foresee. Industrial practices such as just-in-time scheduling may also affect the siting needs of companies as well as their use of freight vehicles. How the nation's households and companies will respond to telecommuting, teleshopping, and other potential travel-reducing options remains an open question. Some telecommuters may decide to move farther away from their place of employment, thus lengthening their commute on those days they do travel to the office.

Noise

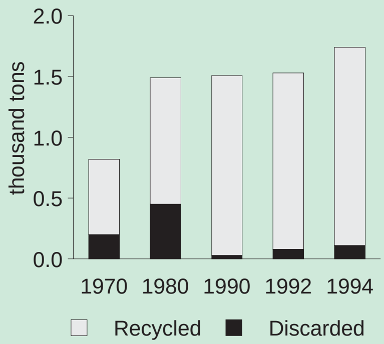
The transportation system is a pervasive source of noise in the United States, especially affecting people who live or work near major highways (Figure 19.14) and near airports and flight paths of jet aircraft. Transportation noise rarely leads to hearing impairment, but is an annoyance and can interfere with sleep. Policy measures are primarily aimed at reducing the noise at the source and shielding or removing the receptor from the source. Dramatic progress has been made in reducing exposure to annoying levels of aircraft noise reflecting noise standards and much quieter aircraft engines. The number of Americans significantly impacted by aircraft noise dropped from

Figure 19.14 Exposure to Traffic Noise Greater Than 65 Decibels



Source: OECD, *Environmental Data Compendium 1995.*
Note: Data are for 1993 or the latest available year.

Figure 19.15 U.S. Recovery and Discards of Batteries, 1970-1994



Source: See Source for Part III, Table 68.
Note: Data refer to lead acid batteries.

roughly six million in 1976 to two million in 1994.

Vehicle Recycling

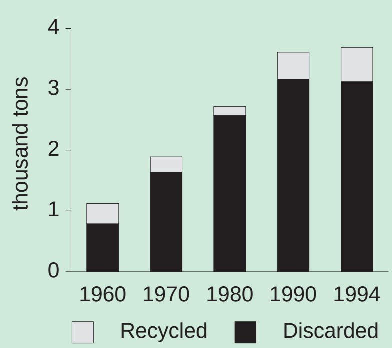
Vehicles and infrastructure are major sources of solid waste. Recycling and reuse of pavement is extensive, as is the partial recycling of retired cars. However, over the past two decades, manufacturers have increasingly replaced steel and other metals with various plastic and composite materials that are less cost-effective to recycle. These materials are often shredded and delivered to landfills. As the materials used continue to change, so do the challenges for recycling and reuse. Recovery for specific automobile components or parts varies. Well over 95 percent of batteries are recycled (Figure 19.15). The rate for tires was estimated to be 20 percent in 1990 (Figure 19.16), however recent data suggests a substantial increase.

The railroad industry has encouraged extensive recycling and reuse of locomotives, cars and track components. Railroad equipment, rail, and other steel track components, are often reused or recycled. Approximately 80 percent of wooden crossties are used for landscaping or energy production.

FUTURE CHALLENGES

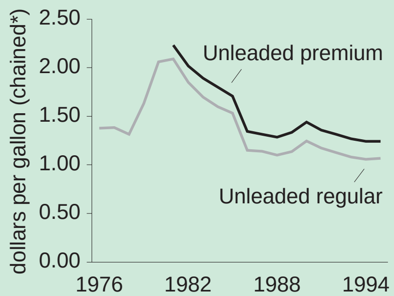
Despite the major gains in automobile fuel efficiency in the last 15 years, market forces and demographic changes threaten to undermine the effects of these improvements. The real cost of gasoline has dropped over the same period (Figure 19.17), encouraging Americans to drive more miles and to purchase less fuel-efficient vehicles such as sport-utility vehicles and light trucks, which now account for nearly 40 percent of new vehicle sales. The typical American licensed driver travels 13,130 miles per

Figure 19.16 U.S. Recovery and Discards of Tires, 1960-1994



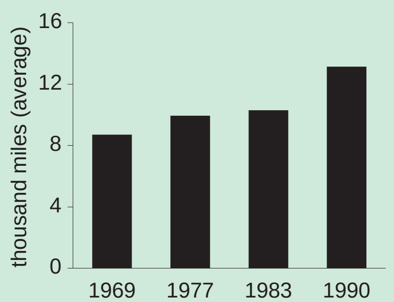
Source: See Source for Part III, Table 68.

Figure 19.17 Real Price of U.S. Motor Gasoline, 1976-1995



Source: Energy Information Administration (EIA), *Annual Energy Review 1995* (EIA, Washington, DC, 1996).
Note: *based on GDP price deflators in Part III, Table 9.

Figure 19.18 U.S. Annual Travel per Licensed Driver, 1969-1990



Source: See Part III, Table 93.
Note: Data refer to travel in personal vehicles.

year in a light-duty personal vehicle (Figure 19.18). All of these factors lead to increased fuel consumption, hamper efforts to fight air pollution in metropolitan areas, and contribute to human-induced climate change.

Increasing transportation efficiency and fuel flexibility are cornerstones of the Administration's transportation policy. Policies in these areas are critical to improving environmental quality, as well as improving energy security and reducing economic risks posed by this sector's heavy dependance on oil.

To meet near-term objectives, the Administration's transportation policy encourages increased efficiency in the existing stock of vehicles, promotes the expanded use of efficient technologies in new vehicles, targets opportunities to better manage travel demand, and spurs market development of alternative fuels. The Administration is pursuing development of vehicle and fuel technologies that will substantially improve vehicle efficiency and fuel flexibility.

Promoting Near-Term Efficiency Improvements

The Administration has statutory responsibilities for administering measures to promote fuel-economy improvements and to maintain fuel-economy levels in the face of declining real fuel prices. These include corporate average fuel economy (CAFE) standards and the "gas guzzler" law, which imposes a cost penalty on cars getting less than 22.5 miles per gallon. The CAFE standard for the 1997 model year is 27.5 and 20.7 miles per gallon for passenger cars and light trucks, respectively. Congress has precluded any increases in these standards in fiscal years 1996 and 1997.

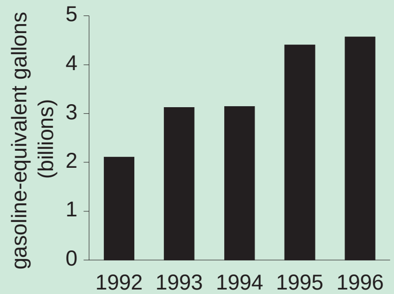
Supporting these policies are education programs designed to ensure a well informed marketplace. For example, the federal government's *Gas Mileage Guide* continues to assist consumers in comparing the fuel efficiency of new cars and trucks.

Developing Markets for Alternative-Fuels

The Administration supports the development of markets for alternatives to petroleum-based fuels, including encouraging infrastructure investment and alternative-fuel vehicle technologies. Alternative fuels include compressed natural gas, propane, electricity, methanol, ethanol, and biodiesel. Such fuels often result in less environmental impact than petroleum-based fuels. These fuels are used in vehicles today (Figures 19.19 and 19.20) and some are used as non-petroleum inputs into gasoline. The environmental and other benefits of this market support will increase over time as more advanced vehicle and fuel technologies become commercially available, and as the refueling infrastructure expands.

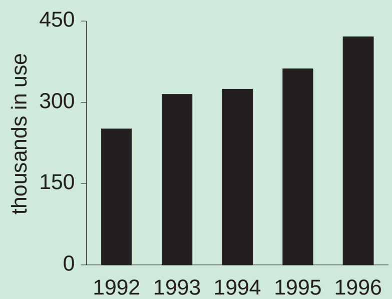
Current polices support an orderly evolution of the market for alternative transportation fuels under challenging conditions that include perceived high risks, uncertain costs, and limited infrastructure for the distribution and use of alternative fuels. The Alternative Motor Fuels Act of 1988, the Clean Air Act Amendments of 1990, the Intermodal Surface Transportation Efficiency Act of 1991, and the Energy Policy Act of 1992 established a number of programs and policy goals that are being implemented by the Departments of Energy and Transportation, and the Environmental Protection Agency. These programs have been supplemented by new initiatives to further increase federal agency purchases of alternative fuel vehicles and to support local efforts to bolster the use of alternative fuels through coordinated federal, local, and private efforts. Current federal programs and market developments are expected to lead to 2.5 million alternative fuel vehicles on the road by 2010 (Box 19.1).

Figure 19.19 U.S. Alternative-Fuels Consumption, 1992-1996



Source: Energy Information Administration, *Alternatives toTraditional Transportation Fuels 1994* (EIA, Washington, DC, 1995).

Figure 19.20 U.S. Alternative-Fueled Vehicles, 1992-1996



Source: Energy Information Administration, *Alternatives toTraditional Transportation Fuels 1994* (EIA, Washington, DC, 1995).

A New Generation of Vehicles

Transportation technologies are key to the Administration's strategy for realizing

Box 19.1
Alternative-Fuel Vehicles:
Leveraging Federal Purchases to Stimulate Markets

The Energy Policy Act of 1992 requires 75 percent of new purchases for the federal fleet, which currently includes about 200,000 civilian cars and trucks, to be alternative-fuel vehicles by fiscal year 1999.

The Federal Fleet Conversion Task Force recommended a plan to leverage the federal purchase of alternative vehicles to stimulate markets for alternative-fuel vehicles. In establishing the Clean Cities Program, the Administration initiated a regional effort to overcome infrastructure barriers for alternative fuels. Through this voluntary program, cities partner with the federal government to coordinate fleet conversions of government and industry fleets. As of April 1995, 35 cities have joined the program. In this way, a critical market mass can provide the market pull for private-sector infrastructure investment for the fuel that communities determine best fit their regional needs.

environmental, economic and energy security goals. The Administration supports a policy of long-term, highly focused research and development to improve vehicle fuel economy and alternative-fuel technologies and to make these technologies available to manufacturers and, ultimately, consumers.

With regard to vehicles, the Administration's long-term development efforts include programs like the government-industry Partnership for a New Generation of Vehicles, which targets breakthrough technologies capable of increasing vehicle fuel efficiency by as much as three times current levels (Box 19.2). To help achieve these potentials, the government, through its national labs and working with industry and academia, supports research in areas such as advanced lightweight materials, improved electric and hybrid vehicles, advanced energy storage concepts, and advanced energy conversion technologies such as fuel cells.

With regard to fuels, the Administration policy focuses on the feedstock and production costs of renewable fuels (such as hydrogen, and biomass-based ethanol and biodiesel), and increasing the efficiency and performance of alternative-fuel vehicle technologies. Hydrogen is used today as input to a wide variety of chemical processes and is generally produced from natural gas. Hydrogen can also be extracted from water through electrolysis, using electricity generated from renewable resources, biomass, and others. The costs of producing, transporting, and storing hydrogen on vehicles must decline and other technical issues must be resolved before this clean burning alterative can be viable as a transportation fuel in widespread use.

Ethanol from various biomass sources is another promising long-term opportunity. Research is underway to develop commercially competitive ethanol from low-energy-input crops and wastes with desirable environmental attributes. The

Box 19.2
The Partnership for a New Generation of Vehicles

In September 1993 President Clinton, together with the major automakers (Chrysler, Ford, and General Motors) and the United Autoworkers, announced formation of a unique "Partnership for a New Generation of Vehicles."

The goal is a production prototype vehicle by 2004 that is three times as fuel efficient as today's vehicles, while maintaining or improving on the safety, emissions, performance, size, and price of current vehicles. This effort has identified areas of research with the technical potential to reduce vehicle weight by 40 percent, to more than double engine efficiency, and to lower aerodynamic drag and rolling resistance by up to 30 percent.

Led by the Department of Commerce, the Partnership joins the unique resources of seven federal agencies, their laboratories and university-based research institutions, together with the major automakers and their supplier network, as well as hundreds of other small and large businesses, to meet a critical national need. Substantial progress has already been made toward achieving the goals of the Partnership, including several major technical accomplishments that will help reduce automotive emissions. For example:

- A cost-shared project of General Motors and the Department of Energy produced the nation's first successful proton-exchange membrane fuel cell powered by methanol. Cars powered by fuel cells will have exceptionally high fuel efficiency combined with ultra-low emissions.
- Researchers at DOE's National Renewable Energy Laboratory teamed with Benteler Industries to develop a vacuum-insulated catalytic converter that reduces emissions when a car is first started up. For their work, the National Renewable Energy Laboratory and Benteler received a coveted "R&D 100" award from *R&D Magazine*.
- A team of five DOE laboratories and the automakers developed a new catalyst for automobile catalytic converters that substantially reduces emissions of nitrogen oxides.

Department of Energy and the Department of Agriculture coordinate research to lower the cost of producing starch and cellulose-derived ethanol and agricultural oil-based biodiesel fuels. Initially, cellulosic ethanol would be commercialized using fiber and waste from current agricultural production as feedstocks. However, this could ultimately evolve into independent domestic energy industries. In addition to addressing environmental and energy security concerns, biofuels production creates new markets for agricultural crops. Expanded biofuel production could add value to crops, increase farm income, and build economic opportunity for rural communities.

Managing the Demand For Travel

The Administration supports community-driven transit-oriented development to reduce single-occupancy vehicle trips and increase the efficiency of transportation systems generally. Even with successful development of high-efficiency and alternative-fuel vehicle technologies, stemming the rapid growth in annual vehicle miles traveled will be important in reducing greenhouse gas emissions, air pollution, the need for new roads and highways, oil use, and the number of transportation fatalities. Even given expected reductions in the annual growth rates, the Energy Information Administration projects that Americans will be driving 50 percent more by 2010 than in 1990.

The flexible funding provisions of the Intermodal Surface Transportation Efficiency Act (ISTEA) have allowed states and localities to explore and implement alternative transportation options including transit and pedestrian and bicycling improvements. ISTEA increased the discretion for State and local governments to fund a wide variety of activities, and this Administration has increased funding for transit and other options to mitigate environmental impacts. The Department of Transportation's Congestion Mitigation and Air Quality Improvement program has provided funding for significant alternative transportation services and efficiency improvements to the existing transportation network.

ISTEA increases statewide and metropolitan area planning and emphasis on intermodal planning, coordination with land use planning and development, and consideration of the economic, energy, environmental and social effects of transportation decisions. The act also allows states to experiment with congestion pricing as a means to encourage alternatives to single occupancy driving during peak hours of congestion.

In addition to longstanding Department of Transportation support of vanpooling and other demand management programs, a number of Administration initiatives are designed to improve the efficiency of travel and provide Americans with convenient modes of alternative travel. The Administration's Climate Change Action Plan includes new efforts to promote telecommuting and to reform the tax code to allow commuters to chose between employer-subsidized parking and cash.

The Environmental Protection Agency has established the voluntary Transportation Partners Program, which assists localities in implementing and receiving credit for transportation efficiency measures that reduce emissions of carbon dioxide and other air pollutants by reducing the need for travel. The Administration is supporting considerable research to develop "intelligent transportation systems" and experimental programs such as the Department of Transportation's Congestion Pricing Pilot Program, to improve understanding of the feasibility, costs, and benefits of an array of strategies to increase transportation system efficiency.

Managing Hazardous Materials

In addition to encouraging emergency planning and rapid response strategies, Administration efforts and statutes aimed at pollution prevention are reducing the risks posed by transporting hazardous materials. For example, the Emergency Planning and Community Right-to-Know Act has quickly led to voluntary reductions in the production, transport, and eventual disposal of toxic materials.

Wetland Banking

In addition to other measures to mitigate damage to ecosystems, habitat and wildlife, wetland banking and other measures to offset the impacts to wetland resources are eligible for federal-aid funding under ISTEA. Wetland mitigation measures may occur in advance of construction and may include direct contributions to statewide and regional wetland conservation and mitigation planning efforts.

FUTURE CHALLENGES

The programs and policy initiatives outlined above represent a comprehensive effort to capitalize on a range of opportunities to improve environmental quality while providing an effective and convenient transportation system. Nonetheless, there remain some further opportunities, issues not fully addressed, and significant challenges to meet these dual goals. The Administration continues to examine new ways to increase efficiency in transportation, encourage the use of domestic alternative fuels, and work with state and local governments to help manage the growing demand for travel in ways that will enhance the overall environmental and economic performance of the transportation system.

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CHAPTER TWENTY

Solid Waste

Waste management in the United States is historically a local responsibility. In the 1970s, however, a crisis over the environmental and health implications of landfills prompted calls for a national system of guidelines that would both reduce health risks and curtail the growth of waste generation. This crisis was precipated in part by the fact that state and local governments exercised very little control over solid waste disposal sites. Of an estimated 16,000 or more municipal land disposal sites in 1976, only about 5,800 were recognized as complying with state regulations in 1976. Another factor contributing to the crisis was local authorities' inability to respond to increasing public opposition to new waste disposal sites.

In response, Congress in 1976 enacted the Resource Conservation and Recovery Act (RCRA), which established a cradle-to-grave management system for hazardous wastes and developed disposal criteria for nonhazardous solid wastes.

RCRA prohibited new open dumping sites, called for Environmental Protection Agency (EPA) criteria for sanitary landfills, and required that all open dumps be closed or upgraded to sanitary landfills. The act mandated nationwide minimum requirements for various disposal options, including incineration and landfilling. RCRA also was intended to reduce waste at the source, promote resource recovery and recycling, and help identify markets for recycled waste.

RCRA sets federal standards to improve human health and the environment, but encourages state responsibility for program implementation.

In most cases, states have adopted landfill rules similar to the federal rules. Once a state has created a program to oversee and enforce RCRA landfill rules, the federal government can delegate authority to take over the RCRA program. So far, 49 states have assumed control of the program. By 1995, 40 states also had comprehensive recycling/waste reduction laws, and 44 states had legislated or announced goals for recycling/waste reduction ranging from 20 to 70 percent. Many states have enacted waste disposal bans on selected materials such as vehicle batteries and tires; many have passed mandatory source separation laws to promote collection of waste components such as glass, metals, paper, and plastics.

The goal of cradle-to-grave management is largely being met. The proportion of municipal solid waste recovered more than tripled from 1970 to 1994. Municipal waste is now either disposed of in lined landfills, incinerated, or composted. Between 1994 and 2010, incineration is

Communities have found creative solutions to waste management through recycling programs and new partnerships between the public and private sectors.

Photo Credit:
Aluminum Company of America

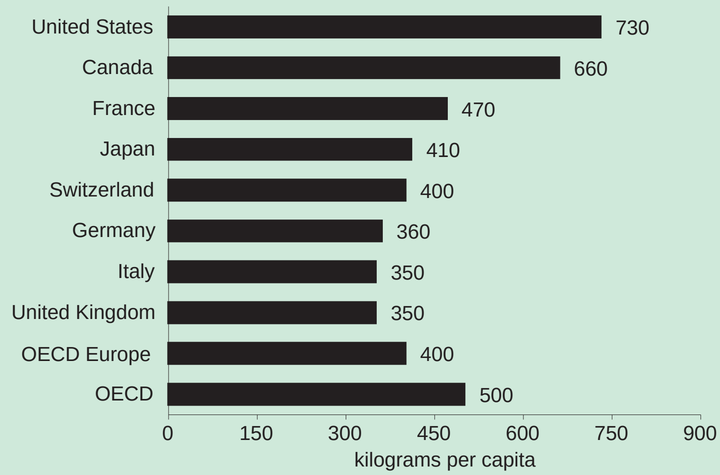
expected to continue to account for about 15 percent of total municipal waste disposal, according to EPA estimates; landfilling is expected to fall from 60.9 percent of the total to 50.5 percent. EPA estimates that the remaining proportion—about 35 percent—will be accounted for by recovery.

BACKGROUND

Both in absolute and per capita terms, the United States is the largest generator of municipal solid waste among the industrialized countries of the Organisation for Economic Co-operation and Development (Figure 20.1). In fact, average per capita waste generation in Europe is only about half that of the United States.

In absolute terms, municipal waste generation in the United States has grown steadily and is expected to continue to grow (Figure 20.2). From 1960 to 1994, waste generation increased from 88 million tons to 209 million tons; projections indicate that it will rise to 262 million tons by the year 2010. Per capita generation, which rose from 2.7 pounds per day in 1960 to 4.4 pounds per day in 1994, is projected to hold steady at 4.4 pounds through the year 2000, but increase to 4.7 pounds by the year 2010 (Figure 20.3).

Figure 20.1 Municipal Waste Generated in the United States and Other Selected OECD Countries



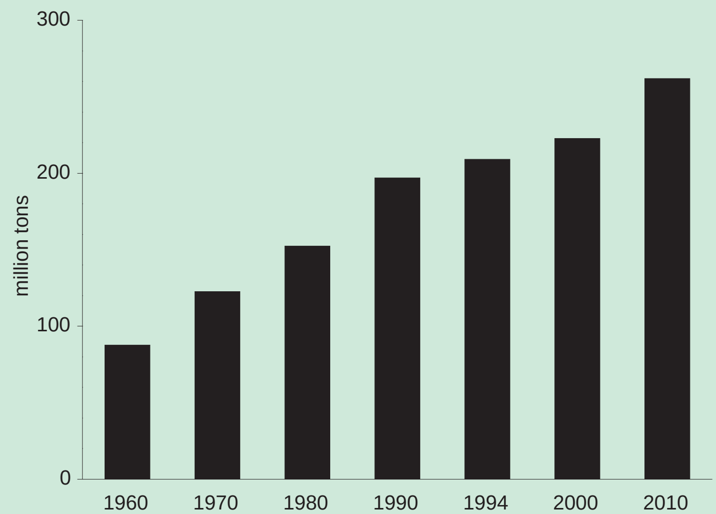
Source: *OECD Environmental Data, Compendium 1995* (OECD, Paris, 1995).
Note: The definition of municipal waste and the survey methods used may vary from country to country. Data are for 1992 or latest available year.

Solid waste management is undergoing a significant change in the United States. According to EPA, by 1995, the number of municipal solid waste landfills had declined to about 3,581. This is a substantial drop from the 5,345 landfills reported in 1992, and almost half as many as were operating in 1986—7,683 (Figure 20.4). The largest declines in landfills occurred in the Southern, Midwestern, and Rocky Mountain states.

(Estimates of the number of existing landfills compiled by other organizations show a generally similar trend but somewhat different totals. According to data collected by the National Solid Wastes Management Association, there were 5,726 landfills in 1991 and 2,893 in 1995. The journal *BioCycle* reported 7,924 landfills in 1988, 5,383 in 1992, and 3,197 in 1995.)

While the number of landfills has declined, landfill disposal capacity has increased. In 1991, the majority of states had fewer than 10 years of disposal capacity, according to surveys conducted by Environmental Industry Associations. Between 1991 and 1995, 21 states increased their landfill disposal capacity, two states (Louisiana and Massachusetts) decreased theirs, and 27 states did not experience a change in capacity. In 1995, only two states (Massachusetts and New Jersey) had fewer than five years of remaining disposal capacity. This apparent lack of capacity is part of a deliberate state policy: Massachusetts has a policy of limiting development of "excess disposal capacity" until goals of source reduction,

Figure 20.2 U.S. Solid Waste Generation, 1960-1994, With Projections to 2010

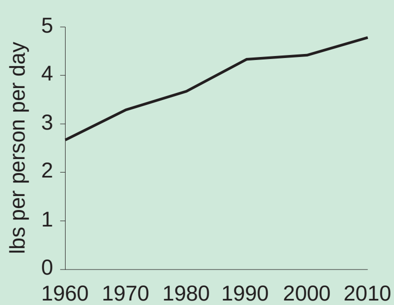


Source: See Part III, Table 67.

waste diversion, and incineration are met; and New Jersey permits facilities only in five-year increments.

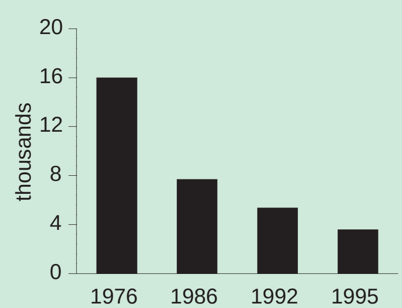
The national average tipping (disposal) fee has increased nearly fourfold in the past 10 years, rising (in nominal terms) from \$8.20 per ton in 1985 to \$32.19 per ton in 1995, according to Environmental Industry Associations (Figure 20.5). Fees vary in different regions of the country, ranging from a low of \$20.30 per ton in the South Cen-

Figure 20.3 U.S. Solid Waste per Capita, 1960-2010



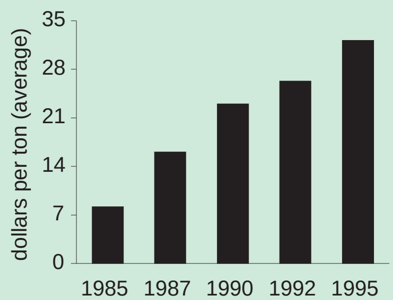
Source: See Part III, Table 67.
Note: Data are based on estimates and projections.

Figure 20.4 U.S. Solid Waste Landfills in Use, 1986-1995



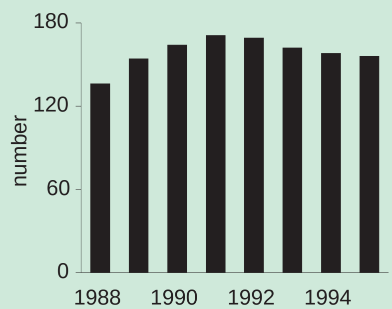
Source: EPA, *1995 List of Municipal Solid Waste Landfills* (1996), and unpublished data.

Figure 20-5 U.S. Solid Waste Landfill Tipping Fees, 1985-1995



Sources: National Solid Wastes Management Association (data for 1985, 1987, 1990, and 1992); *Solid Waste Digest* (data for 1995).

Figure 20.6 U.S. Solid Waste Incinerators in Use, 1988-1995



Source: R. Steuteville, "The State of Garbage in America, Part I," *BioCycle* (April 1996).

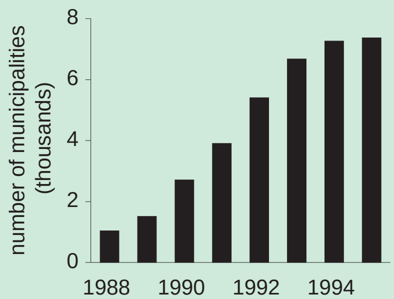
tral states (Arizona, Arkansas, Louisiana, New Mexico, Oklahoma, and Texas) to as much as $73.17 per ton in the Northeast (Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont).

Refuse transfer stations, which facilitate the consolidation of wastes, are in many cases replacing closed landfills; *BioCycle* reports 2,625 such stations in the 44 states that provided data. Transfer stations generally offer more opportunities to separate and recover materials, so this changeover should further progress in recovery and recycling.

Combustion, which handled as much as 30 percent of generated waste in 1960, has shrunk considerably in importance as a solid waste management option. Combustion tonnage was estimated at about 32 million tons, or 15 percent of total waste generation, in 1994 and is expected to maintain that share through the rest of the decade. *BioCycle* reports that there were 156 incinerators in operation nationally at the end of 1995, down slightly since 1991 (Figure 20.6). About 80 percent of these facilities have waste-to-energy components. Tipping fees at incinerators averaged about $51 per ton nationwide.

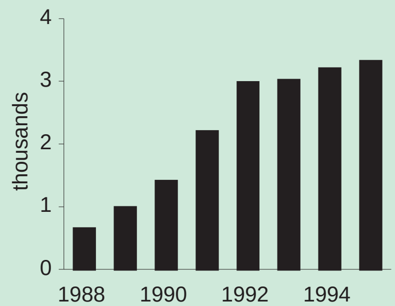
An estimated 7,375 curbside recycling programs were in operation by 1995—a roughly sevenfold increase since 1988 (Figure 20.7). Growth in new curbside programs appears to be leveling off; however, there were 110 new programs in 1995, compared to 587 in 1994 and 1,274 in 1993. The population served by these programs is still rising; 121 million people were served in 1995, compared to 108 million people the year before. Pennsylvania leads the nation in the number of curbside programs with 772, followed by Minnesota (679) and Wisconsin (600). In addition, 35 states reported a combined total of 8,773 recycling dropoff sites. Three states—Florida, Minnesota, and New Jersey—report recycling rates of 40 percent or more; nine other states indicate that they are recycling 30 percent or more of their waste. (Rates are not

Figure 20.7 U.S. Participation in Curbside Recycling, 1988-1995



Source: R. Steuteville, "The State of Garbage in America, Part I," *BioCycle* (April 1996).

Figure 20.8 U.S. Yard Trimmings Facilities, 1988-1995

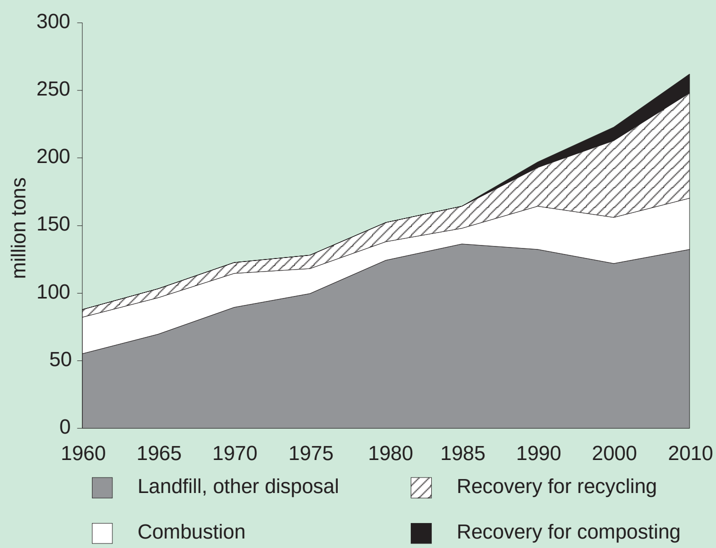


Source: R. Steuteville, "The State of Garbage in America, Part I," *BioCycle* (April 1996).

entirely consistent across states because of differences in definition and data gathering.)

The number of facilities handling "yard trimmings" (grass, leaves and brush), currently estimated at 3,316, also is up dramatically since 1988, but the growth in new facilities seems to be leveling off (Figure 20.8). Florida, which has a disposal ban on yard trimmings, reports the highest total recovery of grass, leaves, and brush (1.8 million tons). New Jersey,

Figure 20.9 U.S. Municipal Solid Waste Management, 1960-1994, with Projections to 2010



Source: See Part III, Table 67.

Paper and Paperboard represent the largest category of the waste stream. Today the United States supplies more than half the world's recovered paper.

Photo Credit: S.C. Delaney
U.S. Environmental Protection Agency

Massachusetts, and New York each are diverting more than 500,000 tons annually of yard trimmings. In managing yard trimmings—in addition to composting—22 states use direct land application, 38 states are using mulching, and about half the states have backyard composting programs.

Most of the future increase in waste generation will be handled through recovery for recycling or composting programs (Figure 20.9 and Box 20.1). Traditional disposal methods—landfilling or combustion—will continue to be used for the majority of solid waste, but their share of total waste will gradually diminish. For example, landfill tonnage is expected to decrease from 127 million tons (61 percent of generation) in 1994 to 122 million tons in 2000 (55 percent of generation), largely because of a projected significant diversion of yard trimmings. Combustion, which handled as much as 30 percent of generated waste in 1960, has shrunk in importance. Recovery programs, on the other hand, are growing steadily, both in number and in terms of the proportion of total solid waste they handle. In 1994, recovery accounted for 49.3 million tons—that is, almost a quarter of all solid waste generated that year was recovered.

Under the right conditions—continued emphasis by state and local governments on recovery programs and purchase of recycled products, continued

Box 20.1
Recycling and Recovery Trends

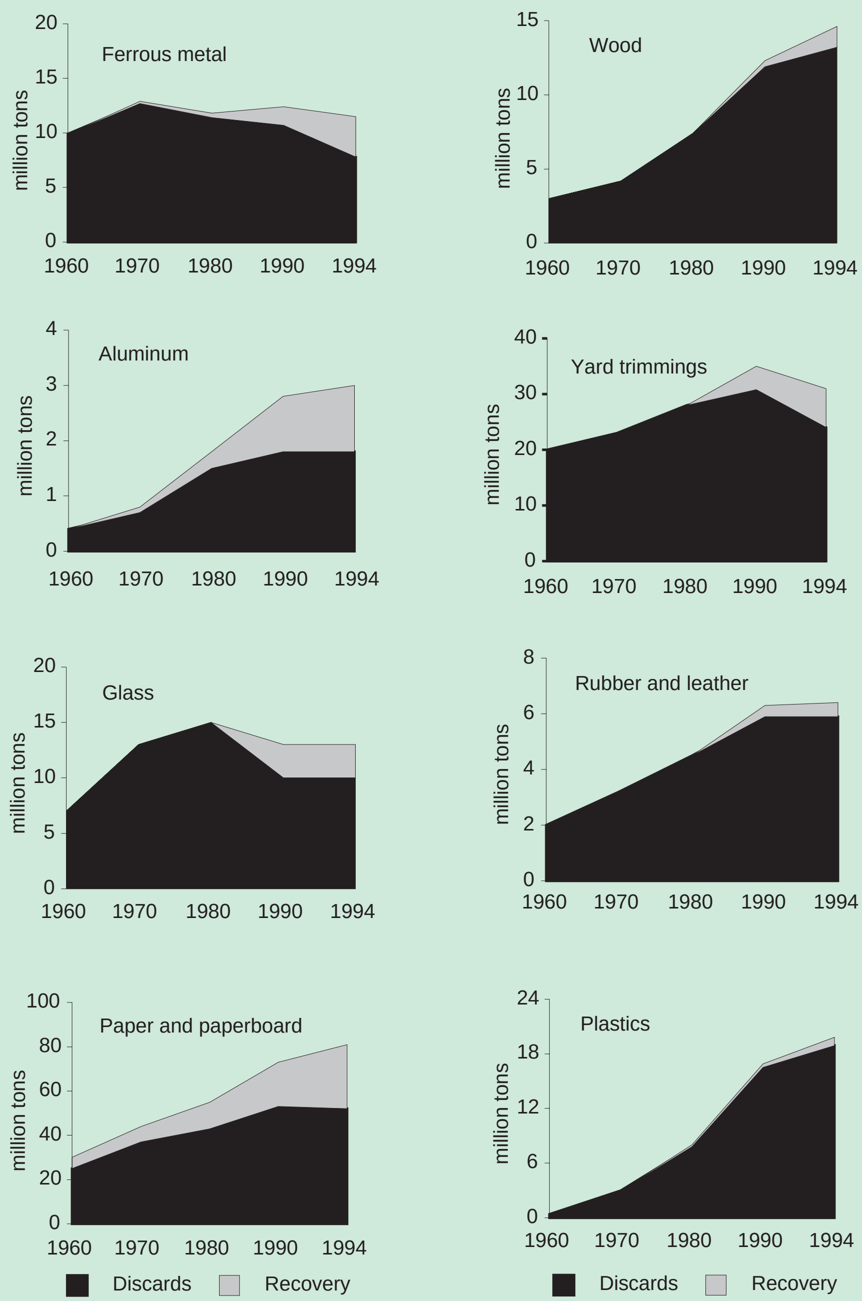
- **Ferrous Metal.** Steel can and appliance recycling rates have increased approximately 250 percent between 1988 and 1994.
- **Aluminum.** The overall recovery rate for aluminum was 34 percent in 1994; for aluminum cans alone, the recovery rate was 65 percent.
- **Glass.** Glass was recovered at a rate of 24 percent in 1994, with glass containers being recovered at a rate of 37 percent.
- **Paper and Paperboard.** Paper and paperboard represent the largest category of the waste stream, with 81.3 million tons generated annually. Recovery of paper and paperboard is at 35 percent of generation, and accounts for more than half (nearly 29 million tons) of total municipal solid waste recovery. The Unites States supplies more than half of the world's recovered paper.
- **Wood.** Wood, at 14.6 million tons, accounts for 7 percent of the waste stream. Sources of wood in municipal solid waste include furniture and wood packaging (i.e., pallets).
- **Yard Trimmings.** Yard trimmings account for 14.6 percent of the waste stream at 30.6 million tons annually. Currently, 23 states—comprising more than 50 percent of the nation's population—have legislation banning yard trimmings from landfills. Over 3,300 composting facilities for yard trimmings are now in operation.
- **Rubber.** The predominant source of rubber in municipal solid waste is tires from automobiles and trucks. Recovery of rubber from tires was estimated at 450,000 tons in 1994—roughly 15 percent of tire production.
- **Plastics.** While overall recovery of plastics for recycling is relatively small, recovery of some plastic containers is increasing. Polyethylene terephthalate (PET) bottles, which are commonly used for soft drinks, were recovered at a rate of 50 percent in 1994. Recovery of high-density polyethylene milk and water bottles was estimated at 30 percent in 1994.

investment by industries, continued efforts to expand programs to keep yard trimmings out of landfills, and continued access to recovery programs for most U.S. citizens—30 percent of total solid waste generation could be recovered by the year 2000 and 35 percent by 2010. According to EPA estimates, to reach a recovery rate of 30 percent nationwide in 2000, 43 percent of all paper and paperboard, 27 percent of all glass, 44 percent of metals, 40 percent of yard trimmings, and over 7 percent of plastics would have to be recovered.

TRENDS IN SOLID WASTE MANAGEMENT

Compared to the practice, commonplace until just a few decades ago, of dumping trash in an open landfill, solid waste disposal practices have undergone a major transformation that provides both economic and environmental benefits

Box Figure 20.1 U.S. Recovery and Recycling Trends, 1960-1994



Source: See Part III, Table 68.

Box 20.2
Recycling Creates Jobs

Studies suggest that recycling has a strong positive impact on jobs. In North Carolina, it is estimated that for every 100 jobs created by recycling, 13 jobs are lost in solid waste and virgin material extraction within the state. Recycling is a significant employer in North Carolina, providing about 9,000 jobs, mostly in the private sector. And a study of three cities—Baltimore, Richmond, and Washington—found more than 5,100 individuals employed in recycling, compared to about 1,100 employed in solid waste disposal, despite four times as much material going to disposal than to recycling.

(Box 20.2). Components of this transformation include source reduction and recycling, community composting, and new types of public-private partnerships.

Source Reduction and Recycling

The goal of source reduction is to prevent the creation of waste, either by reducing the quantity of materials, reusing materials already manufactured, lengthening the life of products to postpone disposal, or managing nonproduct organic wastes through onsite composting or other alternatives to disposal.

Many creative new approaches are under way to promote source reduction and recycling. For example, regulatory measures can be used to mandate or encourage reduced waste. Many states have adopted bans on the disposal of specific materials. These disposal bans were largely a product of the landfill crisis era, but most that were enacted seem likely to endure because they help keep problem materials out of landfills and reduce overall disposal tonnage. According to a 1996 *BioCycle* survey, 42 states now ban disposal of vehicle batteries, 32 ban tires, 23 ban yard materials, and 20 ban motor oil. Banning disposal of products such as lead-acid batteries can increase the incentive to return them to retailers for recycling. Bans on materials such as yard waste can be coupled with educational campaigns to encourage people to leave grass clippings and compost waste in their backyards.

Governments are major generators of solid waste and can use source reduction strategies to reduce this waste. In 1993, President Clinton issued a series of executive orders to promote recycling and use of recyled products.

Connecticut has legislation requiring state agencies to take steps to eliminate purchase of products that are not reusable. The state has begun a successful—and profitable—program in which agency employees place all paper, cans, and bottles in canisters to be picked up by a recycling contractor. The state also is using remanufactured laser toner cartridges, which are functioning just as well as the disposable cartridges used previously.

Minnesota also has a creative source reduction program. Highlights of its efforts include refurbishing highway signs instead of disposing of old signs, seeking extended warranties for purchases of some durable goods, and contracting with a company to retread radial and off-road truck tires; this last measure alone is saving about 23 tons of waste per year.

Governments also are using grants and education programs to encourage source reduction and recycling. It is currently estimated that 39 states are spending about $245 million annually in state grants to support waste diversion programs. Most of the money is used to support local solid waste recovery programs, while some is spent for disposal of problem materials such as tires or for the private sector to develop new uses for recycled materials.

Overall, the strongest programs are in a half-dozen states with dedicated sources of funding. Florida, with a 0.2 percent surcharge on its sales tax, spent $35 million on recycling grants in 1995, mostly for local programs and tire disposal. California, Minnesota, New Jersey, Pennsylvania, and Wisconsin also have dedicated funding sources; altogether, these six states account for about 70 percent of all recycling grants.

More than 2,700 communities in North America now have adopted pricing systems that require customers to pay more for throwing away more garbage. This variable rate pricing is catching on fast; a 1992-93 study had identified only 1,000 communities with such programs. A few states mandate variable rates, and many states actively promote such programs either through legislation or state policy. Programs are now in place in 37 states and cover about 11 percent of the U.S. population. Surveys have shown average recycling increases of more than 50 percent after variable rate programs are implemented.

In response to President Clinton's executive orders and agency-specific initiatives, many federal agencies are actively involved in source reduction and recycling efforts. For example, the immense supply depot operated by the Department of Defense in New Cumberland, Pennsylvania, processes over 20,000 customer orders per day and spends over $6 million annually on pallets, dimension lumber, and packing materials. The center saves all incoming packing material either for reuse or recycling. In 1995, almost 100,000 cardboard cartons were reused along with about 250,000 cubic feet of packaging, saving more than $400,000 in procurement costs. The recycling of corrugated cardboard generated another $144,000 in revenue. However, there may be additional costs associated with collecting and reusing these materials.

The U.S. Postal Service reported in June 1995 that it was generating 1.2 million tons annually of undeliverable mail and discards. Weyerhaeuser agreed to purchase 550 tons per week from 375 post offices in an 11-state region in the West. Additionally, the Post Office plans to implement recycling in all 35,000 U.S. post offices by the end of the decade.

Community Composting

Community composting can be an economically attractive alternative to landfilling. In 1994, for example, officials in Montgomery County, Maryland, had to choose between spending $2 million to expand and upgrade the county's existing composting site in Dickerson or aggressively promote "grasscycling" and backyard composting. County officials took the latter option, spending $600,000 over two years for a high-visibility marketing and advertising program to promote backyard composting. Among other activities, the county sold 16,000 subsidized compost bins for $5 each, held over 300 workshops, and offered rebates for the purchase of mulching mowers. Instead of the 36,000 tons of grass clippings that were expected to go to the Dickerson plant in 1994, only around 9,000 tons actually made it to the composting site.

Many other communities are reaping significant benefits through backyard composting programs. In Alameda County, California, a survey of bin-using families indicated that trash disposal dropped by about one-half can per family per week. In Gainesville, Florida, it was estimated that each backyard composter was keeping about 200 pounds of waste per year out of the city's landfill.

The economic benefits of composting can be significant for communities. According to a recent study by a California consulting firm, local governments reduce solid waste disposal and collection by an average of at least $43 for every ton of yard trimmings and kitchen scraps that are composted at home by residents. Home composting programs that responded to the survey were diverting an average of 14 percent of the yard trimmings generated in their communities.

New Partnerships

Many communities are devising successful new partnerships with the private sector in the collection and disposal of solid waste. Such partnerships can free municipal resources for other investments and provide improved environmental services at the lowest possible cost to the public.

There are several keys to a successful partnership, according to an EPA study. These include a strong local incentive to seek private assistance, a legal and institutional environment that fosters such endeavors, a pricing system that can ensure the private sector partner a reasonable return, the willingness of the community to work with other communities in providing environmental services, strong community support, and agreement on the allocation of risks.

There are numerous examples of such partnerships:

- In Lee County, Alabama, a private company sited, constructed, operates, and owns a landfill. The company has separate agreements to accept waste from public and private customers in a multicounty area. Because of the large volume of waste disposed at the landfill, the company can provide disposal services at low per-unit costs.
- In Bristol, Connecticut, communities worked together to reach an arrangement with a private firm to design, construct, operate, and own a resource recovery facility. The facility was financed by tax-exempt state revenue bonds. Bristol receives tax revenues from the facility and fees from 10 other communities using the facility. Tipping fees are reduced by revenues from the sale of electricity generated by the facility.

- In Hillsborough County, Florida, officials entered into an arrangement with a private partner for the design, construction, and operation of a resource recovery facility owned by the county. Tax-exempt bonds sold to finance the facility are backed by revenues from the countywide solid waste disposal system. The sale of electricity generated by the facility to Tampa Electric Company provides revenues to the county.

RECENT DEVELOPMENTS

Two important policy debates—both spawned by Supreme Court decisions—continue to cloud the future course of solid waste practices: the authority of state and local governments to adopt "flow control" laws, which give local governments the right to dictate the disposal of waste generated within their borders; and the "interstate waste" issue, which concerns the authority of states to ban imports of waste from other states.

In May 1994, the U.S. Supreme Court ruled, in *C.A. Carbone Inc. vs. Town of Clarkstown,* that flow control was an unconstitutional interference with interstate commerce. The court held that, in the absence of authorization by Congress, state and local governments may not use their regulatory powers to favor local enterprises by prohibiting out-of-state competitors or their facilities. The decision has significant implications for the future of state and local solid waste management plans.

According to a March 1995 Environmental Protection Agency report, 35 states authorize flow control directly, 4 states authorize it through mechanisms such as solid waste management plans and home rule authority, and 11 states have no flow control authority.

Flow control authority has been used by state and local governments to foster development of in-state capacity to manage municipal solid waste by making it easier to adequately size and finance waste management facilities. Controlling the disposition of locally generated solid waste allows planners to accurately determine how much waste must be managed. It also ensures that waste management facilities will be fully utilized.

Supporters say flow controls have assisted state and local governments in financing new solid waste capacity—particularly new waste-to-energy and high-tech materials recovery facilities—by ensuring long-term receipt of enough waste to generate sufficient revenues to service the public bonds and other costs associated with the facility.

Opponents of flow control argue that such arrangements substantially increase the cost of local solid waste disposal. A study by National Economic Research Associates found that flow control adds approximately $14 per ton, or 40 percent, to the average disposal charge. EPA found that flow control was an "administratively efficient tool for local governments to plan and fund solid waste management systems," but was "not essential for developing MSW management capacity, or for achieving recycling goals."

Some environmental groups also argue that flow control has tended to favor the use of high-tech incineration and materials recovery approaches to waste disposal over low-tech recycling. The EPA study, for example, found that flow control supported about 58 percent of municipal waste-to-energy plants, but only about 3 percent of materials that were recycled.

Reflecting their larger capital costs, flow control has been significant in high-tech materials recovery facilities. EPA found that flow controls direct 32 percent of the throughput at high technology facilities, but only 7 percent of throughput in low-tech recovery facilities.

The second major and unresolved policy debate confronting Congress and the states is that of interstate waste. A 1978 case, *New Jersey v. Philadelphia*, held that states were without authority to ban waste imports from other states unless Congres provides express authorization. This decision has resulted in persistent efforts by "importing" states to secure Congressional authorization for interstate waste bans, and countervailing efforts by "exporting" states and affected industries to oppose Congressional authorization of interstate waste measures that will increase disposal costs.

State and local governments have continued to press Congress for authorization to impose interstate waste import bans and flow control measures. In March 1995, the Senate Environment and Public Works Committee approved a bill (S. 534) that would allow states and localities limited rights to restrict both imports and exports of solid waste to or from their jurisdiction. The bill also stipulated that flow control arrangements started before May 15, 1994, could continue for no more than 30 years.

Policy Reforms

Within the Clinton Administration, the emphasis is on removing barriers to recycling and easing the regulatory burden on low-risk wastes.

To encourage recycling of household hazardous wastes, such as discarded batteries, thermostats, and pesticides, EPA revised its rules to help stores and businesses collect these items for recycling. In April 1995, EPA issued a new regulation that eases the burden by as much as a half-million work hours on participating retail stores and businesses.

To advance EPA's commitment to target the highest risks to public health and the environment, in November 1995 EPA proposed a new hazardous waste identification rule that will refocus the regulatory program on high risk wastes. The purpose of the rule is to exempt wastes that do not pose a significant public health threat from the hazardous waste management regulatory system—resulting in substantial savings to businesses handling these low-risk wastes. The proposed rule is currently undergoing public comment.

To increase local flexibility in handling waste, EPA in January 1996 proposed a rule that provides flexibility to states and tribes to implement performance standards for municipal solid waste landfill permits. Most states and many tribes have already opted to use this new flexibility in setting their standards.

FUTURE CHALLENGES

While there have been significant advances in solid waste disposal practices, major uncertainties remain. The flow control and interstate waste issues remain unresolved, and may remain at an impasse. In addition, under severe pressure to curtail spending, some state legislatures are cutting back on programs to support source reduction and recycling. Whether localities have developed sufficient infrastructure to be self-sufficient remains to be seen.

New waste management alternatives such as recycling are providing significant new economic opportunities that should carry on into the future. In October 1995, the Chicago Board of Trade opened a recyclables commodities exchange. Prices for recyclable materials have fluctuated, but the long-term outlook remains good.

Overall, both the economy and the environment should continue to benefit from solid waste disposal practices, which have undergone a quiet revolution in the United States over the past two decades. Traditional waste disposal methods are now much more protective of the environment; and new approaches emphasizing source reduction, recycling, and reuse may provide both environmental and economic benefits. Such innovations should provide states and localities more cost-effective ways to deal with the rising volume of solid waste generation.

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CHAPTER TWENTY-ONE

Toxic, Hazardous and Nuclear Waste

Toxic, hazardous, and nuclear waste present two distinct challenges: addressing a legacy resulting from improper and inadequate methods for disposing of hazardous substances, and ensuring that present procedures are satisfactory for safeguarding the future. In addition, there is a further challenge: protecting public health and the environment from toxic pollution in ways that are more effective, efficient, affordable, and fair.

The legacy of past behavior and the inadequacy of scientific understanding came to light dramatically in the late 1970s, when the nation was alerted to extensive contamination at Love Canal, New York, and other sites. In response, Congress in 1980 passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)—better known as the "Superfund" law. The law created a program to clean up abandoned hazardous waste and restore natural resources at sites across the country. At most sites, cleanup work is performed or funded by companies responsible for the contamination, who are strictly liable for the costs of response incurred by governmental or private parties. Taxes on chemical and petroleum production support a trust fund that pays for cleanup where these companies are insolvent or defunct, and that supports EPA's program costs for overseeing cleanup at priority sites.

Superfund complements the provisions of the 1976 Resource Conservation and Recovery Act (RCRA), which requires tracking of the generation and transport of hazardous waste and provides for regulations to ensure safe treatment and disposal. RCRA also established programs to address leaking underground tanks and other waste management issues, such as waste minimization and recycling. In 1992, the Federal Facilities Compliance Act amended RCRA to clarify that federal facilities are subject to this law to the same extent as any person, with the result that most U.S. military and nuclear waste is subject to control under this act. Nuclear waste is primarily under the purview of the Nuclear Waste Policy Act of 1982.

While CERCLA and RCRA rely on more traditional liability and regulatory schemes, the 1986 Emergency Planning and Community Right-to-Know Act (EPCRA) enhances public protection through the power of information and local preparedness. The centerpiece of EPCRA's data disclosure and emergency planning provisions is the Toxics Release

Inventory (TRI), a database on releases, off-site transfers, and other waste-management activities for over 650 chemicals and chemical categories from manufacturing facilities. The act also provides for states to establish state and local planning groups to develop emergency response plans for each community. To date, states have established over 3,400 Local Emergency Planning Committees (LEPCs). Facilities are required to make information available to the public through LEPCs on the hazardous chemicals present at that facility. A 1994 nationwide survey indicated that 79 percent of the LEPCs are functioning and most of these have completed emergency response plans, thereby strengthening their ability to respond to chemical emergencies.

DEALING WITH THE PAST: SUPERFUND CLEANUPS

The 1980 Superfund law (CERCLA) is designed to deal primarily with the cleanup of hazardous waste sites. Under the law, parties who owned or operated a vessel or facility, or transported or arranged for disposal of hazardous substances at the vessel or facility, are subject to strict, joint, and several liability for the costs of response and related natural resource damages. These liability provisions are coupled with an array of enforcement tools, which enable EPA to compel the parties responsible for contamination to perform the cleanup. Under the July 1996 Executive Order 13016, certain other agencies also may compel response actions. Alternatively, EPA may clean up a site using the CERCLA Trust Fund, which is supported by excise taxes on chemical feedstocks and petroleum, by a more broadly based corporate environmental tax, and by general revenues.

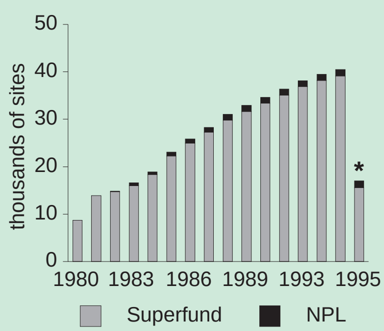
Whether the government or a private party conducts the cleanup, any Superfund monies expended at the site may be recovered from responsible parties. However, EPA recovery of cleanup costs is not possible where contamination is attributable to non-viable parties at a site. To ensure that litigation does not delay cleanup, CERCLA generally provides that challenges to EPA cleanup decisions may not be brought until after the cleanup action has been completed or an enforcement action has been brought.

CERCLA was amended and reauthorized in 1986 and reauthorized without amendments in 1990. The 1990 legislation extended the Superfund taxes through December 31, 1995. The statute's liability provisions remain in effect and Congress has continued to appropriate to the Superfund program using surplus monies in the Hazardous Substances Trust Fund—the Superfund. Because Congress has traditionally appropriated most funds to the program from the Superfund, reinstatement of a funding source for the Superfund will be necessary if the program is to continue without interruption once this surplus is depleted.

CERCLA authorizes EPA to investigate sites and to create a National Priorities List (NPL) of those sites where contamination presents the most serious threat to human health and the environment. EPA's remedial program is focused on these NPL sites. By September 1995, a total of 1,374 sites had been listed or proposed for listing. Work was under way at 93 percent of these sites, and permanent cleanup construction was in progress or complete at 60 percent of these sites. Permanent cleanup construction had been completed at 346 sites, or 25 percent of the sites on the NPL, since the inception of the program. In addition, EPA had identified 40,094 potentially hazardous waste sites across the nation (Figure 21.1). About 94 percent of these sites have been assessed by EPA to determine if further action is needed. By the end of 1995, EPA had removed 24,472 low-priority sites, leaving 15,622 remaining in the inventory.

In addition to long-term remediation of NPL sites, EPA conducts "removals"—short-term response actions—at many more sites where a release or threatened release of hazardous substances presents a threat to public health, welfare, or the environment. Removals can be conducted at both NPL and non-NPL sites, but are limited to actions that can be completed in less than one year and that cost no more than $2 million. Through fiscal 1995, the removal program had conducted 4,271 removal actions at 3,245 sites, including 2,617 non-NPL sites.

Figure 21.1 U.S. Superfund and NPL Sites, 1980-1995



Source: See Part III, Table 70.
Note: *>24,000 low-priority sites removed under EPA's Brownfields initiatives. NPL=National Priorities List.

State and federal agencies other than EPA also have significant authorities for hazardous substances response and natural resource restoration. In addition to the cleanup responsibilities each agency has for its own facilities, federal agencies, states, and Indian tribes serve as trustees for natural resources that are injured as a result of a release or threatened release of hazardous substances. These natural resource trustees, which include the Department of the Interior, the Department of Agriculture, the National Oceanic and Atmospheric Administration, the Department of Defense, and the Department of Energy, have authority to seek natural resource damages. These damage recoveries then may be used to replace, restore, or acquire the equivalent of the injured resource. At NPL sites, this role consists primarily of ensuring that remedial action fully addresses natural resource concerns, and seeking any additional steps that may be necessary to achieve restoration. At non-NPL sites, trustee agencies may seek to recover damages and use them for restoration and for source control, an activity that can also be part of response actions.

Superfund monies are not available, however, to fund natural resource restoration, and thus the natural resource damage programs have had more limited support than EPA's remedial program. To enhance the program authority of natural resource agencies that now lack access to the Superfund, Executive Order 13016 provides these agencies with authority to issue administrative orders to compel responsible parties to perform response work.

At Love Canal, perhaps the most famous of all Superfund sites, EPA's remedial program has substantially improved conditions by successfully completing site remediation, recovered a significant amount of the response cost, and secured the agreement of the responsible party to assume responsibility for long-term monitoring. From 1942 to 1952, Hooker Chemicals and Plastics (now Occidental Chemical Corporation) used Love Canal as a dump for over 21,000 tons of mixed chemical wastes. In the ensuing years, homes and even an elementary school were built in the area above and around the covered landfill. Over time, contamination migrated to groundwater and into basements of houses, sewers, creeks, and ultimately the nearby Niagara River. In the late 1970s, the area was declared an environmental emergency and 950 families were evacuated.

Cleanup of Love Canal has been complex but successful. Cleanup operations have included containment of the leaking landfill; removal and disposal of sediments from sewers and creeks; removal and cleaning of soils near the school; and buyout of properties in the area. In 1988, EPA issued the Love Canal Habitability Study. The agency concluded that several portions of the area were again clean enough for people to move back to the neighborhood. Other areas, while not suitable for homes, were sufficiently clean for commercial or industrial use. Today, revitalization of the area continues. Nearly 200 homes have been sold, 60 others are undergoing renovation, and new residential developments are being built. In addition, a settlement with Occidental Chemical resulted in recovery of most of EPA's response costs and $325,000 in natural resource damages.

Reinventing Superfund

Superfund has been subject to numerous criticisms over the years. People who live near these sites often have been frustrated by the slow pace of the cleanup process. Many of those who are subject to Superfund liability have complained that enforcement actions are not fair and that cleanup costs are excessive.

Beginning in 1993, EPA initiated three rounds of administrative improvements to increase enforcement fairness, reduce transaction costs, improve cleanup effectiveness and consistency, expand public involvement, and enhance the states' role in the program. These include:

- To streamline the settlement process, EPA established model "de minimis" settlement agreements. By allowing the "little guy" to get out of the process early and fairly, these agreements have protected well over 12,000 small-volume contributors of hazardous waste at approximately 190 sites. EPA indirectly provided relief to many thousands of even smaller contributors by issuing guidance in July 1993 clearly stating the agency's intention not to pursue such parties.

- EPA's reforms are intended to enhance enforcement fairness for larger firms as well, and thereby promote more rapid settlement of liability for cleanup costs. To minimize contribution litigation, EPA has issued guidance to ensure that cleanup orders are issued to as many viable, responsible companies at a site as practicable by stating that cleanup orders will be issued to the largest manageable number of known viable parties. EPA also has increased use of the Superfund Trust Fund to pay for part of the "orphan shares" of responsibility attributable to insolvent or defunct parties (where the viable parties agree to undertake the cleanup), and is testing an allocation process in which a neutral party establishes the basis for settlements by allocating shares of cleanup responsibility among all responsible parties.

- EPA reformed the remedy selection process by giving greater emphasis to future land use; clarifying consideration of cost and risk issues; and reducing redundancy through RCRA/CERCLA integration guidance. To ensure that these reforms are consistently applied and that costs are appropriate to cleanup needs, EPA has established presumptive remedies for several classes of contamination, and introduced cost-effectiveness "rules of thumb" for remedy selection. In addition, EPA created a National Remedy Review Board comprised of EPA personnel. This board reviews proposed cleanup decisions and makes advisory recommendations to regional management for exceptionally high-cost actions. This process ensures sound, cost-effective decisionmaking that is consistent with current law and regulations.

- EPA is providing a facilitator in each region to serve as a direct point of contact for concerns of the community and other affected groups. The ombudsman will have access to a top regional management official and will facilitate resolution of concerns that cannot be informally resolved by regional personnel.

- EPA has created an electronic bulletin board on the Internet that allows communication among all Superfund stakeholders. The bulletin board includes an easily accessible guide to current state and federal guidance. The bulletin board will provide access to information for organizations that maintain site information repositories and administrative records within communities. Universities and the Hazardous Substance Research Centers may be utilized to provide additional information.

These reforms, coupled with the general maturing of the program, appear to be generating greater success in completion of cleanups. From FY 1983 through FY 1992, construction was completed at only 149 toxic waste sites on the NPL, an average of less than 15 sites per year. By contrast, from FY 1993 through FY 1995, construction was completed at 197 NPL sites, an average of more than 65 sites per year. The Administration is seeking appropriations to ensure completion of approximately 500 sites from FY 1997 through FY 2000, an average of 125 sites per year—nearly doubling the pace of cleanup. Not counting sites where construction has been completed, there are an additional 472 NPL sites where construction is underway.

Redeveloping Brownfields

Many of America's older cities and towns are scarred by brownfields—contaminated and/or abandoned industrial sites. In many cities and towns, the number of such vacant parcels is increasing, and redevelopment is difficult because of the many uncertainties associated with cleanup, liability, and cost issues. Fear of liability under Superfund and other laws posed severe impediments to cleanup and redevelopment of contaminated property on the part of municipalities, lenders, real estate developers, and investors. Understandably, private investors and developers tend to favor greenfields in outlying areas.

The Clinton Administration has developed a comprehensive approach to reduce the barriers and encourage redevelopment of these properties. EPA's Brownfields Action Agenda, which was unveiled in January 1995, includes funding for 60 pilot projects at brownfield sites. These projects are intended to provide EPA, states, and localities with useful information and new strategies for promoting environmental cleanup through redevelopment. These modest investments in brownfields assessment yield major returns for the communities that receive them. The first such project in Cleveland, Ohio, leveraged $4.2 million in private investment, created 200 jobs, and generated more than $1 million in new payroll taxes for the city.

These steps have been reinforced with administrative and legislative efforts to encourage lending for cleanup and redevelopment. By the end of 1995, EPA had removed more than 24,000 sites (or nearly two-thirds) from the Superfund site data base (CERCLIS). These sites represent those that the states and EPA investigated and found to be of no further federal concern. Many were found not to be seriously contaminated while others are being cleaned up under state programs. This action is making it easier for potential purchasers, developers, lenders, and communities to make investments in these properties and clean them up. The Clinton Administration also advocated legislation to clarify the potential liability of lenders and fiduciaries, thereby removing impediments to brownfield financing. These proposals were enacted in the final days of the 104th Congress.

In March 1996, the President also proposed a package of tax incentives to encourage brownfield redevelopment in distressed communities. Under this proposal, environmental cleanup costs incurred by new purchasers may be fully deducted in the year in which they were incurred, which would reduce the cost of capital for these types of investments by more than half. This $2 billion incentive is expected to leverage $10 billion in private investment, which would return an estimated 30,000 brownfields to productive use. The tax incentive would be available in existing brownfield pilot areas, in areas with a poverty rate of 20 percent or more, in adjacent industrial or commercial areas, and in Empowerment Zones and Enterprise Communities. In August 1996, President Clinton further proposed an additional $300 million over four years to finance the assessment, cleanup, and redevelopment of brownfields sites.

This program advances the recommendations of the President's Council on Sustainable Development, which include calls for expanded partnership with communities and industry, new incentives for brownfields cleanup and redevelopment, and liability reforms that remove impediments to redevelopment while preserving the polluter-pays principle.

Federal Facilities

Contaminated federal facilities present some of the more prominent legacies of past mismanagement of toxics and hazardous materials. These facilities can be grouped into three major categories: the nuclear weapons complex; non-nuclear industrial contamination sites resulting from federal operations; and land managed by federal agencies with contamination from governmental or private activities.

The most difficult and costly challenge concerns the Department of Energy facilities that developed, produced, and tested nuclear weapons. These sites contain radiological and mixed wastes that present unique technological and practical impediments to prompt remediation and restoration. The cleanup effort is focused on 15 major DOE facilities and a dozen or so smaller facilities. Six of the major facilities—Hanford, Savannah River, Oak Ridge, Fernald, Idaho National Engineering Laboratory, and Rocky Flats—account for about 80 percent of DOE's environmental management budget.

The federal government is currently spending about $9 billion a year to address the federal facility cleanup problem, including DOE's ongoing waste management. Over the next 75 years, the cost of cleanup at DOE facilities is estimated to be $200-$350 billion (in 1995 dollars, including management of storage facilities), while costs at the facilities of other federal agencies (Defense, Agriculture, Interior, and the National Aeronautics and Space Administration) are estimated at $34-$38.5 billion (in 1994 dollars).

Improving Federal Facilities Cleanup, the October 1995 report of the interagency Federal Facilities Policy Group, found significant progress in the cleanup effort at federal facilities. This progress has been most notable at Defense Department sites, where contamination typically is comparable to that at private sector industrial sites. Progress also has been evident at DOE, where major management and contracting reforms have been implemented. However, there has been slower progress in site assessments, response actions, and natural resource restoration at land management agencies, such as DOI and USDA.

The report also found that a number of reforms are necessary to maximize the efficiency and effectiveness of the cleanup effort, and to ensure that the cleanups can be achieved within anticipated budget constraints. These include reforms to CERCLA; regulatory and administrative reforms to cleanup programs; management reforms at the agencies responsible for cleanups; and budget reforms to ensure more predictable funding streams for the cleanup effort. Many of the cleanup problems at these facilities may require more than reform. The Galvin Commission recently concluded that existing technology and scientific understanding may be inadequate to clean up federal facilities.

Separately, EPA convened a broad range of constituencies in its Federal Facilities Environmental Restoration Dialogue Committee (FFERDC), and developed a series of recommendations to improve the pace and public acceptance of federal facility cleanups. These recommendations have been endorsed by the relevant federal agencies, and are expected to yield more successful relationships between the federal agencies and their regulators, and between the individual facilities and their host communities.

DEALING WITH THE PRESENT

The principal thrust of the current federal approach to hazardous waste is to minimize generation, to recycle waste that is generated, to safely dispose of waste that cannot be prevented or recycled, to protect community right-to-know about toxic substances released into the environment, and to take firm but fair enforcement action against persons who violate environmental laws or who are liable for pollution. Concurrently, federal agencies are implementing reforms to eliminate regulatory burdens that yield high costs but little environmental benefit. In addition, some federal agencies such as DOE are supporting innovative technology development and research to improve scientific understanding of fundamental processes affecting waste transport and cleanup.

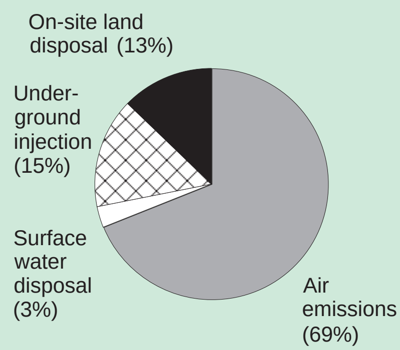
TRI

The Toxics Release Inventory (TRI) presents a useful but not completely comprehensive picture of toxic releases into the environment. The reporting requirement historically has been limited to certain specified industrial categories, to firms with 10 or more employees, and to firms that manufacture or process more than 25,000 pounds or use more than 10,000 pounds of any listed chemical during the calendar year. For 1994, the TRI list included 343 chemicals and 22 chemical categories. The Clinton Administration repeatedly expanded the scope of TRI reporting, requiring reporting by federal facilities in 1994, nearly doubling the list of chemical releases that must be reported for 1995 (to about 650 substances), and proposing the addition of seven new industrial categories to the list of TRI reporters.

The risk to human health and the environment posed by these releases depends on many factors, including the toxicity of the chemical, the extent of exposure, the type of release, and the conditions of the environment. Small releases of highly toxic chemicals may present a greater risk than large releases of less toxic chemicals. Direct releases to the air may pose a greater threat to human health than contained releases, such as certain types of underground injection.

According to TRI data for on-site releases in 1994, 22,744 facilities released 2.26 billion pounds of listed toxic chemicals into the environment (Figure 21.2). Air emissions accounted for 69 percent of the total, followed by underground injection (much of it controlled releases into subsurface wells) at 15 percent, releases to landfills and other types of land disposal at 13 percent, and releases to water at 3 percent.

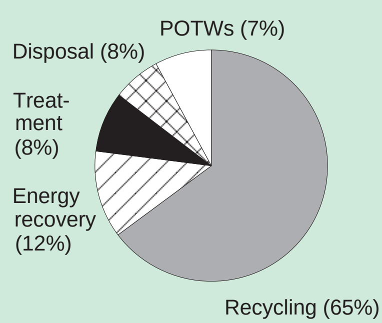
Figure 21.2 Distribution of U.S. Toxics Releases, 1994



Source: U.S. Environmental Protection Agency, *1994 Toxics Release Inventory: Public Data Release* (EPA, Washington, DC, 1996).
Note: Total releases=2.26 billion pounds.

Facilities also transferred nearly 3.8 billion pounds of toxic chemicals to off-site locations for recycling, energy recovery, treatment, and disposal (Figure 21.3). Nearly 65 percent of all transfers (by weight) were for recycling, while less than 8 percent were for disposal.

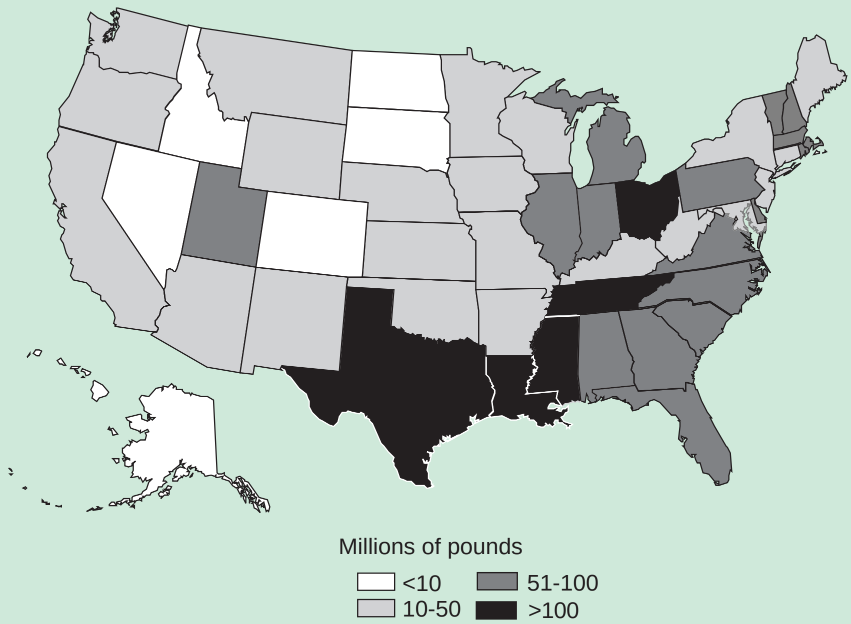
Figure 21.3 Distribution of U.S. Toxics Transfers, 1994



Source: U.S. Environmental Protection Agency, *1994 Toxics Release Inventory: Public Data Release* (EPA, Washington, DC, 1996).
Note: Total transfers=3.795 billion pounds. POTWs= publicly owned treatment works.

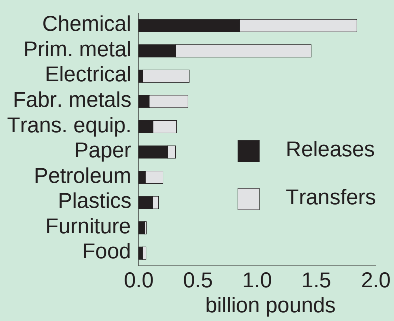
The states with the largest quantities of toxic releases are primarily in the South and Midwest (Figure 21.4). Texas, with 250 million pounds of releases, was the leading state in terms of total releases. By industrial sector, the chemical industry (851 million pounds) is the leading sector, followed by primary metals and paper (Figure 21.5). By company, DuPont (203 million pounds) leads in total releases. By individual facility, the leaders for total releases are DuPont facilities in Pass Christian, Mississippi, with 60 million pounds, and in New Johnsonville, Tennessee, with 57 million pounds.

Figure 21.4 Toxic Releases by State, 1994



Source: U.S. Environmental Protection Agency, *1994 Toxics Release Inventory: Public Data Release* (EPA, Washington, DC, 1996).

Figure 21.5 Toxics Releases and Transfers by Selected U.S. Industries, 1994



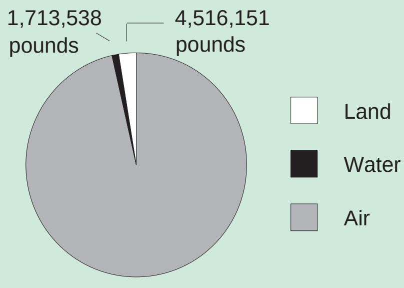
Source: See Part III, Table 73.

Note: Data are from EPA's Toxics Release Inventory.

TRI designates 118 chemicals as known or suspected carcinogens. More than 177 million pounds of TRI-listed carcinogens were released to the air, water, and land (excluding underground injection) in 1994 (Figure 21.6). Two chemicals—dichloromethane and styrene—accounted for more than half of the total releases.

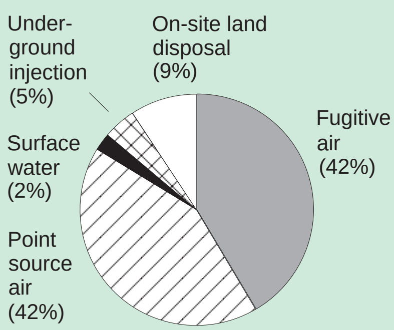
Federal facilities were required to report to the TRI for the first time in 1994. Releases by federal facilities totaled 9.8 million pounds in 1994 (Figure 21.7). Air emissions constituted nearly 84 percent of all releases. The Department of Defense accounted for nearly 73 percent of the total. Off-site transfers totaled

Figure 21.6 U.S. Releases of OSHA* Carcinogens, 1994



Source: U.S. Environmental Protection Agency, *1994 Toxics Release Inventory: Public Data Release* (EPA, Washington, DC, 1996).
Note: *Occupational Safety and Health Administration.

Figure 21.7 Toxics Releases by U.S. Federal Facilities, 1994



Source: U.S. Environmental Protection Agency, *1994 Toxics Release Inventory: Public Data Release* (EPA, Washington, DC, 1996).
Note: Total releases=9.8 million pounds.

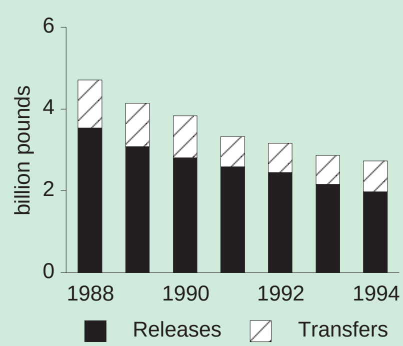
10.4 million pounds, of which half was for recycling and one fourth for disposal. The Department of Defense accounted for nearly 95 percent of all transfers in 1994.

Trends in TRI Releases

Since 1988, EPA's baseline year for TRI comparisons, reported toxic releases have declined by 44.1 percent (Figure 21.8). The sharpest declines have been to air and surface water, while declines in underground injection and releases to land have been less dramatic. From 1993 to 1994, releases to land and underground injection actually increased slightly.

Discharges to surface water decreased by 156 million pounds between 1993 and 1994, from 203 million pounds to 47 million pounds. Virtually all of this decrease is attributable to large decreases from just two IMC-Agrico fertilizer facilities in Louisiana. These two facilities implemented pollution prevention and control measures to decrease runoff of phosphoric acid and other chemicals.

Figure 21.8 Trends in U.S. Toxics Releases and Transfers, 1988-1994



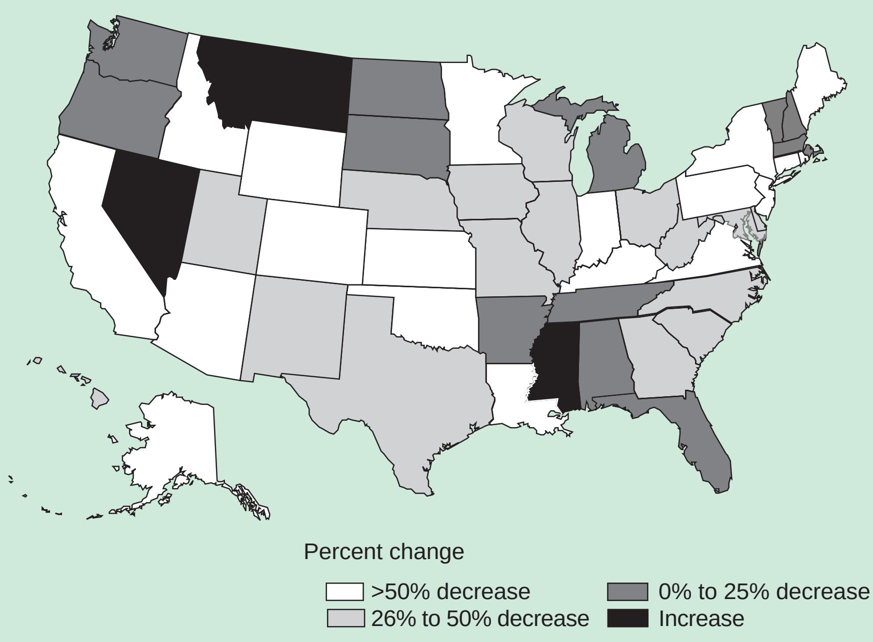
Source: See Source for Part III, Table 72.
Note: Data are standardized to account for changes in reporting requirements. Graph does not include transfers for recycling or energy recovery as these transfers were not required to be reported for 1988-1990.

Since 1988, air emissions have declined by 912 million pounds, or 40.5 percent. From 1993 to 1994, total air emissions declined by more than 50 million pounds, from 1.40 billion pounds to 1.35 billion pounds. Of the 10 chemicals with the greatest decreases in air emissions, three were ozone-depleting chemicals that were scheduled for phaseout by January 1, 1996. Air emissions of methanol rose 24 percent, largely because of changes in the methods used by pulp and paper mills to estimate their releases in 1994.

Texas, currently first in the nation for total TRI releases, has reduced its emissions by 98 million pounds (31.5 percent) since 1988 (Figure 21.9). Tennessee, now ranked second, has reduced emissions by 13 million pounds (8.1 percent). Louisiana, now ranked third, has reduced its emissions by 315 million pounds (72.4 percent), which is by far the largest decrease of any state in terms of pounds. Mississippi's emissions have climbed 19.7 percent, from 94 million pounds in 1988 to 113 million pounds in 1994, which has moved the state from seventeenth overall in 1988 to fourth in the nation in 1994.

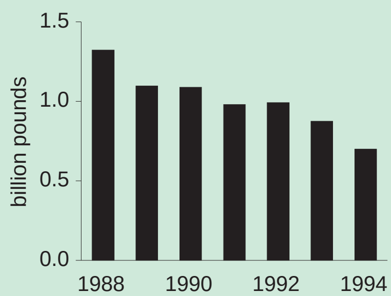
By industry, the chemical industry has had the largest absolute decrease in releases (622 million pounds) (Figure 21.10), whereas in percentage terms the

Figure 21.9 Percent Change in Toxic Releases by State, 1988-1994



Source: U.S. Environmental Protection Agency, *1994 Toxics Release Inventory: Public Data Release* (EPA, Washington, DC, 1996).

Figure 21.10 Toxics Releases by the U.S. Chemical Industry, 1988-1994



Source: See Part III, Table 73.

largest decreases from 1988–94 were reported by the electrical equipment, leather, and measurement/photographic instruments industries. The chemical industry has reduced its releases by 47.1 percent since 1988, or slightly better than the overall rate of 44.1 percent for all industry groups. The paper industry, which accounted for the third largest quantity of TRI releases in 1994, has reduced its releases by just 4 percent since 1988.

Trends in Source Reduction

The 1990 Pollution Prevention Act expanded TRI to require reporting of chemicals managed in waste. The law also established a waste management hierarchy, with a preference for source reduction activities.

Overall, facilities managed more than 26.5 billion pounds of TRI chemicals in waste in 1994. The chemicals, primary metals, and paper industries generated the most toxic chemicals in waste; these same three industries also ranked highest for total releases of TRI chemicals.

The quantity of toxic chemicals in waste increased 5.4 percent from 1993 to 1994 and is projected to continue to increase. Quantities that are released declined by 20.2 percent from 1991 to the projected total in 1996. Over the 1991–96 period, recycling is projected to increase by 17.9 percent, energy recovery by 13 percent, and treatment by 9.9 percent.

Some 32 percent of all TRI facilities reported at least one source reduction activity in 1994. Of all TRI forms submitted, 23 percent reported some source reduction activities.

Many companies are discovering that pollution prevention programs can significantly lower their operating costs (see Box 21.1).

The 33/50 Program

The 33/50 program is an EPA voluntary pollution reduction initiative that targets 17 high-priority TRI chemicals. For these 17 chemicals, EPA set two goals: by 1992, a 33 percent reduction in TRI releases and transfers (using 1988 as the baseline year), and by 1995, a 50 percent reduction. These goals translate to a reduction of nearly 750 million pounds of pollution from the nearly 1.5 billion pounds reported to TRI for 1988.

The 33/50 program has been remarkably successful. It has enlisted the active cooperation of 1,300 corporations and more than 6,000 TRI facilities. The 1992 interim 33-percent goal was achieved a year ahead of time, while the 1995 50-percent goal was actually achieved by

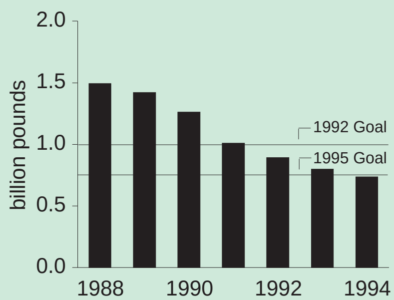
Box 21.1
Economic Gain Through Waste Minimization

One of the most attractive features of pollution prevention is the potential for “win-win” outcomes—those where a facility can reduce pollution and simultaneously lower its own costs. This was the result under a lawsuit filed by EPA against the DuPont Company’s Chambers Works chemical plant in Deepwater, New Jersey—one of the largest chemical manufacturing facilities in the United States.

As part of the settlement between DuPont and EPA, DuPont agreed to pay a substantial penalty for past RCRA violations, to conduct an internal audit of its waste-generating activities, and to evaluate pollution prevention opportunities at the facility. In consultation with EPA, company officials identified 15 manufacturing processes with pollution prevention potential. The individual projects focused on reducing solvent waste, tar waste, and other chemical waste. One project even reduced packaging waste by introducing reusable chemical containers in place of disposable 55-gallon drums.

The effort has been a striking success. With 7 of the 15 projects implemented, DuPont has reduced waste from the affected processes by 73 percent. Once all projects are in place, DuPont expects that waste from all 15 processes will be cut roughly in half. More importantly, this waste reduction will yield benefits to the company as a result of reduced waste disposal and other regulatory costs. The total up-front investment for all 15 projects is expected to be about $6 million, while DuPont anticipates annual savings of about $15 million. DuPont is making the study publicly available as an example of how technological progress can be shared to further waste minimization.

Figure 21.11 U.S. Releases and Transfers of 33/50 Program Chemicals, 1988-1994



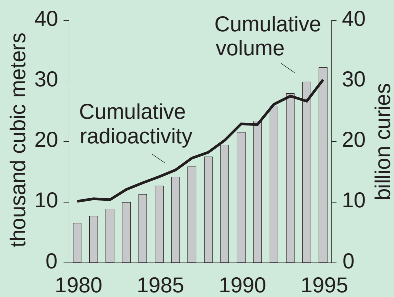
Source: U.S. Environmental Protection Agency, *1994 Toxics Release Inventory: Public Data Release* (EPA, Washington, DC, 1996).

1994, when reductions since 1988 totaled 757 million pounds (Figure 21.11).

Since the program’s announcement in 1991, 33/50 chemicals have been reduced at nearly twice the rate observed for all other TRI chemicals (41.6 percent versus 22.3 percent). Since 1988, facilities owned by participants have reduced their releases and transfers of 33/50 chemicals by 60 percent, compared with a 35 percent reduction by nonparticipants.

As for chemicals in production-related waste, 33/50 chemicals have decreased slightly (0.9 percent) since 1991 and are forecast to decline by 4.5 percent in 1995 and more than 7 percent by 1996. Other TRI chemicals have increased significantly (9.2 percent) since 1991 and are

Figure 21.12 U.S. Generation of Spent Nuclear Fuel, 1980-1995



Source: See Part III, Table 69.
Note: Cumulative radioactivity includes decay.

forecast to continue increasing (4.3 percent in 1995 and 6 percent in 1996).

As a group and individually, 33/50 chemicals are being targeted for more source reduction activities than other TRI chemicals; 30 percent of all TRI facilities reported the occurrence of source reduction for 33/50 chemicals, compared to 20 percent for other TRI chemicals.

NUCLEAR WASTE

Nuclear waste encompasses a wide range of material. The Department of Energy and Nuclear Regulatory Commission (NRC) recognize six major types of waste.

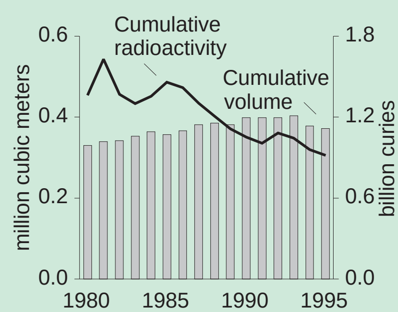
Spent Nuclear Fuel. These are fuel rods that have been permanently withdrawn from a nuclear reactor because they can no longer efficiently sustain a nuclear chain reaction. Spent fuel contains some relatively short-lived fission products as well as long-lived radionuclides such as plutonium, which remains dangerously radioactive for tens of thousands of years. Measured in terms of radioactivity, spent fuel accounts for about 95 percent of all accumulated radioactivity (Figure 21.12).

U.S. commercial nuclear reactors currently generate about 2,000 metric tons of spent fuel annually. The current total of about 30,000 metric tons of spent fuel is stored at about 70 power plant sites around the nation. The total is expected to reach 40,000 metric tons by the turn of the century.

High-level Waste. High-level waste includes highly radioactive residue created by spent fuel reprocessing, mostly for defense purposes in the United States. Enough long-lived radioactive elements remain to require isolation for 10,000 years or more (Figure 21.13).

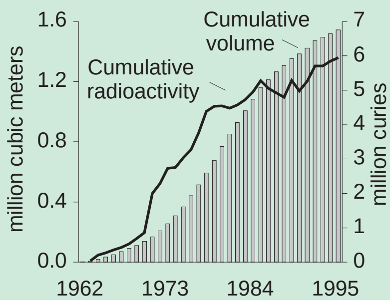
Transuranic Waste. Transuranic waste —relatively low-activity waste with some long-lived elements heavier than uranium (primarily plutonium)—is generated

Figure 21.13 U.S. Generation of High-Level Nuclear Waste, 1980-1995



Source: See Part III, Table 69.
Note: Cumulative radioactivity includes decay.

Figure 21.14 U.S. Generation of Low-Level Nuclear Waste, 1962-1995



Source: See Part III, Table 69.
Note: Cumulative radioactivity includes decay.

almost entirely by nuclear weapons production processes. Disposal via long-term isolation is planned for these wastes in the nation's Waste Isolation Pilot Plant. EPA will review and certify the ability of the facility to comply with established disposal standards.

Uranium Mill Tailings. These are sand-like residues from the processing of uranium ore. Mill tailings have low radioactivity but represent a large volume.

Low-level Waste. This is radioactive waste not classified as spent fuel, high-level waste, TRU waste, or mill tailings.

By volume, low-level waste makes up more than 85 percent of the U.S. total. In terms of radioactivity, it accounts for less than a tenth of 1 percent (Figure 21.14).

Mixed Waste. This is high-level, low-level, or TRU waste that contains hazardous non-radioactive waste.

The 1982 Nuclear Waste Policy Act called for disposal of spent nuclear fuel in a repository in a stable deep geologic formation. A 1987 amendment to the act restricted DOE's repository site studies to Yucca Mountain in Nevada. Answering questions about the viability of the site is expected to require several additional years of scientific work. DOE estimates that it will be able to complete this work in 1998 if requested budget amounts remain available. The 1982 act set a 1998 goal for loading waste into the repository. A permanent repository could not open until after a site is found viable and is licensed, a process that will take several years after completion of site characterization.

The nuclear industry is supporting legislation that would require DOE to open an interim waste storage facility near Yucca Mountain by 1998. By May 1996, House and Senate committees had approved the legislation. The Administration opposes early siting of an interim waste facility, arguing that waste should not be stored near Yucca Mountain before DOE has made a technical determination of the site's suitability for a permanent repository, and that adequate environmental safeguards must be in place.

Under the 1980 Low-Level Radioactive Waste Policy Act, states are authorized to form regional disposal compacts. Two commercial low-level waste sites are currently operating. The Washington site is accepting waste from states within its compact. South Carolina reopened its site to nationwide disposal in July 1995. A planned facility in California is currently undergoing additional environmental reviews.

Reform Steps

In recent years the Clinton Administration has tried to fine-tune federal policies on hazardous waste, emphasizing the targeting of regulations toward higher-risk chemicals, reducing the economic burden of the program, and encouraging greater community participation.

In November 1995, EPA proposed a new hazardous waste identification rule that will dramatically refocus the regulatory program on high-risk waste. When finalized, this rule will exempt from RCRA Subtitle C regulation certain waste that does not pose a significant public health threat—resulting in substantial savings to businesses handling this low-risk waste and allowing more time to focus on greater hazards to public health and the environment.

As part of its initiative for reinventing environmental regulation, the Clinton Administration also committed to identifying targeted amendments to provisions of RCRA that result in high costs and marginal environmental benefits. As a result of this initiative, the 104th Congress enacted the Land Disposal Program Flexibility Act of 1996, which eliminated a RCRA mandate requiring EPA to promulgate stringent and costly treatment requirements for certain low-risk wastes that already are regulated in Clean Water Act or Safe Drinking Water Act units. EPA considers these wastes to present little or no risk, due to existing regulation under other statutes and under state law, but a court decision (*Chemical Waste Management v. EPA*— also known as the "Third-third" decision) had required the agency to promulgate far more stringent requirements than the agency itself had sought for these low-risk wastes, which are not even classified as hazardous wastes. This targeted legislative fix to the LDR provisions eliminated these unduly stringent treatment requirements for certain wastes managed in injection wells already regulated under the Safe Drinking Water Act and surface impoundments already regulated under the Clean Water Act. Preliminary estimates suggest that this amendment could yield hundreds of millions of dollars in savings for the private sector.

The Administration also supported enactment of the Mercury Containing and Rechargeable Battery Management Act of 1996, which would establish uniform national labeling, storage, and transportation standards to encourage environmentally sound recycling of batteries, and prohibit the sale of certain mercury-containing batteries.

This bill furthered the steps EPA had taken administratively, most recently through the RCRA universal waste rule, to encourage recycling of rechargeable batteries in a manner that does not compromise environmental protection. As a result of this change, retailers and other entities that collect used batteries for recycling will be relieved of excessively burdensome regulations, and mercury loadings attributable to mercury-containing batteries should be reduced.

The Administration also has supported reforms to promote greater community participation in environmental protection. For example, East St. Louis is a highly industrialized area that has historically suffered from a variety of environmental problems. Key stakeholders have worked together to inform the community of ongoing environmental initiatives and progress, and to solicit input on future initiatives. The program has employed "good neighbor dialogues" to inform residents of progress in reducing releases of TRI chemicals. These chemicals have shown a marked decrease between 1988 and 1993. The effect can be seen directly: local hospital staff contend that the elimination of chemical spills at Monsanto and other industrial facilities has resulted in hundreds fewer emergency room admissions.

FUTURE CHALLENGES

In most respects, the Toxics Release Inventory has been a striking success. Faced with TRI information and community pressures, as well as fair but firm enforcement of statutory controls, environmental leaders in the business community have responded by aggressively reducing toxic releases, in part through commendable voluntary efforts. Building on this success, President Clinton announced a major right-to-know initiative in August 1996, aimed at increasing information available to families about potential toxic exposures to children. This Family Right-to-Know initiative is currently being developed by EPA and other federal agencies, and is likely to include new administrative and possibly legislative proposals to expand the information available to parents about toxic chemicals that may affect their families.

There are shortcomings in existing right-to-know programs, however, that remain to be addressed. For example, critics contend that TRI reporting can include "phantom reductions," such as changes in measurement or estimation that reduce releases on paper only, downturns in production, or shifts to unreported waste management activities. According to a 1991 EPA study, changes in production were the most frequently cited reason for reported reductions and accounted for the largest absolute change.

Although pollution prevention is clearly a policy goal, the TRI program does not effectively distinguish between pollution prevention measures and other practices that reduce pollution. For example, take the case of 1991 TRI reports for two New Jersey firms: Hatco Corporation released 10 pounds of phosgene gas (an acute neurotoxin) and DuPont emitted 1,298 pounds. What this report does not show, however, is that Hatco ships in almost 5 million pounds of phosgene annually, which poses a serious risk of a transportation or storage accident, while DuPont produced phosgene on-site and consumed most of the gas as an intermediate component.

In another case, Polaroid Corporation in 1994 reported an increase in releases, largely because record sales prompted the company to use older manufacturing processes that were not retooled for waste reduction. The data masked Polaroid's aggressive and successful effort to reduce toxics use. In 1994, the company used 8,642 pounds of ozone-depleting chemicals, a tiny fraction of the 125,949 used in 1988. Yet under TRI, such dramatic reductions in use are hidden.

Finally, many scientific challenges lie ahead. There is a critical need to increase our fundamental understanding of processes affecting waste and improve our ability to model and predict the fate of toxic chemicals in the environment.

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Part III

Environmental Data and Trends

List of Tables

Ecosystems and Biodiversity

Air Quality and Climate

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Population

Table 1. Total U.S. Population and Population Growth Rate, 1903-1995

Year	Population	Growth rate	Year	Population	Growth rate	Year	Population	Growth rate
	millions	*%*		*millions*	*%*		*millions*	*%*
1903	80.63	1.9	1934	126.49	0.7	1965	194.30	1.2
1904	82.17	1.9	1935	127.36	0.7	1966	196.56	1.1
1905	83.82	2.0	1936	128.18	0.6	1967	198.71	1.1
1906	85.45	1.9	1937	128.96	0.7	1968	200.71	1.0
1907	87.01	1.8	1938	129.97	0.8	1969	202.68	1.0
1908	88.71	2.0	1939	131.03	0.8	1970	205.05	1.3
1909	90.49	2.0	1940	132.59	0.9	1971	207.66	1.2
1910	92.41	2.1	1941	133.89	1.0	1972	209.90	1.0
1911	93.86	1.6	1942	135.36	1.3	1973	211.91	0.9
1912	95.34	1.6	1943	137.25	1.3	1974	213.85	0.9
1913	97.23	2.0	1944	138.92	1.2	1975	215.97	1.0
1914	99.11	1.9	1945	140.47	1.0	1976	218.04	1.0
1915	100.55	1.4	1946	141.94	1.5	1977	220.24	1.0
1916	101.96	1.4	1947	144.70	1.8	1978	222.59	1.1
1917	103.41	1.4	1948	147.21	1.7	1979	225.06	1.1
1918	104.55	1.1	1949	149.77	1.7	1980	227.73	1.2
1919	105.06	0.5	1950	152.27	1.7	1981	229.97	1.0
1920	106.46	1.3	1951	154.88	1.7	1982	232.19	1.0
1921	108.54	2.0	1952	157.55	1.7	1983	234.31	0.9
1922	110.05	1.4	1953	160.18	1.7	1984	236.35	0.9
1923	111.95	1.7	1954	163.03	1.8	1985	238.47	0.9
1924	114.11	1.9	1955	165.93	1.8	1986	240.65	0.9
1925	115.83	1.5	1956	168.90	1.8	1987	242.80	0.9
1926	117.40	1.4	1957	171.98	1.7	1988	245.02	0.9
1927	119.04	1.4	1958	174.88	1.7	1989	247.34	0.9
1928	120.51	1.2	1959	177.83	1.7	1990	249.91	1.0
1929	121.77	1.0	1960	180.67	1.6	1991	252.65	1.1
1930	123.19	0.9	1961	183.69	1.6	1992	255.42	1.1
1931	124.15	0.7	1962	186.54	1.5	1993	258.14	1.1
1932	124.95	0.6	1963	189.24	1.4	1994	260.66	1.0
1933	125.69	0.6	1964	191.89	1.3	1995	263.03	0.9

Sources: U.S. Department of Commerce, Bureau of the Census, *Estimates of the Population of the United States to December 31, 1995* (GPO, Washington, DC, 1995).

--, *U.S. Population Estimates by Age, Sex, Race, and Hispanic Origin: 1990 to 1995* (GPO, Washington, DC, 1996).

Notes: The population estimates shown here are based on the April 1, 1990, population as enumerated in the 1990 census. Estimates for dates prior to April 1, 1990, have been revised. Annual population estimates are for July 1 of each year. Total population for the years 1900-1916 and 1920-1929 are resident population. Total population for the years 1917-1919, 1930-1939, and 1940-1995 are resident population plus armed forces overseas. All years 1903-1939 exclude Alaska and Hawaii.

Table 2. Components of Total U.S. Population Change, 1940-1994

Year	Births	Deaths	Net civilian immigration	Net change
		millions		
1940	2.570	1.432	0.077	1.221
1945	2.873	1.549	0.162	1.462
1950	3.645	1.468	0.299	2.486
1955	4.128	1.537	0.337	2.925
1960	4.307	1.708	0.328	2.901
1965	3.801	1.830	0.373	2.315
1970	3.739	1.927	0.438	2.617
1975	3.144	1.894	0.449	2.165
1980	3.612	1.990	0.845	2.510
1985	3.761	2.086	0.649	2.171
1990	4.148	2.155	0.576	2.569
1994	3.949	2.291	0.816	2.471

Source: U.S. Department of Commerce (DOC), Bureau of the Census (BOC), *U.S. Population Estimates, by Age, Sex, Race, and Hispanic Origin*, Current Population Reports, Series P-25, No. 1045 (1990) and No. 1095 (1993) (GPO, Washington, DC) and Population Paper Listings, PPL-21 (DOC, BOC, Washington, DC, 1995).

Table 3. Age Structure of the U.S. Population, including Armed Forces Overseas, 1940-1995

	Age classes, in years							
Year	< 5	5-14	15-24	25-34	35-44	45-54	55-64	> 64
				millions				
1940	10.6	22.3	24.0	21.5	18.4	15.6	10.7	9.0
1955	16.3	24.5	22.3	23.9	21.6	17.4	13.4	12.4
1960	20.3	35.7	24.6	22.9	24.2	20.6	15.6	16.7
1970	17.2	40.7	36.5	25.3	23.1	23.3	18.7	20.1
1980	16.5	34.8	42.8	37.6	25.9	22.7	21.8	25.7
1985	17.8	33.7	40.2	41.9	31.8	22.5	22.1	28.4
1990	18.9	35.3	36.9	43.1	37.8	25.2	21.1	31.2
1995	19.6	38.1	35.9	41.0	42.5	31.1	21.1	33.5

Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970*, Part I, Series A 30-37 (GPO, Washington, DC, 1975).

--, *U.S. Population Estimates, by Age, Sex, Race, and Hispanic Origin*, Current Population Reports, Series P-25, No. 1045 (1990) and No. 1095 (1993) (GPO, Washington, DC) and Population Paper Listings, PPL-21 (DOC, BOC, Washington, DC, 1995).

Note: Annual population estimates are for July 1 of each year.

Table 4. U.S. Population in Urban, Suburban, and Rural Areas, 1950-1994

Year	Urban population		Suburban population		Rural population	
	millions	*%*	*millions*	*%*	*millions*	*%*
1950	49.661	32.8	35.193	23.3	66.472	43.9
1960	58.004	32.3	54.881	30.6	66.438	37.0
1970	63.797	31.4	75.622	37.2	63.793	31.4
1980	67.949	30.0	101.481	44.8	57.115	25.2
1990	77.844	31.3	114.882	46.2	55.984	22.5
1994	75.591	29.4	129.063	50.1	52.687	20.5

Source: U.S. Department of Commerce, Bureau of the Census, *Population Censuses Number of Inhabitants, U.S. Summary, 1950-1990* (GPO, Washington, DC) and updates by agency.

Notes: Urban refers to population inside central cities of metropolitan areas (MAs). Suburban refers to MA population in suburbs outside central cities. Rural refers to nonmetropolitan population. MAs are defined for each population census.

Table 5. U.S. Population by Region, 1900-1994, and Net U.S. Population Migration by Region, 1960-1994

Year	Northeast	Midwest	South	West
	regional population, in millions			
1900	21.047	26.333	24.524	4.309
1910	25.869	29.889	29.389	7.082
1920	29.662	34.020	33.126	9.214
1930	34.427	38.594	37.858	12.324
1940	35.977	40.143	41.666	14.379
1950	39.478	44.461	47.197	20.190
1960	44.678	51.619	54.973	28.053
1970	49.061	56.590	62.813	34.838
1980	49.137	58.867	75.367	43.171
1990	50.809	59.669	85.446	52.786
1994	51.396	61.394	90.692	56.859

Region	1960-1970	1970-1980	1980-1990	1990-1994
	migration gains and losses, in millions			
Northeast	0.324	-2.888	-0.592	-0.616
Midwest	-0.752	-2.703	-2.293	0.154
South	0.593	5.992	5.143	2.626
West	2.855	4.115	4.568	1.513

Sources: U.S. Department of Commerce, Bureau of the Census, *1990 Census of Population and Housing,* CPH-2-1 (GPO, Washington, DC, 1993).

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Note: Migration is that portion of population change not attributed to births and deaths.

Table 6. U.S. Population Density, 1960-1994

Year	Total United States	Counties in coastal regions: Pacific	Gulf of Mexico	Atlantic	Great Lakes	Interior of U.S.
	Land area, in thousands of square miles					
1994	3,536.3	509.9	114.5	147.8	115.4	2,648.7
	Population, in millions					
1960	179.3	17.9	8.4	44.5	23.7	84.8
1970	203.3	22.8	10.0	51.1	26.0	93.3
1980	226.5	27.0	13.1	53.7	26.0	106.7
1990	248.7	33.2	15.2	59.0	26.9	115.3
1994	260.3	35.1	16.3	60.7	26.4	121.8
	Population per square mile					
1960	50.7	35.1	73.4	301.1	205.4	32.0
1970	57.5	44.7	87.3	345.7	225.3	35.2
1980	64.0	53.0	114.4	363.3	225.6	40.3
1990	70.3	66.1	136.2	399.2	224.8	43.5
1994	73.6	68.8	142.9	410.7	228.8	46.0

Source: U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1995* (GPO, Washington, DC, 1996), data from the 1990 Census of Population and Housing, and updates by agency.

Notes: Coastal area includes 672 counties and independent cities with at least 15 percent of their land area either in a coastal watershed or in a coastal cataloging unit defined in 1992 by the National Oceanic and Atmospheric Administration.

Table 7. U.S. Population Below Poverty Level by Race, Residence, and Region, 1969-1994

	Total		Race			Residence			Region			
Year	Number	Rate	White	African American	Hispanic origin	MA central city	MA suburb	Rural	Northeast	Midwest	South	West
	millions	*%*	*millions*									
1969	24.15	12.1	16.66	7.10	na	7.99	5.09	11.06	4.11	5.42	11.09	3.53
1970	25.42	12.6	17.48	7.55	na	8.12	5.20	12.10	na	na	11.48	na
1971	25.56	12.5	17.78	7.40	na	8.91	5.65	10.99	4.51	5.77	11.18	4.10
1972	24.46	11.9	16.20	7.71	na	9.18	5.33	9.95	4.27	5.26	10.93	4.01
1973	22.97	11.1	15.14	7.39	2.37	8.59	5.17	9.21	4.21	4.86	10.06	3.84
1974	23.37	11.2	15.74	7.18	2.58	8.37	5.48	9.52	4.47	4.99	10.76	4.04
1975	35.88	12.3	17.77	7.55	2.99	9.09	6.26	10.53	4.90	5.46	11.06	4.45
1976	24.98	11.8	16.71	7.60	2.78	9.48	5.75	9.75	4.95	5.66	10.35	4.02
1977	24.72	11.6	16.42	7.73	2.70	9.20	5.66	9.86	4.96	5.59	10.25	3.93
1978	24.50	11.4	16.26	7.63	2.61	9.29	5.81	9.41	5.05	5.19	10.26	4.00
1979	26.07	11.7	17.21	8.05	2.92	9.72	6.42	9.94	5.03	5.59	10.63	4.10
1980	29.27	13.0	19.70	8.58	3.49	10.64	7.38	11.25	5.37	6.59	12.36	4.96
1981	31.82	14.0	21.55	9.17	3.71	11.23	8.12	12.48	5.82	7.14	13.26	5.61
1982	34.40	15.0	23.52	9.70	4.30	12.70	8.55	13.15	6.36	7.77	13.97	6.30
1983	35.30	15.2	23.98	9.88	4.63	12.87	8.88	13.52	6.56	8.54	13.48	6.68
1984	33.70	14.4	22.96	9.49	4.81	na	na	na	6.53	8.30	12.79	6.07
1985	33.06	14.0	22.86	8.93	5.24	14.18	9.10	9.79	5.75	8.19	12.92	6.20
1986	32.37	13.6	22.18	8.98	5.12	13.30	9.36	9.71	5.21	7.64	13.11	6.41
1987	32.22	13.4	21.20	9.52	5.42	13.70	9.36	9.17	5.48	7.50	13.29	6.29
1988	31.75	13.0	20.72	9.36	5.36	13.62	9.44	8.69	5.09	6.80	13.53	6.32
1989	31.53	12.8	20.79	9.30	5.43	13.60	9.33	8.61	5.06	7.04	12.94	6.48
1990	33.59	13.5	22.33	9.84	6.01	14.25	10.26	9.08	5.79	7.46	13.46	6.88
1991	35.71	14.2	23.75	10.24	6.34	15.31	11.51	8.88	6.18	7.90	13.78	7.76
1992	38.01	14.8	25.26	10.83	7.59	16.35	12.03	9.63	6.41	8.06	15.20	8.34
1993	39.27	15.1	26.23	10.88	8.13	16.81	12.81	9.65	6.84	8.17	15.38	8.88
1994	38.06	14.5	25.38	10.20	8.42	16.10	13.51	8.45	6.60	7.97	14.73	8.77

Sources: U.S. Department of Commerce, Bureau of the Census, *Income, Poverty, and Valuation of Noncash Benefits: 1994,* Current Population Reports, P60-189 (GPO, Washington, DC, 1996).

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Notes: Total includes other races not shown separately. Persons of Hispanic origin may be of any race. Poverty rate (percent of persons below poverty level) for all races for years not shown are: 1959, 22.4; 1960, 22.2; 1961, 21.9; 1962, 21.0; 1963, 19.5; 1964, 19.0; 1965, 17.3; 1966, 14.7; 1967, 14.2; and 1968, 12.8. Poverty thresholds are updated annually to reflect changes in the consumer price index.

Table 8. Employment and Revenues in U.S. Environmental Industries, 1980 to 1994

Industry	Employment 1980	Employment 1990	Employment 1994	Revenues 1980	Revenues 1990	Revenues 1994
	thousands			*billions of dollars*		
Analytical services	6	20	20	0.4	1.5	1.6
Water treatment works	54	95	114	9.2	19.8	25.7
Solid waste management	83	210	230	8.5	26.1	31.0
Hazardous waste management	7	57	53	0.6	6.3	6.4
Remediation/industrial services	7	107	100	0.4	8.5	8.6
Consulting & engineering	21	144	163	1.5	12.5	15.3
Water equipment & chemicals	62	98	101	6.3	12.1	13.5
Instrument manufacturing	3	19	25	0.2	1.6	1.9
Air pollution control equipment	28	83	83	3.0	3.7	3.7
Waste management equipment	42	89	88	4.0	10.4	11.2
Process & prevention technology	2	9	15	0.1	0.4	0.8
Water utilities	77	105	118	11.9	19.8	24.2
Resource recovery	49	118	128	4.4	13.1	15.4
Environmental energy sources	22	21	24	1.5	1.8	2.2
Total	463	1,174	1,262	52.0	137.7	161.5

Source: Environmental Business International, Inc. *Environmental Business Journal*, (Environmental Business International, Inc., San Diego, CA, monthly).

Notes: Environmental industries covers approximately 59,000 private and public companies engaged in environmental activities. Analytical services covers environmental laboratory testing and services. Solid waste management covers activities such as collection, transportation, transfer stations, disposal, landfill ownership, and management for solid waste.

Economy and the Environment

Table 9. U.S. Gross Domestic Product, 1959-1995

Year	Gross domestic product: Current dollars	Gross domestic product: Chained (1992) dollars	Price deflators for GDP
	.... billions	....	(1992=100)
1959	507.2	2,212.3	22.9
1960	526.6	2,261.7	23.3
1961	544.8	2,309.8	23.6
1962	585.2	2,449.1	23.9
1963	617.4	2,554.0	24.2
1964	663.0	2,702.9	24.5
1965	719.1	2,874.8	25.0
1966	787.8	3,060.2	25.7
1967	833.6	3,140.2	26.5
1968	910.6	3,288.6	27.7
1969	982.2	3,388.0	29.0
1970	1,035.6	3,388.2	30.6
1971	1,125.4	3,500.1	32.2
1972	1,237.3	3,690.3	33.5
1973	1,382.6	3,902.3	35.4
1974	1,496.9	3,888.2	38.5
1975	1,630.6	3,865.1	42.2
1976	1,819.0	4,081.1	44.6
1977	2,026.9	4,279.3	47.4
1978	2,291.4	4,493.7	51.0
1979	2,557.5	4,624.0	55.3
1980	2,784.2	4,611.9	60.4
1981	3,115.9	4,724.9	65.9
1982	3,242.1	4,623.6	70.1
1983	3,514.5	4,810.0	73.1
1984	3,902.4	5,138.2	75.9
1985	4,180.7	5,329.5	78.4
1986	4,422.2	5,489.9	80.6
1987	4,692.3	5,648.4	83.1
1988	5,049.6	5,862.9	86.1
1989	5,438.7	6,060.4	89.7
1990	5,743.8	6,138.7	93.6
1991	5,916.7	6,079.0	97.3
1992	6,244.4	6,244.4	100.0
1993	6,550.2	6,383.8	102.6
1994	6,931.4	6,604.2	104.9
1995	7,247.7	6,740.8	107.6

Sources: U.S. Department of Commerce, Bureau of Economic Analysis, "Summary National Income and Product Series, 1959-94," *Survey of Current Business* 76:107-118 (GPO, Washington, DC, January/February 1996) and Tables 2 and 3, Gross Domestic Product Press Release, February 23, 1996.

Table 10. U.S. Pollution Abatement and Control Expenditures by Function, 1972-1994

Year	Pollution abatement		Regulation & monitoring		Research & development		Total	
	billion dollars	*price index*	*billion dollars*	*price index*	*billion dollars*	*price index*	*billion dollars*	*price index*
1972	15.45	31.5	0.37	31.6	0.82	30.0	16.64	31.5
1973	17.93	34.5	0.49	33.8	0.90	31.9	19.33	34.5
1974	21.85	40.6	0.60	37.6	0.99	35.4	23.43	40.4
1975	26.55	43.8	0.65	40.2	1.10	39.2	28.30	43.6
1976	29.80	46.3	0.73	42.4	1.28	41.8	31.80	46.2
1977	32.79	49.4	0.83	45.9	1.48	44.8	35.10	49.3
1978	36.90	53.2	0.95	49.0	1.65	48.6	39.50	53.0
1979	42.43	61.0	1.07	52.9	1.78	53.2	45.27	59.8
1980	47.75	67.9	1.26	58.9	1.75	59.8	50.76	67.4
1981	51.39	74.8	1.31	64.7	1.71	66.4	54.41	74.3
1982	52.99	77.8	1.32	69.7	1.64	71.5	55.95	77.5
1983	56.23	80.3	1.30	73.0	1.60	74.8	59.12	80.0
1984	63.26	82.8	1.29	75.7	1.51	77.6	66.06	82.5
1985	68.73	85.2	1.25	78.5	1.38	79.5	71.36	84.9
1986	72.91	84.8	1.46	81.4	1.67	80.5	76.04	84.6
1987	75.61	86.8	1.65	84.2	1.69	82.3	78.95	86.6
1988	80.55	89.3	1.66	86.4	1.54	86.3	83.75	89.2
1989	85.10	92.8	1.73	89.5	1.68	90.0	88.51	92.7
1990	91.61	96.1	1.79	92.9	1.42	93.0	94.82	95.9
1991	93.75	98.3	2.29	97.3	1.87	96.6	97.90	98.2
1992	100.46	100.0	2.60	100.0	1.56	100.0	103.83	100.0
1993	105.84	102.6	2.34	101.9	1.87	102.9	110.05	102.6
1994	117.62	106.0	2.20	101.5	1.99	103.2	121.81	105.8

Source: C.R. Vogan, "Pollution Abatement and Control Expenditures, 1972-94," *Survey of Current Business* (GPO, Washington, DC, September 1996).

Notes: Dollars=current dollars. Price index=chained-type price index, 1992=100. Expenditures are for goods and services that U.S. residents use to produce cleaner air and water and to manage solid waste. Pollution abatement directly reduces emissions by preventing the generation of pollutants, by recycling the pollutants, or by treating the pollutants prior to discharge. Regulation and monitoring are government activities that stimulate and guide action to reduce pollutant emissions. Research and development by business and government not only support abatement but also help increase the efficiency of regulation and monitoring. Estimates do not include interest costs. Totals may not agree with sum of components due to independent rounding.

Table 11. U.S. Pollution Abatement and Control Expenditures by Type, 1972-1994

Year	Air		Water		Solid waste		Other	
	billion dollars	*price index*	*billion dollars*	*price index*	*billion dollars*	*price index*	*billion dollars*	*price index*
1972	6.43	32.5	7.21	32.1	3.18	30.4	-0.19	38.3
1973	7.68	34.9	8.21	36.0	3.59	32.7	-0.15	49.8
1974	9.68	43.3	9.77	40.9	4.18	36.5	-0.19	72.0
1975	11.92	47.3	12.07	43.7	4.52	39.2	-0.22	76.2
1976	13.03	49.4	14.06	46.7	5.00	41.7	-0.28	77.3
1977	14.72	52.6	14.96	50.2	5.72	44.1	-0.29	79.1
1978	16.38	56.1	17.10	54.8	6.51	46.6	-0.39	85.8
1979	19.40	65.0	19.19	60.7	7.28	51.6	-0.59	103.9
1980	22.35	76.5	20.64	66.4	8.52	56.4	-0.75	122.2
1981	25.42	84.0	20.15	72.5	9.69	64.0	-0.86	130.6
1982	25.96	86.1	20.70	76.1	9.80	68.4	-0.52	120.3
1983	26.68	87.3	21.71	79.9	11.12	70.9	-0.39	111.1
1984	29.42	88.9	24.18	83.1	13.03	74.0	-0.56	111.9
1985	30.68	88.9	26.17	86.2	15.18	76.7	-0.66	103.2
1986	31.43	87.4	28.23	86.9	17.06	79.1	-0.69	92.7
1987	29.36	89.5	30.76	88.5	19.43	81.7	-0.61	96.8
1988	31.33	91.6	31.29	91.1	22.43	85.0	-1.30	102.7
1989	29.34	94.8	33.68	94.2	26.66	89.4	-1.17	108.3
1990	28.33	97.3	37.13	96.7	30.64	94.2	-1.28	111.1
1991	27.79	98.7	37.92	98.9	32.83	97.3	-0.63	104.0
1992	29.79	100.0	39.07	100.0	36.58	100.0	-0.81	100.0
1993	32.48	101.6	39.38	103.8	38.37	102.2	-0.18	0.97
1994	37.60	104.6	42.38	108.1	41.74	104.6	-0.09	-0.91

Source: C.R. Vogan, "Pollution Abatement and Control Expenditures, 1972-94," *Survey of Current Business* (GPO, Washington, DC, September 1996).

Notes: Dollars=current dollars. Price index=chained-type price index, 1992=100. Expenditures cover most, but not all, pollution abatement and control activities, which are defined as those resulting from rules, policies and conventions, and formal regulations restricting the release of pollutants into common-property media such as the air and water. Solid waste management includes the collection and disposal of solid waste and the alteration of production processes that generate less solid waste. Other consists of the value of reclaimed materials and energy that can not be assigned to a specific media category. Estimates do not include interest costs.

Table 12. U.S. Pollution Abatement Expenditures by Sector, 1972-1994

Year	Personal consumption		Business		Government	
	billion dollars	*price index*	*billion dollars*	*price index*	*billion dollars*	*price index*
1972	1.35	32.3	10.69	30.9	3.41	32.0
1973	1.86	34.4	12.20	34.1	3.86	34.7
1974	2.33	43.0	14.59	40.1	4.93	39.5
1975	3.25	46.2	16.41	44.0	6.89	41.1
1976	3.81	48.6	18.38	46.4	7.62	43.8
1977	4.34	51.3	21.04	49.6	7.41	46.8
1978	4.85	54.3	23.40	53.3	8.65	53.1
1979	5.52	65.5	26.97	59.7	9.94	51.6
1980	6.65	79.8	29.99	67.4	11.11	65.3
1981	8.20	86.5	32.51	74.7	10.68	67.4
1982	8.36	86.6	33.54	78.4	11.09	70.4
1983	9.76	86.9	35.02	80.9	11.45	74.1
1984	11.04	88.0	39.36	83.7	12.86	76.9
1985	12.16	90.1	42.04	85.6	14.54	80.9
1986	12.68	86.4	44.11	85.3	16.11	82.7
1987	11.34	89.5	46.74	87.0	18.54	84.7
1988	12.48	91.2	48.40	89.5	19.67	88.1
1989	11.09	94.0	52.23	93.2	21.77	91.1
1990	9.33	96.2	58.30	96.6	23.99	94.5
1991	7.43	97.5	61.09	98.6	25.23	97.9
1992	7.90	100.0	65.93	100.0	26.64	100.0
1993	8.44	102.5	69.01	102.7	28.39	102.5
1994	9.76	106.0	76.63	106.2	31.23	105.6

Source: C.R. Vogan, "Pollution Abatement and Control Expenditures, 1972-94," *Survey of Current Business* (GPO, Washington, DC, September 1996).

Notes: Dollars=current dollars. Price index=chained-type price index, 1992=100. Expenditures are attributed to the sector that performs the air or water pollution abatement or solid waste collection and disposal. Personal consumption refers to expenditures to purchase and operate motor vehicle emission abatement devices. Government refers to pollution abatement expenditures by federal, state, and local governments and to government enterprise fixed capital for publicly-owned electric utilities and public sewer systems. Data do not include interest costs.

Table 13. U.S. Pollution Abatement Expenditures by Industry, 1973-1994

	Chemicals and allied products								
	Capital expenditures				Operating costs				
Year	Air	Water	Solid waste	Total	Air	Water	Solid waste	Total	Cost offsets
				millions of current dollars					
1973	164.4	214.6	16.8	395.9	174.1	247.6	80.2	502.3	83.1
1974	250.6	264.4	24.1	539.2	203.8	335.6	104.0	643.3	104.5
1975	359.5	387.7	35.0	780.2	249.9	430.9	126.7	807.4	140.7
1976	319.8	577.4	44.7	942.0	295.6	514.7	173.2	983.5	188.7
1977	339.9	593.1	49.6	982.5	335.5	685.2	217.6	1,238.3	206.4
1978	376.3	385.9	65.1	827.5	398.8	794.1	280.1	1,473.0	231.3
1979	314.6	360.7	95.6	770.9	485.3	895.2	287.0	1,667.5	230.4
1980	325.9	350.0	104.8	780.7	539.9	942.9	368.8	1,851.8	305.9
1981	335.0	322.2	95.6	752.8	571.7	1,069.1	406.9	2,047.8	341.1
1982	272.8	256.5	98.3	627.6	556.1	1,112.3	438.2	2,106.5	345.2
1983	159.0	187.4	49.0	395.4	624.9	1,106.0	467.4	2,198.2	297.4
1984	142.9	212.4	32.7	418.1	622.0	1,206.3	517.1	2,345.4	357.5
1985	193.7	271.5	272.5	738.1	672.9	1,267.7	599.4	2,540.0	268.6
1986	197.8	325.5	101.0	624.4	646.5	1,301.8	705.9	2,654.3	336.4
1988	370.7	487.8	236.5	1,095.0	706.4	1,428.5	940.1	3,074.9	443.8
1989	380.3	598.6	215.9	1,194.8	794.0	1,613.8	1,101.4	3,509.2	395.9
1990	596.2	995.0	260.9	1,852.1	841.9	1,799.0	1,302.5	3,943.4	405.7
1991	816.4	942.3	307.5	2,066.1	879.6	1,786.9	1,380.5	4,046.9	353.7
1992	774.5	1,017.3	329.1	2,120.9	1,026.9	1,946.8	1,451.3	4,425.1	511.2
1993	767.5	937.9	252.5	1,957.9	1,013.6	1,957.0	1,377.6	4,348.2	362.1
1994	676.9	1,005.6	248.4	1,931.0	1,138.7	1,996.7	1,431.5	4,566.9	321.0
	Petroleum and coal products								
1973	222.5	96.1	3.2	321.8	192.5	125.4	19.9	337.8	44.3
1974	341.3	119.7	1.3	462.3	238.3	153.3	28.5	420.1	83.5
1975	398.2	155.7	1.7	555.7	339.4	192.1	31.7	563.1	137.7
1976	236.5	199.8	5.2	441.4	466.1	263.3	45.3	774.8	183.8
1977	167.7	195.6	5.3	368.5	601.3	289.3	57.4	948.0	238.4
1978	311.2	100.5	7.6	419.3	636.4	304.1	57.0	997.4	261.8
1979	397.8	119.4	17.1	534.3	750.7	370.8	25.3	1,173.8	324.1
1980	402.3	114.2	15.4	531.9	910.1	406.9	101.0	1,418.0	506.7
1981	440.8	131.7	18.2	590.6	1,118.0	437.2	130.2	1,685.5	565.6
1982	533.2	165.7	13.1	712.1	1,195.1	472.0	133.7	1,800.8	335.3
1983	308.2	164.7	12.0	485.0	1,203.6	552.3	137.9	1,893.7	524.9
1984	195.1	96.8	19.8	311.7	1,327.9	583.8	171.1	2,083.5	552.8
1985	175.0	88.4	27.0	290.4	1,278.5	586.5	198.5	2,063.4	500.0
1986	273.6	121.5	29.2	424.3	1,230.9	578.0	196.4	2,005.2	498.2
1988	208.2	203.7	70.8	482.8	1,175.8	561.7	268.0	2,005.5	480.0
1989	146.5	230.4	40.7	417.6	1,258.2	578.7	333.0	2,170.0	523.1
1990	425.7	400.8	90.3	916.8	1,472.2	701.9	530.8	2,704.9	562.0
1991	996.7	373.3	92.5	1,462.5	1,464.7	793.9	590.4	2,849.0	480.5
1992	2,079.8	492.6	112.6	2,685.0	1,428.9	742.8	413.7	2,585.4	475.9
1993	1,974.7	567.2	106.6	2,648.5	1,585.3	685.2	377.4	2,647.9	419.4
1994	1,982.3	466.9	122.9	2,572.0	1,742.0	755.7	417.2	2,914.9	337.8

See next page for continuation of table.

Table 13. U.S. Pollution Abatement Expenditures by Industry, 1973-1994 (continued)

	Primary metal industries								
	Capital expenditures				Operating costs				
Year	Air	Water	Solid waste	Total	Air	Water	Solid waste	Total	Cost offsets
	millions of current dollars								
1973	397.2	84.7	16.8	498.6	264.7	148.3	53.8	466.8	51.5
1974	510.5	132.7	12.5	646.8	339.6	181.2	69.5	590.2	76.9
1975	640.6	187.5	5.4	833.5	429.9	209.4	75.9	715.2	95.3
1976	632.5	197.8	3.4	833.7	575.7	229.5	90.7	895.8	100.7
1977	616.0	250.2	8.4	874.6	721.6	268.3	132.3	1,122.3	126.3
1978	563.3	219.1	9.4	791.8	809.6	333.0	178.9	1,321.4	141.7
1979	588.8	227.3	6.9	823.1	981.7	442.0	163.5	1,587.2	241.8
1980	539.7	180.7	19.6	740.0	998.2	463.2	215.3	1,677.3	169.5
1981	567.2	144.1	16.9	728.2	1,111.9	549.2	250.7	1,911.8	189.7
1982	423.1	133.7	13.0	569.8	897.2	448.4	167.6	1,513.6	148.5
1983	147.6	100.2	7.5	225.3	904.3	454.6	256.7	1,615.6	95.4
1984	175.2	72.9	26.0	274.0	1,017.3	450.7	301.7	1,769.7	171.6
1985	142.9	84.3	25.6	252.9	1,067.0	517.4	278.7	1,863.0	136.8
1986	102.8	74.6	48.4	225.9	968.5	509.4	264.1	1,721.9	184.6
1988	167.3	100.6	41.8	309.8	965.8	516.1	327.2	1,809.0	189.8
1989	216.3	138.7	52.1	407.0	883.1	574.3	473.7	1,931.1	190.4
1990	278.6	166.8	53.7	499.1	943.7	565.4	516.4	2,025.5	206.3
1991	499.2	131.9	42.2	673.4	911.7	564.0	526.9	2,002.6	185.1
1992	342.6	123.5	59.5	525.7	933.1	575.0	485.3	1,993.4	164.2
1993	280.7	92.0	69.5	442.2	944.5	598.2	474.6	2,017.2	136.4
1994	290.1	98.5	39.4	428.0	982.1	692.2	537.2	2,211.5	133.8
	Transportation equipment								
1973	52.6	41.7	6.9	101.2	35.2	51.1	43.4	129.8	20.1
1974	52.7	41.5	9.2	103.4	44.8	59.5	50.5	154.8	13.6
1975	32.1	36.4	6.8	75.4	52.2	66.4	49.7	168.3	13.4
1976	21.1	53.6	3.8	78.5	56.9	83.5	57.6	197.9	14.5
1977	36.9	39.4	6.3	82.6	60.6	97.3	76.1	233.9	13.5
1978	71.0	57.9	10.7	139.5	77.3	110.2	93.0	280.5	16.6
1979	120.1	59.5	9.9	189.5	96.4	126.3	109.1	331.8	36.9
1980	201.4	60.7	12.9	275.0	110.7	137.4	153.2	401.5	24.6
1981	209.2	60.0	14.2	283.3	117.5	150.7	157.7	426.1	19.3
1982	59.7	36.5	12.1	108.3	105.6	153.5	137.6	396.5	18.2
1983	33.0	55.0	10.2	98.3	157.5	224.2	178.6	560.3	22.3
1984	71.3	116.9	19.4	207.6	192.9	280.1	212.6	685.6	22.7
1985	254.5	165.1	36.9	456.5	194.5	283.9	260.3	738.8	23.7
1986	432.4	81.8	26.8	541.1	195.7	338.5	304.9	839.0	28.2
1988	87.6	80.4	42.2	210.2	215.7	299.2	459.5	974.4	38.7
1989	156.0	84.6	46.2	286.8	212.2	318.1	470.1	1,000.3	43.1
1990	206.6	142.6	46.1	395.3	247.3	373.1	611.6	1,232.0	41.2
1991	175.8	94.7	30.8	301.4	254.7	319.6	544.0	1,118.3	45.9
1992	179.4	69.2	32.5	281.0	298.5	347.0	526.2	1,171.7	68.7
1993	178.7	67.1	31.8	277.6	302.4	350.9	541.2	1,194.4	64.1
1994	244.8	60.8	31.3	336.9	293.7	342.5	480.2	1,116.4	71.4

See next page for continuation of table.

Table 13. U.S. Pollution Abatement Expenditures by Industry, 1973-1994 (continued)

Year	Capital expenditures: Air	Capital expenditures: Water	Capital expenditures: Solid waste	Capital expenditures: Total	Operating costs: Air	Operating costs: Water	Operating costs: Solid waste	Operating costs: Total	Cost offsets
	millions of current dollars								
	Food and kindred products								
1973	77.6	104.8	14.3	196.7	39.1	110.4	53.6	203.1	32.6
1974	73.4	111.7	14.3	199.2	48.8	143.5	76.8	268.9	52.2
1975	75.6	93.9	11.4	180.9	53.2	153.7	87.7	294.2	62.6
1976	102.5	97.6	7.4	207.5	57.7	187.5	100.5	345.9	63.7
1977	67.9	103.6	12.5	183.9	56.2	211.6	89.5	357.1	53.3
1978	67.7	94.4	12.9	175.0	69.4	243.2	99.4	412.0	57.1
1979	57.9	111.1	13.6	182.7	91.0	297.9	115.3	504.2	80.3
1980	61.7	133.0	13.5	208.2	81.6	314.3	123.6	519.4	79.5
1981	53.9	104.8	14.8	173.5	78.3	343.3	157.5	579.1	91.2
1982	47.4	110.9	11.0	169.3	77.1	328.1	116.2	522.1	51.1
1983	37.7	105.1	10.9	153.8	96.1	402.3	151.3	649.6	32.7
1984	50.6	91.8	12.2	154.5	101.3	458.1	155.0	714.4	43.7
1985	66.2	77.4	11.7	155.1	106.3	525.2	201.0	832.1	33.4
1986	61.9	108.2	15.7	185.8	126.0	559.9	246.1	932.1	w/h
1988	100.2	91.0	19.8	211.0	157.8	673.3	328.9	1,160.0	110.6
1989	51.7	183.6	25.2	260.6	137.4	663.5	255.3	1,056.2	82.0
1990	64.6	163.3	21.1	249.0	145.9	692.4	270.4	1,108.8	87.0
1991	94.6	359.5	27.7	481.8	149.6	788.5	316.1	1,254.2	71.6
1992	85.1	202.6	29.1	316.8	162.7	835.7	313.6	1,312.0	82.2
1993	73.9	113.6	32.4	219.9	156.1	857.8	325.4	1,339.3	65.1
1994	105.9	152.8	15.5	274.3	172.4	940.5	334.7	1,447.6	91.5
	Paper and allied products								
1973	166.4	161.0	12.1	339.6	59.2	118.1	43.2	220.5	54.6
1974	270.8	193.2	12.9	476.9	81.2	152.0	55.7	289.0	84.8
1975	323.0	266.0	16.3	605.3	100.9	185.5	57.5	344.0	112.2
1976	180.6	278.6	27.3	486.6	123.3	239.1	67.3	430.3	137.6
1977	134.1	261.7	31.6	427.4	133.5	309.0	86.4	529.0	150.8
1978	123.9	189.0	28.7	341.6	158.4	357.6	105.6	622.0	175.6
1979	207.0	180.6	38.8	426.4	176.6	400.5	121.1	698.2	161.5
1980	197.4	111.2	31.0	339.6	196.2	436.7	129.1	762.1	248.1
1981	168.0	86.5	31.1	285.5	211.8	469.9	148.0	829.7	298.5
1982	190.0	93.7	29.7	313.4	206.7	455.2	134.1	796.0	213.7
1983	122.3	65.9	27.9	216.1	226.5	508.9	183.6	919.1	255.3
1984	151.9	68.2	42.1	262.3	280.7	566.1	213.2	1,060.1	118.4
1985	190.9	106.0	35.6	332.4	313.0	573.4	234.4	1,120.8	107.3
1986	137.1	96.9	37.3	271.3	319.2	565.7	269.7	1,154.6	133.8
1988	233.4	97.2	87.1	417.7	372.4	627.7	343.2	1,343.3	245.6
1989	392.4	261.0	154.9	808.2	388.1	686.8	374.2	1,449.0	264.9
1990	414.0	509.6	151.7	1,075.2	397.5	788.3	421.0	1,606.8	266.4
1991	480.8	552.7	199.0	1,232.6	400.8	790.7	443.5	1,635.0	170.4
1992	396.7	373.4	234.5	1,004.6	535.6	822.7	502.4	1,860.7	254.6
1993	307.3	289.2	119.2	715.6	511.2	852.7	537.5	1,901.5	234.0
1994	241.9	195.9	198.1	635.9	536.9	829.5	513.1	1,879.5	285.1

See next page for continuation of table.

Table 13. U.S. Pollution Abatement Expenditures by Industry, 1973-1994 (continued)

	Rubber and miscellaneous plastic products								
	Capital expenditures				Operating costs				
Year	Air	Water	Solid waste	Total	Air	Water	Solid waste	Total	Cost offsets
	millions of current dollars								
1973	13.5	7.3	3.3	24.2	12.2	10.1	20.4	42.6	4.6
1974	22.2	13.5	2.2	37.9	15.7	15.1	28.2	58.8	19.5
1975	22.2	6.6	3.1	31.9	20.7	18.4	25.7	64.8	12.5
1976	24.2	10.0	3.1	37.4	22.3	24.0	34.0	80.3	15.8
1977	17.4	13.8	5.4	36.6	19.8	18.9	35.1	73.8	7.7
1978	18.7	5.5	3.4	27.7	17.7	23.9	43.3	84.9	8.0
1979	12.9	9.3	2.9	25.1	32.2	29.6	49.9	111.7	13.6
1980	12.6	6.9	2.3	21.7	30.4	27.6	50.2	108.2	18.1
1981	15.3	5.9	6.5	21.8	29.8	29.4	58.8	118.3	14.0
1982	14.8	7.7	2.7	25.2	22.2	28.2	39.8	90.2	7.0
1983	12.0	3.8	7.8	23.6	50.9	52.8	62.0	165.8	6.6
1984	20.5	7.0	5.8	33.4	51.1	48.7	68.1	168.0	9.9
1985	21.3	3.2	5.2	29.7	46.7	55.6	90.8	193.1	10.0
1986	20.1	9.7	6.2	36.0	50.9	52.0	123.3	226.2	15.1
1988	21.7	11.3	7.8	40.7	62.5	62.2	153.3	277.9	18.7
1989	50.3	16.0	12.0	78.2	85.3	99.6	218.4	403.3	25.6
1990	68.9	11.0	13.9	93.8	96.6	113.4	217.6	427.6	24.3
1991	50.8	18.8	12.2	81.7	121.0	76.9	243.0	440.9	29.4
1992	71.1	18.2	7.3	96.7	105.7	73.3	200.5	379.6	26.7
1993	44.0	11.6	7.6	63.3	104.6	83.5	197.1	385.2	24.9
1994	52.4	17.2	5.6	75.2	119.2	90.7	229.8	439.6	35.5

Source: U.S. Department of Commerce, Bureau of the Census, *Pollution Abatement Costs and Expenditures*, Current Industrial Reports (GPO, Washington, DC, annual).

Notes: Data for 1987 not available. w/h=withheld by industry. Data are for selected industries; do not include all industries covered in the survey.

Public Lands and Recreation

Table 14. U.S. Federal Lands, 1900-1995

Year	National Park System	National Wildlife Refuge System	National Forest System	Other federal lands	Total
			million acres		
1900	4.1	na	46.5	850.0	900.6
1910	7.9	na	168.0	423.9	599.8
1920	9.9	na	165.0	324.0	498.9
1930	10.8	na	160.1	324.1	495.0
1940	22.3	na	174.8	215.9	413.0
1950	24.6	17.5	179.7	190.2	412.0
1960	26.2	17.9	180.8	546.6	771.5
1970	29.6	30.7	182.6	518.4	761.3
1980	77.0	71.9	183.1	387.5	719.5
1990	80.1	90.6	187.1	292.0	649.8
1993	80.3	91.5	187.2	291.3	650.3
1995	83.2	92.3	187.3	287.5	na

Sources: U.S. Department of Agriculture (USDA), Forest Service (FS), *Land Areas of the National Forest System* (USDA, FS, Washington, DC, annual).

U.S. Department of the Interior (DOI), Fish and Wildlife Service (FWS), *Lands Under the Control of the Fish and Wildlife Service* (DOI, FWS, Washington, DC, annual).

U.S. Department of the Interior (DOI), National Park Service (NPS), *Areas Administered by the National Park Service: Information Tables* (DOI, NPS, Washington, DC, annual).

U.S. General Services Administration (GSA), *Inventory Report of Real Property Owned by the United States Throughout the World* (GSA, Washington, DC, annual).

Notes: na=not available. Data reflect year-end cumulative totals. Prior to 1950, estimated from imperfect data. Prior to 1960, excludes Alaska and Hawaii.

Table 15. National Wilderness Preservation System and National Wild and Scenic River System, 1968-1995

Year	National Wilderness Preservation System	National Wild and Scenic River System
	million acres	*river miles*
1968	10.03	773
1969	10.19	773
1970	10.40	868
1971	10.40	868
1972	11.03	895
1973	11.03	961
1974	11.38	1,018
1975	12.72	1,145
1976	14.45	1,610
1977	14.49	1,610
1978	19.00	2,299
1979	19.00	2,299
1980	79.71	5,662
1981	79.84	6,908
1982	79.88	6,908
1983	80.21	6,908
1984	88.55	7,217
1985	88.70	7,224
1986	88.80	7,363
1987	88.99	7,709
1988	90.81	9,264
1989	91.46	9,281
1990	94.97	9,318
1991	95.03	9,463
1992	95.39	10,506
1993	95.44	10,516
1994	103.72	10,616
1995	na	10,734

Sources: U.S. Department of Agriculture, Forest Service, National Wilderness Preservation System Fact Sheet, unpublished, Washington, DC, annual.

U.S. Department of the Interior, National Park Service, River Mileage Classifications for Components of the National Wild and Scenic River System, unpublished, Washington, DC, annual.

Notes: na=not available. Data reflect year-end cumulative totals.

Table 16. National Estuarine Research Reserves and National Marine Sanctuaries, 1975-1995

Year	Estuarine Research Reserves		Marine Sanctuaries	
	number	*acres*	*number*	*sq. nmi.*
1975	1	4,700	2	101.0
1976	3	14,205	2	101.0
1977	3	14,205	2	101.0
1978	4	22,605	2	101.0
1979	5	216,363	2	101.0
1980	9	223,426	3	1,353.0
1981	11	229,652	6	2,323.0
1982	14	240,571	6	2,323.0
1984	15	242,121	6	2,323.0
1986	16	245,149	7	2,323.3
1987	16	245,149	7	2,323.3
1988	17	247,348	7	2,323.3
1989	18	253,477	8	2,720.3
1990	18	259,945	9	5,320.3
1991	19	399,302	9	5,320.3
1992	21	400,559	13	11,324.3
1993	22	401,570	13	11,324.3
1994	22	433,864	14	13,824.3
1995	22	433,865	14	13,824.3

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Office of Ocean and Coastal Resources Management, Sanctuaries and Reserves Division, unpublished, Washington, DC, 1996.

Notes: sq. nmi.=square nautical miles. Data are year-end cumulative totals.

Table 17. National Register of Historic Places, 1967-1995

Year	Properties listed	Properties removed	Year	Properties listed	Properties removed
	number			*number*	
1967	873	2	1982	29,999	420
1968	903	3	1983	35,112	434
1969	1,106	4	1984	39,121	440
1970	1,888	19	1985	42,538	445
1971	3,026	51	1986	45,936	452
1972	4,376	93	1987	48,254	525
1973	6,646	144	1988	51,286	574
1974	8,247	188	1989	53,838	635
1975	10,805	231	1990	56,688	651
1976	12,561	265	1991	58,209	683
1977	14,203	290	1992	60,500	716
1978	16,575	338	1993	62,095	749
1979	20,589	366	1994	63,710	792
1980	24,680	403	1995	65,255	810
1981	26,499	406			

Source: U.S. Department of the Interior, National Park Service, The National Register of Historic Places, unpublished, Washington, DC, 1996.

Note: Data are year-end cumulative totals.

Table 18. Recreational Fishing and Hunting in the United States, 1955-1991

	Fishermen			Hunters				Total
Year	Fresh-water	Salt-water	Total	Small game	Big game	Water-fowl	Total	sports-men
				millions				
1955	18.42	4.56	20.81	9.82	4.41	1.99	11.78	24.92
1960	21.68	6.29	25.32	12.11	6.28	1.96	14.64	30.44
1965	23.96	8.31	28.34	10.58	6.57	1.65	13.58	32.88
1970	29.36	9.46	33.15	11.67	7.77	2.89	14.34	36.28
1975	36.60	13.74	41.29	14.18	11.04	4.28	17.09	45.77
1980	35.78	11.97	41.87	12.50	11.05	3.18	16.76	46.97
1985	39.12	12.89	45.35	11.13	12.58	3.20	16.34	49.83
1991	31.04	8.89	39.93	7.64	10.75	3.01	22.81	62.74

	Fishing days			Hunting days				Total
Year	Fresh-water	Salt-water	Total	Small game	Big game	Water-fowl	Total	sporting days
				millions				
1955	338.83	58.62	397.45	118.63	30.83	19.96	169.42	566.87
1960	385.17	80.60	465.77	138.19	39.19	15.16	192.54	658.31
1965	426.92	95.84	522.76	128.45	43.85	13.53	185.82	708.58
1970	592.49	113.69	706.19	124.04	54.54	25.11	203.69	909.88
1975	890.58	167.50	1,050.08	269.65	100.60	31.22	401.48	1,459.55
1980	788.39	164.04	952.42	225.79	117.41	26.18	348.54	1,300.98
1985	895.03	171.06	1,064.99	214.54	135.45	25.93	350.39	1,415.38
1991	439.54	74.70	514.24	77.13	128.41	22.24	227.78	761.33

Source: U.S. Department of the Interior (DOI), Fish and Wildlife Service (FWS), *National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* (DOI, FWS, Washington, DC, 1993).

Notes: Number of fishermen and hunters includes persons 12 years and older. Totals may not agree with sum of components due to independent rounding and where sportsmen participate in more than one activity per outing. The 1991 data are not strictly comparable with previous years' data due to changes in survey methodology.

Table 19. U.S. Marine Recreational Fishing, 1979-1995

	Atlantic and Gulf Coasts		Pacific Coast	
Year	Number of fish caught	Number of angler trips	Number of fish caught	Number of angler trips
	millions			
1979	439	63	49	8
1980	463	74	84	15
1981	331	52	51	11
1982	371	61	53	11
1983	398	69	45	11
1984	356	62	47	10
1985	382	71	43	10
1986	407	62	55	11
1987	272	51	46	10
1988	291	59	51	12
1989	249	49	41	9
1990	250	46	na	na
1991	385	58	na	na
1992	292	53	na	na
1993	284	51	31	7
1994	331	58	31	8
1995	312	58	28	8

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *Fisheries of the United States 1995*(GPO, Washington, DC, 1996).

Notes: na=not available. No data available for the Pacific Coast for 1990, 1991, and 1992. The 1993-1995 data for the Pacific Coast do not include Washington. Data for 1995 are preliminary.

Table 20. Visits to U.S. Federal Recreation Areas, 1977-1993

Year	National Park Service	U.S. Fish and Wildlife Service	Bureau of Reclamation	National Forest System	Army Corps of Engineers	Bureau of Land Mgt.
	million visits	*million visitors*		*million visitor days*		
1977	na	27	55	205	424	na
1978	na	26	63	219	439	na
1979	na	25	59	220	449	na
1980	198	23	60	234	457	na
1981	211	26	69	236	469	64
1982	214	24	63	233	480	40
1983	217	22	66	228	480	42
1984	218	23	76	228	482	34
1985	216	24	76	225	502	31
1986	237	25	80	237	506	36
1987	246	25	80	239	181	64
1988	250	26	82	242	191	57
1989	256	26	84	253	191	50
1990	263	27	80	263	190	70
1991	268	28	80	279	192	68
1992	275	28	83	287	203	65
1993	273	28	84	296	200	39

Sources: U.S. Army Corps of Engineers, Directorate of Civil Works, Operations, Construction and Readiness Division, Natural Resources Management Branch, Visitation to Corps Recreation Areas, unpublished, Washington, DC, 1994.

U.S Department of Agriculture, Forest Service, Recreation Information Management System, unpublished, Washington, DC, 1994.

U.S. Department of the Interior (DOI), Bureau of Land Management (BLM), *Public Land Statistics* (DOI, BLM, Washington, DC, annual).

U.S. Department of the Interior, Bureau of Reclamation, Utilization of Recreation Areas on Reclamation Projects, unpublished, Denver, CO, 1994.

U.S. Department of the Interior, Fish and Wildlife Service, Refuge Division, Public Use Statistics Through 1987, With Estimates for 1988-1993, unpublished, Washington, DC, 1994.

U.S. Department of the Interior (DOI), National Park Service (NPS), Statistical Office, *National Park Statistical Abstract*, (DOI, NPS, Denver, CO, annual).

Ecosystems and Biodiversity

Table 21. Trends in Selected U.S. Resident and Neotropical Migrant Birds, 1966-1994, 1966-1979, and 1980-1994

	Resident birds		
Common name	Long-term trend (1966-1994)	Mid-term trend (1966-1979)	Short-term trend (1980-1994)
	% change per year		
Northern bobwhite	- 2.4	- 1.0	- 2.8
Great horned owl	1.8	3.1	na
Downy woodpecker	- 0.3	0.1	- 0.3
Hairy woodpecker	- 0.2	1.9	- 0.3
Pileated woodpecker	1.3	1.0	1.1
Red-cockaded woodpecker	- 1.5	8.6	- 13.0
Black-capped chickadee	1.7	1.6	0.2
Carolina chickadee	- 0.8	- 0.8	- 1.7
Tufted titmouse	0.8	- 1.9	2.4
Brown-headed nuthatch	- 1.7	- 2.0	- 2.1
Carolina wren	0.9	0.1	3.0
American robin	0.9	0.7	0.8
Eastern bluebird	2.4	- 4.9	4.7
Northern mockingbird	- 1.0	- 2.0	0.5
Northern cardinal	- 0.1	- 0.8	0.9
House sparrow	- 1.8	- 0.7	- 3.5

	Neotropical migrant birds		
Common name	Long-term trend (1966-1994)	Mid-term trend (1966-1979)	Short-term trend (1980-1994)
	% change per year		
Yellow-billed cuckoo	- 1.4	3.2	- 3.2
Chuck-will's-widow	- 1.4	- 1.0	- 0.3
Whip-poor-will	- 1.2	- 2.0	na
Ruby-throated hummingbird	1.2	1.2	1.7
Eastern wood pewee	- 1.7	- 2.1	- 1.2
Least flycatcher	- 1.6	- 2.3	- 0.5
Olive-sided flycatcher	- 4.1	- 2.3	- 3.7
Yellow-bellied flycatcher	0.1	2.6	5.3
Great-crested flycatcher	0.2	0.6	na
Veery	- 1.1	0.8	- 1.8
Wood thrush	- 1.7	0.5	- 1.0
Gray catbird	- 0.2	0.5	0.3
White-eyed vireo	- 0.0	0.2	0.7
Red-eyed vireo	1.0	2.2	1.4
Solitary vireo	3.3	3.2	4.3
Golden-winged warbler	- 3.6	- 3.2	0.1
Tennessee warbler	6.3	8.3	11.7
Northern parula	0.1	0.4	- 0.3

See next page for continuation of table.

Table 21. Trends in Selected U.S. Resident and Neotropical Migrant Birds, 1966-1994, 1966-1979, and 1980-1994 (continued)

	Neotropical migrant birds		
Common name	Long-term trend (1966-1994)	Mid-term trend (1966-1979)	Short-term trend (1980-1994)
	% change per year		
Cape May warbler	- 7.9	15.1	-16.4
Blue-winged warbler	0.4	1.4	- 0.8
Prairie warbler	- 2.7	- 5.3	- 1.2
Cerulean warbler	- 4.3	- 5.7	- 0.6
Blackpoll warbler	- 0.2	9.7	- 1.0
Chestnut-sided warbler	- 0.4	0.2	- 0.6
Wilson's warbler	0.2	- 2.0	- 1.8
Nashville warbler	1.1	- 2.8	- 0.2
Kentucky warbler	- 1.0	0.2	- 2.0
American redstart	- 0.7	- 1.2	- 0.3
Prothonotary warbler	- 1.6	1.0	- 2.3
Ovenbird	1.2	0.7	1.7
Northern waterthrush	0.0	4.7	- 2.6
Louisiana waterthrush	0.3	0.6	- 1.1
Common yellowthroat	- 0.2	0.7	- 0.9
Yellow-breasted chat	- 0.5	- 3.5	1.1
Scarlet tanager	0.2	3.3	- 0.6
Summer tanager	- 0.2	0.2	- 0.6
Baltimore oriole	- 0.4	2.0	- 2.2
Orchard oriole	- 1.9	- 2.6	- 1.1
Rose-breasted grosbeak	0.0	3.3	- 1.9
Indigo bunting	- 0.7	0.1	- 1.1

Source: U.S. Department of the Interior, National Biological Service, Breeding Bird Survey, unpublished, Laurel, MD, 1996.

Table 22. North American Duck Population Estimates, 1955-1995

Year	Northern pintail	Mallard	Canvasback	Redhead	Gadwall	Green wing teal	Blue wing teal	Scaup	Am. widgeon	No. shoveler	Black duck (Atl)	Black duck (Miss)
						millions						
1955	9.78	8.78	0.59	0.54	0.65	1.81	5.31	5.62	3.32	1.64	0.58	0.18
1956	10.37	10.45	0.70	0.76	0.77	1.53	5.00	5.99	3.15	1.78	0.42	0.21
1957	6.61	9.30	0.63	0.51	0.67	1.10	4.30	5.77	2.92	1.48	0.42	0.23
1958	6.04	11.23	0.75	0.46	0.50	1.35	5.46	5.35	2.56	1.38	0.28	0.26
1959	5.87	9.02	0.49	0.60	0.59	2.65	5.10	7.04	3.79	1.58	0.31	0.18
1960	5.72	7.37	0.61	0.60	0.78	1.43	4.29	4.87	2.99	1.83	0.34	0.17
1961	4.22	7.33	0.44	0.32	0.65	1.73	3.66	5.38	3.05	1.38	0.32	0.16
1962	3.62	5.54	0.36	0.51	0.91	0.72	3.01	5.29	1.96	1.27	0.34	0.11
1963	3.85	6.75	0.51	0.41	1.06	1.24	3.72	5.44	1.83	1.40	0.33	0.14
1964	3.29	6.06	0.64	0.53	0.87	1.56	4.02	5.13	2.59	1.72	0.37	0.22
1965	3.59	5.13	0.52	0.60	1.26	1.28	3.60	4.64	2.30	1.42	0.33	0.16
1966	4.81	6.73	0.66	0.71	1.68	1.62	3.73	4.44	2.32	2.15	0.30	0.15
1967	5.28	7.51	0.50	0.74	1.38	1.59	4.49	4.93	2.33	2.32	0.29	0.21
1968	3.49	7.09	0.56	0.50	1.95	1.43	3.46	4.41	2.30	1.69	0.34	0.14
1969	5.90	7.53	0.50	0.63	1.57	1.49	4.14	5.14	2.94	2.16	0.33	0.15
1970	6.39	9.99	0.58	0.62	1.61	2.18	4.86	5.66	3.47	2.23	0.28	0.14
1971	5.85	9.42	0.45	0.53	1.61	1.89	4.61	5.14	3.27	2.01	0.26	0.13
1972	7.00	9.27	0.43	0.55	1.62	1.95	4.28	8.00	3.20	2.47	0.27	0.14
1973	4.36	8.08	0.62	0.50	1.25	1.95	3.33	6.26	2.88	1.62	0.27	0.15
1974	6.60	6.88	0.51	0.63	1.59	1.87	4.98	5.78	2.67	2.01	0.25	0.08
1975	5.90	7.73	0.60	0.83	1.64	1.67	5.89	6.46	2.78	1.98	0.24	0.12
1976	5.48	7.93	0.61	0.67	1.25	1.55	4.75	5.82	2.51	1.75	0.28	0.15
1977	3.93	7.40	0.66	0.63	1.30	1.29	4.46	6.26	2.58	1.45	0.26	0.10
1978	5.11	7.43	0.37	0.73	1.56	2.17	4.50	5.98	3.28	1.98	0.27	0.09
1979	5.38	7.88	0.58	0.70	1.76	2.07	4.88	7.66	3.11	2.41	0.24	0.08
1980	4.51	7.71	0.74	0.73	1.39	2.05	4.90	6.38	3.60	1.91	0.20	0.08
1981	3.48	6.41	0.62	0.60	1.40	1.91	3.72	5.99	2.95	2.33	0.24	0.08
1982	3.71	6.41	0.51	0.62	1.63	1.54	3.66	5.53	2.46	2.15	0.24	0.07
1983	3.51	6.46	0.53	0.72	1.52	1.88	3.37	7.17	2.64	1.88	0.20	0.09
1984	2.97	5.42	0.53	0.67	1.52	1.41	4.00	6.02	3.20	1.62	0.23	0.06
1985	2.52	4.96	0.38	0.58	1.30	1.86	3.50	5.10	2.05	1.70	0.22	0.06
1986	2.74	6.12	0.44	0.56	1.55	1.68	4.48	5.24	1.74	2.13	0.23	0.10
1987	2.63	5.79	0.45	0.50	1.31	2.01	3.53	4.86	2.01	1.95	0.20	0.07
1988	2.01	6.37	0.44	0.44	1.35	2.06	4.01	4.67	2.21	1.68	0.23	0.11
1989	2.11	5.65	0.48	0.51	1.42	1.84	3.13	4.34	1.97	1.54	0.24	0.07
1990	2.26	5.45	0.54	0.48	1.67	1.80	2.78	4.29	1.86	1.76	0.23	0.01
1991	1.80	5.45	0.49	0.45	1.58	1.56	3.77	5.26	2.25	1.72	0.23	0.05
1992	2.10	5.98	0.48	0.60	2.03	1.77	4.33	4.64	2.21	1.95	0.20	0.08
1993	2.05	5.71	0.47	0.49	1.76	1.70	3.19	4.08	2.05	2.05	0.21	0.08
1994	2.97	6.98	0.53	0.65	2.32	2.11	4.62	4.53	2.38	2.91	0.22	0.08
1995	2.76	8.27	0.77	0.89	2.84	2.30	5.14	4.45	2.62	2.86	0.22	0.09

Source: U.S. Department of the Interior (DOI), Fish and Wildlife Service (FWS), Office of Migratory Bird Management in Conjunction with the Canadian Wildlife Service, *Status of Waterfowl and Fall Flight Forecast* (DOI, FWS, Washington, DC, annual).

Notes: No.=Northern. Am.=American. Alt=Atlantic Flyway. Miss=Mississippi River Flyway.

Table 23. North American Goose and Swan Population Estimates, 1970-1995

Year	Canada goose	Snow goose	Greater white-fronted goose	Brant	Tundra swan Eastern	Tundra swan Western
	millions		*thousands*			
1970	1.608	0.818	50.6	141.7	55	31
1971	1.653	1.116	39.3	300.2	58	99
1972	1.733	1.413	45.8	197.8	63	83
1973	1.841	1.084	43.0	166.0	57	34
1974	1.838	1.285	43.2	218.7	64	70
1975	1.850	1.167	40.2	211.4	67	54
1976	2.372	1.679	53.4	249.0	79	51
1977	2.417	1.311	50.4	221.0	76	47
1978	2.158	2.072	53.1	208.9	70	46
1979	2.088	1.415	49.3	173.4	79	54
1980	2.170	1.525	132.1	215.4	64	65
1981	2.461	1.524	161.0	291.2	93	84
1982	2.192	1.916	182.1	227.0	73	91
1983	2.488	1.871	153.7	233.3	87	67
1984	2.262	1.642	183.2	260.4	81	62
1985	2.557	2.209	181.5	290.8	94	49
1986	2.708	1.615	172.4	246.2	91	66
1987	2.714	2.079	178.6	219.9	95	53
1988	2.848	1.995	207.3	278.0	77	59
1989	3.097	2.222	278.0	273.2	91	79
1990	3.706	1.994	322.1	287.0	90	40
1991	3.880	2.439	376.5	279.4	97	49
1992	3.574	2.386	409.4	302.5	110	64
1993	3.020	1.971	330.1	225.0	76	62
1994	3.487	2.505	449.4	287.2	84	79
1995	3.441	3.225	459.2	281.9	81	53

Source: U.S. Department of the Interior (DOI), Fish and Wildlife Service (FWS), Office of Migratory Bird Management in Conjunction with the Canadian Wildlife Service, *Status of Waterfowl and Fall Flight Forecast* (DOI, FWS, Washington, DC, annual).

Notes: Data for Canada goose are aggregate population totals for 13 separate populations that nest in North America. Data for snow goose are aggregate population totals for the greater snow goose, lesser snow goose, and Ross' goose populations. The 1995 survey of the western tundra swan population was incomplete.

Table 24. Status of Marine Mammal Stocks in U.S. Waters, 1995

Marine mammals of the Pacific					
Species	Stock area	Nmin	PBR	Total annual mortality	Trend
Pygmy killer whale	Hawaii	na	na	na	U
Pilot whale (short finned)	Hawaii	na	na	na	U
Risso's dolphin	Hawaii	na	na	na	U
Killer whale	Hawaii	na	na	0.0	U
Melon-headed whale	Hawaii	na	na	0.0	U
False killer whale	Hawaii	na	na	na	U
Pantropical spotted dolphin	Hawaii	na	na	na	U
Stripped dolphin	Hawaii	na	na	na	U
Spinner dolphin	Hawaii	677	6.8	1.0	U
Rough-toothed dolphin	Hawaii	na	na	na	U
Bottlenose dolphin	Hawaii	na	na	0.0	U
Pygmy sperm whale	Hawaii	na	na	na	U
Dwarf sperm whale	Hawaii	na	na	0.0	U
Sperm whale	Hawaii	na	na	na	U
Cuvier's beaked whale	Hawaii	na	na	0.0	U
Blainville's beaked whale	Hawaii	na	na	0.0	U
California sea lion	U.S.	84,195	5,052	2,434	I
Harbor seal	California	32,800	1,968	729	I
Harbor seal	WA inland	13,053	783	14	I
Harbor seal	OR/WA	28,322	850	233	I
Northern elephant seal	CA breeding	42,000	1,743	166	I
Northern fur seal	San Miguel Is.	10,536	227	0	I
Guadalupe fur seal	Mexico to CA	3,028	104	0	I
Hawaiian monk seal	Hawaii	1,300	4.6	1	D
NE spotted dolphin	E. Trop. Pacific	648,900	6,489	934	D
W/S offshore spotted dolphin	E. Trop. Pacific	1,145,100	11,451	1,226	S
Eastern spinner dolphin	E. Trop. Pacific	518,500	5,185	743	S
Whitebelly spinner dolphin	E. Trop. Pacific	872,000	8,720	619	S
Common dolphin (northern)	E. Trop. Pacific	3,531,000	3,531	101	S
Common dolphin (central)	E. Trop. Pacific	297,400	2,974	151	S
Common dolphin (southern)	E. Trop. Pacific	1,845,600	18,456	0	S
Stripped dolphin	E. Trop. Pacific	1,745,900	17,459	11	S
Coastal spotted dolphin	E. Trop. Pacific	22,500	225	na	S
Central Am. spinner dolphin	E. Trop. Pacific	na	na	11	S
Sea otter	Central CA	na	na	na	I
Sea otter	WA	na	na	na	I

See next page for continuation of table.

Table 24. Status of Marine Mammal Stocks in U.S. Waters, 1995 (continued)

Atlantic and Gulf of Mexico					
Species	Stock area	Nmin	PBR	Total annual mortality	Trend
No. Atlantic right whale	W. No. Atlantic	395	0.4	2.5	I
Humpback whale	W. No. Atlantic	4,848	9.7	1	U
Fin whale	W. No. Atlantic	1,704	3.4	na	U
Sei whale	W. No. Atlantic	155	0.3	0.3	U
Minke whale	E. Coast Canada	2,053	21.0	2.5	U
Blue whale	W. No. Atlantic	na	na	0.0	U
Sperm whale	W. No. Atlantic	226	0.5	1.6	U
Dwarf sperm whale	W. No. Atlantic	na	na	na	U
Pygmy sperm whale	W. No. Atlantic	na	na	na	U
Killer whale	W. No. Atlantic	na	na	0	U
Pygmy killer whale	W. No. Atlantic	6	0.1	0	U
Northern bottlenose whale	W. No. Atlantic	na	na	0	U
Cuvier's beaked whale	W. No. Atlantic	na	na	34	U
True's beaked whale	W. No. Atlantic	na	na	34	U
Gervais beaked whale	W. No. Atlantic	na	na	34	U
Blainville's beaked whale	W. No. Atlantic	na	na	34	U
Sowerby's beaked whale	W. No. Atlantic	na	na	34	U
Risso's dolphin	W. No. Atlantic	11,140	111	68	U
Pilot whale (long-finned)	W. No. Atlantic	3,537	28	109	U
Pilot whale (short-finned)	W. No. Atlantic	457	3.7	109	U
Atlantic white-sided dolphin	W. No. Atlantic	12,538	125	127	U
White-beaked dolphin	W. No. Atlantic	na	na	0.0	U
Common dolphin	W. No. Atlantic	3,233	32	449	U
Atlantic spotted dolphin	W. No. Atlantic	4,885	9.8	31	U
Pantropical spotted dolphin	W. No. Atlantic	na	na	31	U
Stripped dolphin	W. No. Atlantic	9,165	73	63	U
Spinner dolphin	W. No. Atlantic	na	na	1.0	U
Bottlenose dolphin	Mid-Atl. offshore	9,195	92	128	U
Bottlenose dolphin	Mid-Atl. coastal	2,482	25	29	S
Harbor porpoise	Gulf of Maine*	40,279	403	1,876	U
Harbor seal	W. No. Atlantic	28,810	1,729	476	I
Gray seal	N. W. No. Atlantic	2.035	122	4.5	I
Harp seal	N. W. No. Atlantic	na	na	0	I
Hooded seal	N. W. No. Atlantic	na	na	0	I
Sperm whale	N. Gulf of Mexico	411	0.8	0	U
Bryde's whale	N. Gulf of Mexico	17	0.2	0	U
Cuvier's beaked whale	N. Gulf of Mexico	20	0.2	0	U
Blainsville's beaked whale	N. Gulf of Mexico	na	na	0	U
Gervais' beaked whale	N. Gulf of Mexico	na	na	0	U
Bottlenose dolphin	G. of Mexico OCS	43,233	432	5	U
Bottlenose dolphin	G. of Mexico S&S	4,530	45	5	U
Bottlenose dolphin	W. G. of Mexico coast	2,938	29	13	U
Bottlenose dolphin	E. G. of Mexico coast	8,963	90	8	U
Bottlenose dolphin	G. of Mexico inland**	na	39.7	30	U

See next page for continuation of table.

Table 24. Status of Marine Mammal Stocks in U.S. Waters, 1995 (continued)

Atlantic and Gulf of Mexico					
Species	Stock area	Nmin	PBR	Total annual mortality	Trend
Atlantic spotted dolphin	N. Gulf of Mexico	2,555	23	1.5	U
Pantropical spotted dolphin	N. Gulf of Mexico	26,510	265	1.5	U
Stripped dolphin	N. Gulf of Mexico	3,409	34	0	U
Spinner dolphin	N. Gulf of Mexico	4,465	45	0	U
Rough-toothed dolphin	N. Gulf of Mexico	660	6.6	0	U
Clymene dolphin	N. Gulf of Mexico	4,120	41	0	U
Fraser's dolphin	N. Gulf of Mexico	66	0.7	0	U
Killer whale	N. Gulf of Mexico	197	2	0	U
False killer whale	N. Gulf of Mexico	236	2.4	0	U
Pygmy killer whale	N. Gulf of Mexico	285	2.8	0	U
Dwarf sperm whale	N. Gulf of Mexico	na	na	0	U
Pygmy sperm whale	N. Gulf of Mexico	na	na	0	U
Melon-headed whale	N. Gulf of Mexico	2,888	29	0	U
Risso's dolphin	N. Gulf of Mexico	2,199	22	19	U
Pilot whale (short-finned)	N. Gulf of Mexico	186	1.9	0.3	U
West Indian manatee	Florida	na	na	na	D
West Indian manatee	Antillean	na	na	na	D

Source: U.S. Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), *Our Living Oceans, Report on the Status of U.S. Living Marine Resources, 1995*, NOAA Technical Memorandum NMFS-F/SPO-19 (DOC, NOAA, NMFS, Washington, DC, 1996).

Notes: N_{min}=minimum population. PBR=potential biological removal. Trend is increasing (I), decreasing (D), stable (S), and unknown (U). na=not available. *Also includes the Bay of Fundy. **Represents at least 33 individually recognized stocks of bottlenose dolphin in U.S. Gulf of Mexico bays, sounds, and other estuaries. OCS=Outer Continental Shelf. S&S=Shelf and Slope. Three species of marine mammals in the Pacific have Endangered Species Act status: Sperm whale (endangered); Guadalupe fur seal (threatened); and Hawaiian monk seal (endangered). Two species of marine mammals in the Pacific have Marine Mammal Protection Act status: Northeastern spotted dolphin (depleted) and Eastern spinner dolphin (depleted). Nine species of marine mammals in the Atlantic and Gulf of Mexico have Endangered Species Act status: North Atlantic right whale (endangered); Humpback whale (endangered); Fin whale (endangered); Sei whale (endangered); Blue whale (endangered); W. North Atlantic Sperm whale (endangered); Gulf of Mexico Sperm whale (endangered); Florida West Indian manatee (endangered); and Antillean West Indian manatee (endangered). One marine mammal species in the Atlantic and Gulf of Mexico has Marine Mammal Protection Act status: Mid-Atlantic Coastal Bottlenose dolphin (depleted).

Table 25. Status of Sea Turtle Stocks in U.S. Waters, 1995

Region/ Species (ESA status)	Historic level	Current level	Current trend
	number of nesting females		
Atlantic			
Loggerhead (T)	Unknown	20,000 to 28,000[1]	Stable[2]
Green (T,E[3])	Unknown	500 to 500[1]	Increasing
Kemp's ridley (E)	40,000	700 to 800[4]	Stable[2]
Leatherback (E)	Unknown	Unknown	Unknown
Hawksbill (E)	Unknown	Unknown	Declining
Pacific			
Loggerhead (T)	Unknown	Unknown	Declining
Green (T)	10,000	500[5]	Increasing[6]
Olive ridley (T)	Unknown	Unknown	Unknown
Leatherback (E)	Unknown	Unknown	Unknown
Hawksbill (E)	Unknown	>75[7]	Unknown

Source: U.S. Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), *Our Living Oceans, Report on the Status of U.S. Living Marine Resources, 1995*, NOAA Technical Memorandum NMFS-F/SPO-19 (DOC, NOAA, NMFS, Washington, DC, 1996).

Notes: [1]Using 2.5 nests per female. [2]Stable, but critically low. [3]Listed as endangered in Florida; threatened in the U.S. Atlantic and Pacific. [4]Using 1.5 nests per female. Kemp's ridley turtles nest only on one Mexican beach. [5]Historic level for Hawaii only. Estimated 1995 total adult female population is 1,500 in Hawaii; 100-300 in American Samoa; current level in Guam is unknown. [6]Trend in Hawaii only, monitored at French Frigate Shoals; however, great concern exists over increasing frequency of fibropapilloma disease in all Hawaiian green turtles. [7]Estimated total adult population in Hawaii; average number of female hawksbills nesting annually in Hawaii is about 15. Current abundance in Guam and American Samoa is unknown.

Table 26. U.S. Threatened and Endangered Plant and Animal Groups, 1980-1995

	Threatened animal groups											
	Mammals	Birds	Reptiles	Amphibians	Fish	Crustaceans	Snails	Insects	Arachnids	Clams	Threatened plants	Total
	number of species											
1980	3	3	10	3	12	0	5	6	0	0	7	49
1981	3	3	8	3	12	0	5	4	0	0	7	45
1982	3	3	8	3	12	1	5	4	0	0	8	47
1983	3	3	12	3	12	1	5	6	0	0	10	55
1984	3	3	8	3	12	1	5	4	0	0	9	48
1985	4	3	8	3	14	1	5	4	0	0	10	52
1986	4	4	11	3	21	1	5	5	0	0	23	77
1987	7	10	18	4	30	1	5	7	0	0	44	126
1988	3	7	14	4	25	1	5	7	0	0	31	97
1989	6	7	14	4	25	1	6	7	0	0	42	112
1990	5	7	13	4	25	1	6	7	0	0	46	114
1991	8	12	18	5	34	2	6	9	0	2	61	157
1992	6	7	14	4	30	2	6	9	0	2	62	142
1993	6	8	14	4	31	2	7	9	0	5	69	155
1994	6	8	15	4	30	3	7	9	0	6	76	164
1995	9	16	19	5	40	3	7	9	0	6	92	206

	Endangered animal groups											
	Mammals	Birds	Reptiles	Amphibians	Fish	Crustaceans	Snails	Insects	Arachnids	Clams	Endangered plants	Total
	number of species											
1980	32	66	3	5	34	1	2	7	0	23	51	234
1981	15	52	7	5	29	1	2	7	0	23	48	189
1982	15	52	8	5	28	2	3	7	0	23	55	198
1983	33	66	14	5	33	2	3	7	0	23	55	241
1984	15	52	8	5	30	3	3	7	0	22	60	205
1985	20	59	8	5	30	3	3	8	0	22	67	225
1986	45	72	12	5	46	3	3	8	0	24	87	305
1987	50	76	15	5	47	7	3	10	3	30	158	404
1988	28	61	8	5	41	5	3	8	0	29	139	327
1989	32	61	9	6	49	8	3	10	3	34	163	378
1990	33	60	8	6	49	8	3	10	3	35	163	378
1991	55	73	16	6	54	8	7	13	3	40	229	504
1992	37	57	8	6	52	8	7	13	3	40	274	505
1993	37	57	8	6	55	11	12	13	5	51	317	572
1994	36	58	8	6	62	14	14	16	4	50	404	672
1995	55	74	14	7	65	14	15	20	5	51	434	754

Source: U.S. Department of the Interior (DOI), Fish and Wildlife Service (FWS), *Endangered Species Bulletin* (DOI, FWS, Washington, DC, annual December issue).

Notes: Separate populations of a species listed both as Threatened and Endangered are tallied twice. Those species are the grizzly bear, gray wolf, bald eagle, piping plover, roseate tern, green sea turtle, and olive ridley sea turtle.

Air Quality and Climate

Table 27. U.S. Emissions of Six Criteria Air Pollutants by Source, 1940 through 1994

	Carbon monoxide								
	Fuel combustion				Transportation			Miscellaneous	
Year	Electric utilities	Industrial	Other	Total	Highway vehicles	Off-highway vehicles	Total	Wildfires	Other combustion
	million tons								
1940	0.004	0.435	14.890	15.329	30.121	8.051	38.172	25.130	na
1950	0.110	0.549	10.656	11.315	45.196	11.610	56.806	11.159	3.976
1960	0.110	0.661	6.250	7.021	64.266	11.575	75.841	4.487	6.523
1970	0.237	0.770	3.625	4.632	88.034	10.605	98.639	5.620	2.289
1980	0.322	0.750	6.230	7.302	78.049	12.681	90.730	5.396	2.948
1985	0.292	0.670	7.525	8.486	77.387	13.706	91.094	2.957	4.983
1986	0.291	0.650	6.607	7.548	73.347	13.984	87.330	2.271	4.983
1987	0.300	0.649	6.011	6.960	71.250	14.131	85.381	3.795	5.025
1988	0.313	0.669	6.390	7.372	71.081	14.500	85.581	10.709	5.156
1989	0.319	0.672	6.450	7.441	66.050	14.518	80.568	3.009	5.112
1990	0.314	0.677	4.072	5.064	62.858	14.642	77.500	6.079	5.094
1991	0.315	0.667	4.373	5.356	62.074	14.601	76.675	3.439	5.091
1992	0.313	0.672	4.616	5.601	59.859	14.900	74.759	1.674	5.100
1993	0.323	0.670	3.961	4.954	60.202	15.269	75.471	1.586	5.114
1994	0.325	0.671	3.888	4.884	61.070	15.657	76.727	4.115	5.130

	Industrial processes								
Year	Chemical industries	Metals processing	Petroleum industries	Other industries	Solvent utilization	Storage and transport	Waste disposal and recycling	Total	Grand total
	million tons								
1940	4.190	2.750	0.221	0.114	na	na	3.630	10.905	93.615
1950	5.844	2.910	2.651	0.231	na	na	4.717	16.353	102.609
1960	3.982	2.866	3.086	0.342	na	na	5.597	15.873	109.745
1970	3.397	3.644	2.179	0.620	na	na	7.059	16.899	128.079
1980	2.151	2.246	1.723	0.830	na	na	2.300	9.250	115.625
1985	1.845	2.223	0.462	0.694	0.002	0.049	1.941	7.216	114.690
1986	1.853	2.079	0.451	0.715	0.002	0.051	1.916	7.067	109.199
1987	1.798	1.984	0.455	0.713	0.002	0.050	1.850	6.851	108.012
1988	1.917	2.101	0.441	0.711	0.002	0.056	1.806	7.034	115.849
1989	1.925	2.132	0.436	0.716	0.002	0.055	1.747	7.013	103.144
1990	1.940	2.080	0.435	0.717	0.002	0.055	1.686	6.914	100.650
1991	1.944	1.992	0.412	0.710	0.002	0.054	1.701	6.815	97.376
1992	1.964	2.044	0.410	0.719	0.002	0.055	1.717	6.909	94.043
1993	1.998	2.091	0.398	0.732	0.002	0.056	1.732	7.009	94.133
1994	2.048	2.166	0.390	0.751	0.002	0.058	1.746	7.160	98.017

See next page for continuation of table.

Table 27. U.S. Emissions of Six Criteria Air Pollutants by Source, 1940 through 1994 (continued)

Lead									
	Fuel combustion				Transportation			Miscellaneous	
Year	Electric utilities	Industrial	Other	Total	Highway vehicles	Off-highway vehicles	Total	Wildfires	Other combustion
	thousand tons								
1970	0.327	0.237	10.052	10.616	171.961	8.340	180.301	na	na
1975	0.230	0.075	10.042	10.347	130.206	5.012	135.218	na	na
1980	0.129	0.060	4.111	4.299	62.189	3.320	65.509	na	na
1985	0.064	0.030	0.421	0.515	15.978	0.229	16.207	na	na
1986	0.069	0.025	0.422	0.516	3.589	0.219	3.808	na	na
1987	0.064	0.022	0.425	0.510	3.121	0.222	3.343	na	na
1988	0.066	0.019	0.426	0.511	2.700	0.211	2.911	na	na
1989	0.067	0.018	0.420	0.505	2.161	0.207	2.368	na	na
1990	0.064	0.018	0.418	0.500	1.690	0.197	1.888	na	na
1991	0.061	0.018	0.416	0.495	1.519	0.186	1.704	na	na
1992	0.059	0.018	0.414	0.491	1.444	0.193	1.637	na	na
1993	0.061	0.015	0.415	0.491	1.401	0.179	1.580	na	na
1994	0.063	0.015	0.415	0.493	1.403	0.193	1.596	na	na

	Industrial processes								
Year	Chemical industries	Metals processing	Petroleum industries	Other industries	Solvent utilization	Storage and transport	Waste disposal and recycling	Total	Grand total
	thousand tons								
1970	0.103	24.224	0.000	2.028	0.000	0.000	2.200	28.555	219.471
1975	0.120	9.923	0.000	1.337	0.000	0.000	1.595	12.975	158.540
1980	0.104	3.026	0.000	0.808	0.000	0.000	1.210	5.148	74.956
1985	0.118	2.097	0.000	0.316	0.000	0.000	0.871	3.402	20.124
1986	0.108	1.820	0.000	0.199	0.000	0.000	0.844	2.972	7.296
1987	0.123	1.835	0.000	0.202	0.000	0.000	0.844	3.004	6.857
1988	0.136	1.965	0.000	0.172	0.000	0.000	0.817	3.090	6.513
1989	0.136	2.088	0.000	0.173	0.000	0.000	0.765	3.161	6.034
1990	0.136	2.169	0.000	0.169	0.000	0.000	0.804	3.278	5.666
1991	0.132	1.975	0.000	0.167	0.000	0.000	0.807	3.081	5.279
1992	0.093	1.775	0.000	0.056	0.000	0.000	0.847	2.771	4.899
1993	0.096	1.887	0.000	0.054	0.000	0.000	0.829	2.866	4.938
1994	0.093	1.873	0.000	0.055	0.000	0.000	0.847	2.868	4.956

See next page for continuation of table.

Table 27. U.S. Emissions of Six Criteria Air Pollutants by Source, 1940 through 1994 (continued)

Year	Nitrogen oxides: Fuel combustion: Electric utilities	Fuel combustion: Industrial	Fuel combustion: Other	Fuel combustion: Total	Transportation: Highway vehicles	Transportation: Off-highway vehicles	Transportation: Total	Miscellaneous: Wildfires	Miscellaneous: Other combustion
	million tons								
1940	0.660	2.543	0.529	3.732	1.330	0.991	2.321	i	0.990
1950	1.316	3.192	0.647	5.155	2.143	1.538	3.681	i	0.665
1960	2.536	4.075	0.760	7.371	3.982	1.443	5.425	i	0.441
1970	4.900	4.325	0.836	10.061	7.390	1.628	9.018	i	0.330
1980	7.024	3.555	0.741	11.318	8.621	2.423	11.429	i	0.248
1985	6.916	3.209	0.712	10.836	8.089	2.734	10.823	0.142	0.167
1986	6.909	3.065	0.694	10.668	7.773	2.777	10.550	0.089	0.168
1987	7.128	3.063	0.706	10.897	7.651	2.664	10.315	0.182	0.169
1988	7.530	3.187	0.740	11.457	7.661	2.914	10.575	0.554	0.172
1989	7.607	3.209	0.736	11.552	7.682	2.844	10.526	0.121	0.171
1990	7.516	3.256	0.712	11.483	7.488	2.843	10.331	0.203	0.170
1991	7.488	3.175	0.719	11.382	7.373	2.796	10.170	0.112	0.171
1992	7.475	3.216	0.730	11.421	7.440	2.885	10.325	0.078	0.171
1993	7.773	3.197	0.726	11.696	7.510	2.985	10.495	0.047	0.172
1994	7.795	3.206	0.727	11.728	7.530	3.095	10.624	0.203	0.171

Year	Industrial processes: Chemical industries	Metals processing	Petroleum industries	Other industries	Solvent utilization	Storage and transport	Waste disposal and recycling	Total	Grand total
	million tons								
1940	0.006	0.004	0.105	0.107	na	na	0.110	0.332	7.374
1950	0.063	0.110	0.110	0.093	na	na	0.215	0.591	10.093
1960	0.110	0.110	0.220	0.131	na	na	0.331	0.902	14.140
1970	0.271	0.077	0.240	0.187	na	na	0.440	1.215	20.625
1980	0.216	0.065	0.072	0.205	na	na	0.111	0.669	23.281
1985	0.262	0.087	0.124	0.327	0.002	0.002	0.087	0.891	22.860
1986	0.264	0.080	0.109	0.328	0.003	0.002	0.087	0.873	22.348
1987	0.255	0.075	0.101	0.320	0.003	0.002	0.085	0.840	22.403
1988	0.274	0.082	0.100	0.315	0.003	0.002	0.085	0.860	23.618
1989	0.272	0.083	0.097	0.311	0.003	0.002	0.084	0.851	23.222
1990	0.276	0.081	0.100	0.306	0.002	0.002	0.082	0.850	23.038
1991	0.278	0.078	0.097	0.297	0.002	0.002	0.083	0.838	22.672
1992	0.284	0.080	0.096	0.305	0.003	0.003	0.083	0.852	22.847
1993	0.286	0.081	0.095	0.315	0.003	0.003	0.084	0.866	23.276
1994	0.291	0.084	0.095	0.328	0.003	0.003	0.085	0.888	23.615

See next page for continuation of table.

Table 27. U.S. Emissions of Six Criteria Air Pollutants by Source, 1940 through 1994 (continued)

	Volatile organic compounds								
	Fuel combustion				Transportation			Miscellaneous	
Year	Electric utilities	Industrial	Other	Total	Highway vehicles	Off-highway vehicles	Total	Wildfires	Other combustion
	million tons								
1940	0.002	0.108	1.867	1.977	4.817	0.778	5.595	3.420	0.659
1950	0.009	0.098	1.336	1.443	7.251	1.213	8.464	1.510	1.020
1960	0.009	0.106	0.768	0.883	10.506	1.215	11.721	0.768	0.805
1970	0.030	0.150	0.541	0.694	12.972	1.542	14.972	0.770	1.101
1980	0.045	0.157	0.848	1.050	8.979	1.869	10.848	0.739	1.134
1985	0.032	0.134	1.403	1.570	9.376	2.008	11.384	0.283	0.279
1986	0.034	0.133	1.230	1.396	8.874	2.039	10.912	0.259	0.285
1987	0.034	0.131	1.117	1.282	8.477	2.038	10.515	0.361	0.291
1988	0.037	0.136	1.188	1.361	8.290	2.106	10.396	0.918	0.309
1989	0.037	0.134	1.200	1.371	7.192	2.103	9.295	0.335	0.304
1990	0.036	0.135	0.749	0.919	6.854	2.120	8.974	0.768	0.301
1991	0.036	0.135	0.807	0.977	6.499	2.122	8.621	0.440	0.301
1992	0.035	0.135	0.853	1.022	6.072	2.159	8.231	0.164	0.302
1993	0.036	0.134	0.729	0.899	6.103	2.206	8.309	0.212	0.304
1994	0.036	0.135	0.715	0.886	6.295	2.255	8.549	0.379	0.306

	Industrial processes								
Year	Chemical industries	Metals processing	Petroleum industries	Other industries	Solvent utilization	Storage and transport	Waste disposal and recycling	Total	Grand total
	million tons								
1940	0.884	0.325	0.571	0.130	1.971	0.639	0.990	5.510	17.161
1950	1.324	0.442	0.548	0.184	3.679	1.218	1.104	8.499	20.936
1960	0.991	0.342	1.034	0.202	4.403	1.762	1.546	10.280	24.459
1970	1.341	0.394	1.194	0.270	7.174	1.954	1.984	14.311	30.646
1980	1.595	0.273	1.440	0.237	6.584	1.975	0.758	12.861	28.893
1985	1.358	0.076	0.703	0.390	5.699	1.747	2.310	12.282	25.798
1986	1.412	0.073	0.666	0.395	5.626	1.673	2.293	12.138	24.991
1987	1.410	0.070	0.655	0.394	5.743	1.801	2.256	12.329	24.778
1988	1.513	0.074	0.645	0.408	5.945	1.842	2.310	12.737	25.719
1989	1.506	0.074	0.639	0.403	5.964	1.753	2.290	12.629	23.935
1990	1.526	0.072	0.643	0.401	5.975	1.759	2.262	12.638	23.599
1991	1.533	0.069	0.634	0.398	5.918	1.720	2.265	12.537	22.877
1992	1.546	0.072	0.638	0.403	6.031	1.745	2.268	12.702	22.420
1993	1.557	0.074	0.631	0.406	6.156	1.757	2.271	12.851	22.575
1994	1.577	0.077	0.630	0.411	6.313	1.773	2.273	13.054	23.174

See next page for continuation of table.

Table 27. U.S. Emissions of Six Criteria Air Pollutants by Source, 1940 through 1994 (continued)

	Sulfur dioxide								
	Fuel combustion				Transportation			Miscellaneous	
Year	Electric utilities	Industrial	Other	Total	Highway vehicles	Off-highway vehicles	Total	Wildfires	Other combustion
	million tons								
1940	2.427	6.060	3.642	12.129	0.003	3.190	0.319	i	0.545
1950	4.515	5.725	3.964	14.204	0.103	2.392	2.495	i	0.545
1960	9.264	3.864	2.319	15.447	0.114	0.321	0.435	i	0.554
1970	17.398	4.568	1.490	23.456	0.411	0.083	0.494	i	0.110
1980	17.469	2.951	0.971	21.391	0.521	0.175	0.696	i	0.011
1985	16.273	3.169	0.579	20.021	0.522	0.208	0.730	0.006	0.006
1986	15.701	3.116	0.611	19.428	0.527	0.221	0.748	0.003	0.006
1987	15.715	3.068	0.662	19.445	0.538	0.233	0.771	0.007	0.006
1988	15.990	3.111	0.660	19.761	0.553	0.253	0.806	0.022	0.006
1989	16.218	3.086	0.624	19.927	0.570	0.267	0.837	0.005	0.006
1990	15.898	3.106	0.595	19.574	0.571	0.265	0.836	0.008	0.006
1991	15.788	2.915	0.592	19.295	0.570	0.266	0.836	0.004	0.006
1992	15.418	3.002	0.599	19.019	0.578	0.273	0.851	0.003	0.006
1993	15.191	2.942	0.599	18.732	0.517	0.278	0.795	0.002	0.006
1994	14.869	3.029	0.599	18.497	0.295	0.283	0.579	0.008	0.006

	Industrial processes								
Year	Chemical industries	Metals processing	Petroleum industries	Other industries	Solvent utilization	Storage and transport	Waste disposal and recycling	Total	Grand total
	million tons								
1940	0.215	3.309	0.224	0.334	na	na	0.003	4.085	19.953
1950	0.427	3.747	0.340	0.596	na	na	0.003	5.113	22.358
1960	0.447	3.986	0.676	0.671	na	na	0.010	5.790	22.227
1970	0.591	4.775	0.881	0.846	0.000	0.000	0.008	7.100	31.161
1980	0.280	1.842	0.734	0.918	0.000	0.000	0.033	3.773	25.905
1985	0.456	1.042	0.505	0.425	0.001	0.004	0.034	2.467	23.230
1986	0.432	0.888	0.469	0.427	0.001	0.004	0.035	2.256	22.442
1987	0.425	0.648	0.445	0.418	0.001	0.004	0.035	1.976	22.204
1988	0.449	0.707	0.443	0.411	0.001	0.005	0.036	2.052	22.647
1989	0.440	0.695	0.429	0.405	0.001	0.005	0.036	1.937	22.785
1990	0.440	0.663	0.440	0.401	0.001	0.005	0.036	1.985	22.433
1991	0.440	0.633	0.442	0.391	0.001	0.005	0.036	1.928	22.068
1992	0.447	0.650	0.417	0.401	0.001	0.005	0.037	1.957	21.836
1993	0.450	0.667	0.409	0.413	0.001	0.005	0.037	1.982	21.517
1994	0.457	0.692	0.406	0.431	0.001	0.005	0.037	2.029	21.118

See next page for continuation of table.

Table 27. U.S. Emissions of Six Criteria Air Pollutants by Source, 1940 through 1994 (continued)

PM-10 particulates

Year	Fuel combustion: Electric utilities	Fuel combustion: Industrial	Fuel combustion: Other	Fuel combustion: Total	Transportation: Highway vehicles	Transportation: Off-highway vehicles	Transportation: Total	Natural and Miscellaneous: Natural (Wind erosion)	Natural and Miscellaneous: Miscellaneous
	million tons								
1940	0.962	0.708	2.338	4.008	0.210	2.480	2.690	na	2.968
1950	1.467	0.604	1.674	3.745	0.314	1.788	2.102	na	1.934
1960	2.117	0.331	1.113	3.561	0.554	0.201	0.755	na	1.244
1970	1.775	0.641	0.455	2.871	0.443	0.223	0.666	na	0.839
1980	0.879	0.679	0.887	2.445	0.397	0.329	0.726	na	0.852
1985	0.284	0.245	1.009	1.538	0.363	0.368	0.731	4.047	*
1986	0.288	0.243	0.888	1.419	0.356	0.372	0.729	10.324	*
1987	0.284	0.238	0.811	1.333	0.360	0.350	0.710	1.577	*
1988	0.279	0.242	0.862	1.383	0.369	0.387	0.756	18.110	*
1989	0.273	0.241	0.869	1.383	0.367	0.372	0.739	12.101	*
1990	0.282	0.240	0.553	1.075	0.357	0.372	0.729	4.362	*
1991	0.248	0.234	0.593	1.076	0.349	0.367	0.717	10.095	*
1992	0.247	0.236	0.626	1.109	0.343	0.379	0.722	4.626	*
1993	0.268	0.234	0.539	1.041	0.321	0.395	0.716	1.978	*
1994	0.266	0.237	0.529	1.033	0.311	0.411	0.722	2.593	*

Year	Industrial processes: Chemical industries	Industrial processes: Metals processing	Industrial processes: Petroleum industries	Industrial processes: Other industries	Industrial processes: Solvent utilization	Industrial processes: Storage and transport	Industrial processes: Waste disposal and recycling	Industrial processes: Total	Grand total
	million tons								
1940	0.330	1.208	0.366	3.996	na	na	0.392	6.292	15.956
1950	0.455	1.027	0.412	6.954	na	na	0.505	9.353	17.133
1960	0.309	1.026	0.689	7.211	na	na	0.764	9.999	15.558
1970	0.235	1.316	0.286	5.832	na	na	0.999	8.668	13.044
1980	0.148	0.622	0.138	1.846	na	na	0.273	3.027	7.050
1985	0.057	0.142	0.032	0.382	0.002	0.057	0.278	0.952	45.176
1986	0.058	0.132	0.031	0.390	0.002	0.058	0.274	0.945	50.582
1987	0.057	0.126	0.030	0.384	0.002	0.056	0.265	0.921	42.059
1988	0.061	0.136	0.029	0.385	0.002	0.056	0.259	0.929	60.794
1989	0.062	0.137	0.028	0.377	0.002	0.056	0.251	0.913	52.641
1990	0.062	0.136	0.028	0.374	0.002	0.057	0.242	0.900	44.298
1991	0.062	0.130	0.028	0.362	0.002	0.055	0.244	0.881	48.958
1992	0.063	0.133	0.027	0.368	0.002	0.056	0.246	0.894	43.722
1993	0.063	0.136	0.027	0.377	0.002	0.057	0.248	0.910	43.280
1994	0.064	0.141	0.026	0.390	0.002	0.059	0.250	0.932	46.048

See next page for continuation of table. *Detail for miscellaneous PM-10 emissions is presented on next page, but included in grand total above.

Table 27. U.S. Emissions of Six Criteria Air Pollutants by Source, 1940 through 1994 (continued)

	Miscellaneous PM-10 (detail from previous page)						
	Fugitive dust						Wildfires and other com-bustion
Year	Agricul-tural tillage	Construc-tion	Mining and quarrying	Un-paved roads	Paved roads	Total fugitive dust	
	million tons						
1985	6.833	12.670	0.337	11.830	5.071	36.742	1.167
1986	6.899	11.825	0.312	11.773	5.257	36.065	1.101
1987	6.996	12.121	0.375	11.184	5.526	36.203	1.315
1988	7.077	11.662	0.344	12.563	5.893	37.539	2.077
1989	6.923	11.269	0.391	11.849	5.767	36.199	1.305
1990	6.983	10.044	0.350	12.311	5.967	25.655	1.578
1991	6.952	9.672	0.367	11.911	5.967	34.870	1.319
1992	6.838	10.543	0.357	11.527	5.942	35.207	1.164
1993	6.837	10.993	0.358	13.215	6.077	37.480	1.157
1994	6.716	12.397	0.372	13.497	6.343	39.325	1.442

Sources: U.S. Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards (OAQPS), *National Air Pollutant Emission Trends, 1900-1994,* Tables 3-1 through 3-6, EPA-454/R-95-011 (EPA, OAQPS, Research Triangle Park, NC, 1995).

--, *National Air Quality and Emissions Trends Report, 1994*, *Data Appendix,* Tables A-2 through A-8 (EPA, OAQPS, Research Triangle Park, NC, 1995).

Note: na=not applicable. PM-10 refers to particulate matter with a diameter 10 microns or less. Totals may not agree with sum of components due to independent rounding.

Table 28. Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-1994

Gas/Source	1990	1991	1992	1993	1994
			million metric tons		
Carbon dioxide					
Fossil fuel combustion	1,336	1,320	1,340	1,369	1,390
Other	17	17	17	18	17
Total	1,353	1,336	1,357	1,387	1,408
Forests (sinks)	(125)	(125)	(125)	na	na
Net total	1,228	1,211	1,232	na	na
Methane					
Landfills	66	67	66	67	68
Agriculture	56	57	59	59	61
Coal mining	29	28	27	24	29
Oil and gas systems	22	22	22	22	22
Other	6	7	7	6	6
Total	181	182	182	179	188
Nitrous oxide					
Agriculture	16	17	17	17	19
Fossil fuel combustion	12	12	12	12	12
Industrial processes	8	9	8	9	9
Total	37	37	37	38	41
HFCs and PFCs	18.8	19.3	21.1	19.8	23.5
SF_6	6.4	6.5	6.7	6.8	7.0
Total U.S. emissions	1,595	1,582	1,604	1,630	1,666
Net, including sinks	1,470	1,457	1,479	na	na

Source: U.S. Environmental Protection Agency (EPA), Office of Policy, Planning and Evaluation (OPPE), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1994,* EPA-230-R-96-006 (EPA, OPPE, Washington, DC, 1995).

Note: HFCs=hydrofluorocarbons. PFCs=perfluorocarbons. SF6=sulfur hexafluoride. na=not available. Emissions include direct and indirect effects. Other carbon emissions come from fuel production and processing, cement and lime production, limestone consumption, soda ash production and consumption, and carbon dioxide manufacture. Total carbon dioxide does not include emissions from bunker fuels used in international transport activities. U.S. emissions from bunker fuels were approximately 23 million metric tons (carbon-equivalent) in 1994. Other methane emissions come from fuel combustion by stationary and mobile sources and from wastewater facilities.

Table 29. U.S. Precipitation Chemistry by Region, 1985-1994

Year	Ph	Hydro-gen ion	Sulfate ion	Nitrate ion	Ammon-ium ion	Calcium ion	Precip-itation
	units	*ug/l*		*milligrams per liter*			*cm*
				Eastern United States			
1985	4.43	37.57	2.02	1.25	0.23	0.15	106.7
1986	4.42	38.16	2.14	1.30	0.24	0.13	102.2
1987	4.42	38.06	2.09	1.33	0.26	0.14	100.7
1988	4.43	37.05	2.14	1.33	0.21	0.17	95.9
1989	4.47	34.25	2.01	1.35	0.31	0.15	110.8
1990	4.49	32.71	1.80	1.18	0.27	0.12	122.6
1991	4.47	34.00	1.87	1.27	0.26	0.14	111.0
1992	4.49	32.04	1.77	1.22	0.25	0.12	108.4
1993	4.47	33.64	1.78	1.28	0.26	0.11	113.7
1994	4.48	33.07	1.71	1.24	0.28	013.	111.9
				Western United States			
1985	5.13	7.40	0.82	0.71	0.18	0.23	62.0
1986	5.18	6.57	0.78	0.68	0.17	0.19	72.4
1987	5.11	7.82	0.83	0.83	0.24	0.19	62.2
1988	5.10	7.93	0.93	0.83	0.16	0.27	56.6
1989	5.23	5.84	0.87	0.91	0.29	0.25	56.7
1990	5.21	6.22	0.80	0.87	0.29	0.22	66.2
1991	5.20	6.31	0.77	0.80	0.24	0.21	68.4
1992	5.23	5.86	0.77	0.83	0.28	0.18	65.1
1993	5.27	5.41	0.71	0.76	0.23	0.18	74.4
1994	5.07	8.53	0.76	0.92	0.28	0.20	62.0
				Entire United States			
1985	4.57	27.07	1.60	1.06	0.21	0.17	91.1
1986	4.57	27.16	1.67	1.08	0.21	0.15	91.8
1987	4.56	27.53	1.65	1.15	0.25	0.15	87.3
1988	4.57	26.91	1.72	1.16	0.19	0.21	82.2
1989	4.61	24.35	1.61	1.20	0.30	0.19	91.9
1990	4.63	23.49	1.45	1.07	0.28	0.16	102.9
1991	4.61	24.36	1.49	1.11	0.26	0.16	96.1
1992	4.64	22.92	1.42	1.09	0.26	0.14	93.3
1993	4.62	23.81	1.41	1.10	0.25	0.14	100.0
1994	4.61	24.53	1.38	1.13	0.28	0.15	94.5

Source: National Trends Network of the National Atmospheric Deposition Program, unpublished, Fort Collins, C0, 1995.

Notes: ug/l=micrograms per liter. cm=centimeters. Data are from 73 sites in the eastern U.S. and 39 sites in the western U.S. Sites included in the computations are those where (1) precipitation amounts are available for at least 90% of the summary period and (2) at least 60% of the precipitation during the summary period is represented by valid samples.

Table 30. U.S. National Composite Mean Ambient Concentrations of Criteria Air Pollutants, 1985-1994

Year	Sulfur dioxide (475 sites)	Carbon monoxide (328 sites)	Ozone (549 sites)	Nitrogen dioxide (205 sites)	PM-10 particulates (748 sites)	Lead (197 sites)
	ppm				*ug/m3*	*ug/m3*
1985	0.0092	6.97	0.124	0.022	na	0.291
1986	0.0090	7.11	0.120	0.022	na	0.180
1987	0.0088	6.69	0.126	0.022	na	0.156
1988	0.0089	6.38	0.136	0.022	33.4	0.110
1989	0.0086	6.34	0.117	0.022	33.2	0.080
1990	0.0080	5.87	0.114	0.020	29.9	0.079
1991	0.0078	5.55	0.116	0.020	29.8	0.058
1992	0.0073	5.18	0.107	0.020	27.3	0.050
1993	0.0072	4.90	0.110	0.019	26.5	0.050
1994	0.0069	5.00	0.109	0.020	26.6	0.040

Source: U.S. Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards (OAQPS), *National Air Quality and Emissions Trends Report, 1994, Data Appendix*, Table A-1 (EPA, OAQPS, Research Triangle Park, NC, 1995).

Notes: ppm=parts per million. ug/m3=micrograms per cubic meter. na=not available. Sulfur dioxide and nitrogen dioxide records are arithmetic means of measurements, Carbon monoxide records are arithmetic means of second maximum readings over 8-hour periods. Ozone records are arithmetic means of second maximum readings over 24-hour periods. Lead records are arithmetic means of maximum quarterly measurements. PM-10 records are weighted arithmetic means. The National Ambient Air Quality Standards for these pollutants are as follows: sulfur dioxide, 0.03 ppm; carbon monoxide, 9 ppm; ozone, 0.12 ppm; nitrogen dioxide, 0.053 ppm; PM-10, 50 ug/m3; and lead, 1.5 ug/m3.

Table 31. Atmospheric Concentrations of Carbon Dioxide Above U.S. Monitoring Stations, 1973-1994

Year	Mauna Loa, Hawaii	South Pole	American Samoa	Pt. Barrow, Alaska
	parts per million by volume			
1973	329.51	327.45	na	na
1974	330.08	328.29	na	na
1975	330.99	329.35	na	333.20
1976	331.98	330.46	na	334.01
1977	333.73	331.87	na	na
1978	335.34	na	na	na
1979	336.68	334.84	na	na
1980	338.52	na	na	na
1981	339.76	338.07	na	340.88
1982	340.96	na	340.43	342.39
1983	342.61	341.02	341.82	343.73
1984	344.25	na	343.66	345.53
1985	345.73	343.62	na	346.74
1986	346.98	345.17	na	348.49
1987	348.76	346.82	347.85	349.73
1988	351.30	348.75	349.91	352.99
1989	352.71	350.28	351.41	355.06
1990	353.99	351.59	352.73	355.82
1991	355.45	na	354.24	357.32
1992	356.28	354.17	355.11	357.70
1993	356.98	355.08	356.02	358.16
1994	358.78	356.32	357.63	359.66

Source: C.D. Keeling, and T.P. Whorf, "Atmospheric CO2 Records from Sites in the SIO Air Sampling Network," in *Trends '93: A Compendium of Data on Global Change*, T.A. Boden, D.P. Kaiser, R.J. Sepanski, and P.Y. Hughes, eds., ORNL/CDIAC-65 (U.S. Department of Energy, Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center, Oak Ridge, TN, 1994), pp. 16-26, with updates by authors.

Notes: na=not available. Annual mean concentration is reported only when all 12 monthly average concentrations are available.

Table 32. Global Atmospheric Concentrations of Selected Ozone-depleting Chemicals, 1978-1994

	CFC-11 ALE Network Data											
Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	parts per trillion by volume											
1978	na	na	na	na	na	na	135.5	137.4	139.0	138.8	141.1	141.3
1979	143.8	144.0	144.2	144.9	145.8	147.1	147.6	148.5	149.5	150.6	151.4	151.6
1980	152.3	153.4	154.4	155.1	157.1	157.9	158.0	158.7	160.4	159.8	161.1	162.2
1981	162.7	161.3	162.5	163.0	164.6	166.0	166.5	na	166.8	na	168.2	168.7
1982	169.3	170.1	171.3	171.9	172.4	174.0	174.6	175.4	176.1	177.3	178.4	178.7
1983	179.2	179.6	179.4	180.0	180.7	181.5	182.4	183.8	184.8	185.6	186.3	187.0
1984	187.2	187.8	188.5	189.9	190.9	191.0	191.9	192.6	193.2	193.4	193.9	194.5
1985	195.0	195.6	196.3	197.7	198.6	198.9	na	na	na	na	na	na

	CFC-11 GAGE Network Data											
Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	parts per trillion by volume											
1981	na	na	na	na	na	na	na	na	na	na	na	170.4
1982	170.6	171.0	171.9	172.8	174.1	174.7	175.4	176.4	176.9	177.1	177.8	178.2
1983	178.5	179.5	180.0	180.8	181.6	182.3	183.2	183.1	182.4	183.5	184.0	184.6
1984	184.9	185.4	186.5	188.6	189.5	190.3	191.2	192.1	192.6	193.3	193.9	194.7
1985	195.6	196.0	197.3	198.6	199.2	199.8	200.7	201.8	202.6	203.1	203.9	204.2
1986	204.4	205.0	206.1	207.5	209.1	209.8	210.8	212.0	212.4	212.4	211.8	212.4
1987	213.1	213.4	na	na	218.1	218.9	na	222.5	222.5	223.7	224.4	224.9
1988	226.0	226.5	228.0	228.6	230.2	230.6	231.7	232.6	233.5	234.2	234.0	234.2
1989	234.8	235.4	236.9	238.1	239.0	239.9	240.3	241.2	242.3	243.1	243.4	243.8
1990	244.2	244.8	245.8	246.8	247.2	249.1	249.6	249.9	250.9	251.5	251.8	252.0
1991	251.4	251.0	251.5	252.2	253.0	254.1	254.4	254.7	255.4	256.1	256.4	257.0
1992	256.8	257.6	260.2	260.5	260.7	261.3	260.8	259.8	260.4	261.0	261.4	260.8
1993	259.5	259.2	259.5	259.7	260.1	259.4	259.5	260.0	260.8	261.3	261.6	261.7
1994	261.8	261.9	260.5	260.9	260.8	260.8	na	na	na	na	na	na

	CFC-12 ALE Network Data											
Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	parts per trillion by volume											
1978	na	na	na	na	na	na	251.0	252.2	255.1	257.0	262.7	262.5
1979	265.7	266.4	267.4	268.7	270.6	272.1	272.9	274.7	276.1	276.2	277.5	278.0
1980	279.1	na	na	na	na	na	na	na	294.7	294.9	296.8	297.3
1981	298.5	297.6	299.9	301.6	303.6	305.3	306.0	na	308.5	308.9	310.5	311.6
1982	312.9	313.8	316.2	317.6	318.0	321.2	322.8	324.5	325.3	328.5	330.9	331.3
1983	332.2	334.2	336.2	337.5	338.8	340.5	342.0	342.7	342.9	344.6	345.9	347.0
1984	347.8	349.0	350.3	353.2	357.1	358.3	360.0	361.1	362.2	363.2	364.4	365.2
1985	366.0	367.7	369.4	371.7	373.1	373.9	na	na	na	na	na	na

See next page for continuation of table.

Table 32. Global Atmospheric Concentrations of Selected Ozone-depleting Chemicals, 1978-1994 (continued)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	CFC-12 GAGE Network Data											
	parts per trillion by volume											
1981	na	na	na	na	na	na	na	na	na	na	na	315.5
1982	316.9	317.8	319.5	321.5	324.0	325.2	326.3	328.2	329.3	329.8	331.3	331.9
1983	332.6	335.5	337.7	339.1	340.5	341.6	342.9	343.0	342.2	344.0	345.1	345.8
1984	346.2	347.0	348.0	351.8	354.8	355.8	357.1	358.8	358.9	359.8	362.2	365.3
1985	367.6	368.6	370.5	373.0	374.0	375.1	376.6	378.5	379.6	380.7	382.3	383.6
1986	383.8	385.2	386.9	391.8	393.4	395.1	396.5	397.7	399.2	398.5	398.9	399.8
1987	400.7	400.0	na	na	409.3	410.8	na	415.2	415.5	417.5	418.4	419.0
1988	421.1	422.1	424.7	426.1	433.5	433.3	435.7	437.5	438.7	439.9	440.4	441.1
1989	442.3	443.5	445.6	448.2	450.0	451.4	453.2	454.7	456.2	457.5	459.0	460.6
1990	461.4	463.3	465.1	466.6	467.6	468.7	470.1	471.3	473.0	474.4	475.5	476.0
1991	476.3	476.6	477.8	479.5	481.6	482.4	483.6	485.0	487.1	487.9	488.5	489.7
1992	489.9	491.4	494.8	496.0	497.6	498.4	498.2	496.2	496.8	497.5	498.5	498.8
1993	497.0	497.6	498.4	499.0	500.2	500.6	501.3	502.4	504.4	506.4	507.0	507.7
1994	507.6	508.0	508.4	509.4	510.0	510.3	na	na	na	na	na	na

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	CH_3CCl_3 ALE Network Data											
	parts per trillion by volume											
1978	na	na	na	na	na	na	56.2	54.5	56.0	57.9	61.2	60.6
1979	59.8	59.8	61.4	62.5	62.7	63.8	63.2	64.3	65.2	66.1	66.6	66.3
1980	65.9	66.2	67.4	67.0	70.2	71.0	71.6	72.5	73.5	74.2	74.0	73.1
1981	73.1	73.3	74.6	75.3	75.9	76.4	76.2	na	76.6	78.7	78.9	78.1
1982	77.8	77.8	78.5	79.9	81.4	82.7	83.6	84.1	84.3	85.2	85.2	84.4
1983	84.0	84.0	84.2	84.4	85.4	85.9	87.2	87.5	87.2	87.6	87.5	86.7
1984	86.3	86.3	86.9	87.4	na	na	na	na	na	93.2	92.5	91.7
1985	91.0	90.8	91.3	92.9	93.8	94.4	na	na	na	na	na	na

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	CH_3CCl_3 GAGE Network Data											
	parts per trillion by volume											
1981	na	na	na	na	na	na	na	na	na	na	na	80.8
1982	80.2	80.0	80.1	80.7	81.9	82.8	83.2	84.2	84.2	83.9	83.6	83.2
1983	82.6	83.5	84.5	85.2	86.0	86.4	87.2	88.1	88.1	88.3	88.0	87.5
1984	86.8	86.3	86.9	87.5	88.4	89.4	90.2	91.1	91.4	91.0	91.0	90.5
1985	89.7	89.5	90.3	91.6	92.3	92.7	93.7	95.7	96.6	96.1	95.8	94.9
1986	94.0	93.8	94.4	96.6	97.3	98.3	99.1	99.3	99.9	98.7	97.5	96.9
1987	96.3	95.9	96.5	97.6	98.7	99.8	na	102.1	101.9	102.3	101.8	101.3
1988	100.9	100.3	100.8	101.8	104.4	105.1	105.8	106.4	106.7	106.7	106.7	105.9
1989	105.3	105.4	106.2	107.3	108.2	109.0	109.3	109.8	110.3	110.0	109.4	109.5
1990	108.6	108.7	108.7	109.6	na	111.6	112.2	112.8	113.4	113.5	113.2	112.3
1991	111.3	110.7	111.3	112.2	113.8	114.7	115.1	115.8	116.3	117.0	116.7	116.1
1992	115.1	114.9	115.1	115.5	119.1	120.4	119.9	118.9	119.4	119.0	117.4	115.8
1993	114.4	113.5	113.5	113.6	114.0	114.2	114.5	115.0	114.8	111.8	111.3	109.7
1994	108.6	108.0	108.8	108.4	108.4	108.5	na	na	na	na	na	na

See next page for continuation of table.

Table 32. Global Atmospheric Concentrations of Selected Ozone-depleting Chemicals, 1978-1994 (continued)

	CCl_4 ALE Network Data											
Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	parts per trillion by volume											
1978	na	na	na	na	na	na	88.4	87.8	88.3	88.4	88.8	88.4
1979	87.8	87.4	87.7	87.9	87.9	87.7	87.7	87.6	87.6	88.6	88.8	88.9
1980	88.9	89.1	89.5	90.2	90.7	90.6	89.5	89.4	90.1	89.3	90.5	90.4
1981	90.5	89.4	89.8	89.9	90.3	90.8	91.2	na	na	90.5	90.5	90.5
1982	90.8	91.1	91.3	91.5	91.6	92.1	92.1	92.1	92.1	92.6	92.9	92.8
1983	93.0	93.2	93.2	93.3	93.3	93.3	93.3	93.0	92.8	93.0	92.9	93.2
1984	93.2	93.5	93.5	93.8	na	na	na	na	na	95.7	95.5	95.3
1985	95.5	95.4	95.4	95.7	96.0	95.7	na	na	na	na	na	na

	CCl_4 GAGE Network Data											
Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	parts per trillion by volume											
1981	na	na	na	na	na	na	na	na	na	na	na	92.4
1982	92.1	92.2	92.2	92.4	93.5	93.2	93.3	93.4	93.2	92.9	93.0	92.9
1983	93.0	93.5	93.8	94.0	94.0	93.9	93.9	93.9	93.5	93.6	93.6	93.8
1984	93.9	93.9	94.4	95.2	95.2	95.3	95.3	95.4	95.3	95.4	95.5	95.9
1985	96.2	96.3	96.5	96.8	96.9	96.6	96.7	97.1	97.3	97.2	97.4	97.4
1986	97.4	97.5	97.6	98.3	98.3	98.4	98.5	98.3	98.6	98.6	99.0	99.1
1987	99.2	99.5	99.5	99.5	99.6	99.8	na	100.2	100.1	100.3	100.3	100.4
1988	100.7	100.6	100.7	100.9	100.7	101.0	101.0	100.5	100.4	100.4	100.5	100.6
1989	100.7	100.8	101.0	101.1	101.2	101.1	101.2	101.2	101.1	101.1	101.3	102.0
1990	102.1	102.4	102.6	102.3	102.1	102.5	102.4	102.3	102.4	102.3	102.5	102.4
1991	102.1	102.0	102.1	102.1	102.1	102.2	101.8	101.8	101.7	101.8	101.7	101.9
1992	101.8	101.8	100.8	100.9	100.7	100.7	101.1	101.9	101.8	101.7	101.9	101.9
1993	101.8	101.6	101.5	101.4	101.5	101.3	101.1	101.2	101.1	na	na	na
1994	na	100.6	101.5	101.6	101.3	101.2	na	na	na	na	na	na

Source: R.G. Prinn, R.F. Weiss, F.N. Alyea, D.M. Cunnold, P.J. Fraser,P.G. Simmonds, A.J. Crawford, R.A. Rasmussen, and R.D. Rosen, "Atmospheric CFC-11 (CCl_3F), CFC-12 (CCl_2F_2), and N_2O from the ALE-GAGE Network," in *Trends '93: A Compendium of Data on Global Change*, T.A. Boden, D.P Kaiser, R.J. Sepanski & P.Y. Hughes, eds., ORNL/CDIAC-65, (U.S. Department of Energy, Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center, Oak Ridge, TN, 1994), pp. 396-420. with updates by authors.

Notes: Data are from the globally-distributed Atmospheric Lifetime Experiment (ALE)/Global Atmospheric Gases Experiment (GAGE) network. The Cape Grim, Tasmania, station is used as the source of data because data from this station are both representative and have the longest time series for the complete ALE-GAGE schedule of trace gases. Data are monthly mean halocarbon mixing ratios expressed as parts per trillion by volume. ALE began in mid-1978 and was succeeded by GAGE in mid-1986, after a period of overlap. Data are comparable even though ALE and GAGE use different instrumentation to measure trace gas concentrations.

Table 33. Air Quality Trends in Selected U.S. Urban Areas, 1985-1994

PMSA	Trend sites	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
	#	*number of PSI days greater then 100*									
Atlanta	7	9	18	27	21	3	17	6	5	17	4
Baltimore	15	25	23	28	43	9	12	20	5	14	17
Boston	24	3	2	5	15	4	1	3	1	3	1
Chicago	40	9	9	17	22	4	3	8	7	1	8
Cleveland	25	1	2	7	21	6	2	7	1	2	4
Dallas	9	27	9	13	14	7	8	1	3	5	1
Denver	20	38	49	37	19	11	9	7	7	3	2
Detroit	25	2	5	9	17	10	3	8	0	2	8
El Paso	16	32	43	32	16	33	27	10	13	6	10
Houston	28	64	55	67	61	42	61	42	31	26	29
Kansas City	19	3	4	6	4	2	2	1	1	2	0
Los Angeles	37	208	226	201	239	226	178	182	185	146	136
Miami	7	5	4	4	5	4	1	2	0	0	0
Minn/St. Paul	22	14	13	7	1	5	1	0	1	0	3
New York	24	65	58	44	46	18	18	22	4	6	8
Philadelphia	36	31	23	36	35	20	14	25	3	22	6
Phoenix	22	88	88	42	26	30	9	4	9	7	7
Pittsburgh	31	9	8	13	25	9	11	4	2	5	2
San Diego	21	88	70	61	84	90	60	39	37	17	16
San Francisco	11	5	4	1	2	1	1	0	0	0	0
Seattle	13	25	13	14	20	8	5	2	1	0	0
St. Louis	46	10	13	17	18	13	8	6	3	5	11
Wash, DC	32	17	12	26	37	8	5	17	2	13	7
Subtotal	522	778	751	714	791	563	456	416	321	302	280
Other sites	682	878	816	824	1,163	687	552	578	357	374	333
All sites	1,204	1,656	1,567	1,538	1,954	1,250	1,008	994	678	676	613

Source: U.S. Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards (OAQPS), *National Air Quality and Emissions Trends Report, 1994, Data Appendix*, Table A-13 (EPA, OAQPS, Research Triangle Park, NC, 1995).

Notes: PMSA=Primary Metropolitan Statistical Area. PSI=Pollutant Standards Index. Minn=Minneapolis. The PSI index integrates information from many pollutants across an entire monitoring network into a single number which represents the worst daily air quality experienced in an urban area. Only carbon monoxide and ozone monitoring sites with adequate historical data are included in the PSI trend analysis above, except for Pittsburgh, where sulfur dioxide contributes a significant number of days in the PSI high range. PSI index ranges and health effect descriptor words are as follows: 0 to 50 (good); 51 to 100 (moderate); 101 to 199 (unhealthful); 200 to 299 (very unhealthful); and 300 and above (hazardous). The table above shows the number of days when the PSI was greater than 100 (=unhealthy or worse days).

Table 34. Persons Living in U.S. Counties with Air Quality Levels Above National Ambient Air Quality Standards, 1984-1994

Pollutant	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
	millions of persons										
Sulfur dioxide	1.7	2.2	0.9	1.6	1.7	0.1	1.4	5.2	0.0	1.4	0.04
Nitrogen oxide	7.5	7.5	7.5	7.5	8.3	8.5	8.5	8.9	0.0	0.0	0.0
Carbon monoxide	61.3	39.6	41.4	29.4	29.5	33.6	21.7	19.9	14.3	11.6	15.3
Ozone	79.2	76.4	75.0	88.6	111.9	66.7	62.9	69.7	44.6	51.3	50.2
Lead	4.7	4.5	4.5	1.7	1.6	1.6	5.3	14.7	4.7	5.5	4.4
Particulates	32.6	47.8	41.7	21.5	25.6	27.4	18.8	21.5	25.8	9.4	13.1
Any NAAQS	na	na	na	101.8	121.3	84.4	47.4	86.4	53.6	59.1	62.0

Source: U.S. Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards (OAQPS), *National Air Quality and Emissions Trends Report*, EPA-450/F-95-003 (EPA, OAQPS, Research Triangle Park, NC, 1995) and earlier reports.

Notes: Particulates for 1984-1986 refer to total suspended particulates. After 1986, particulates refer to PM-10 (particulate matter with a diameter 10 microns or less).

Aquatic Resources

Table 35. U.S. Precipitation Trends, 1895-1995

Year	Index	Trend	Year	Index	Trend	Year	Index	Trend
	standardized z-score			*standardized z-score*			*standardized z-score*	
1895	-1.03	-0.51	1929	-0.09	-0.43	1963	-1.58	-0.58
1896	-0.12	-0.38	1930	-1.38	-0.60	1964	-0.28	-0.50
1897	-0.06	-0.33	1931	-0.64	-0.63	1965	0.43	-0.37
1898	-0.30	-0.37	1932	0.27	-0.71	1966	-1.11	-0.26
1899	-0.69	-0.47	1933	-1.11	-0.89	1967	-0.11	-0.13
1900	-0.46	-0.54	1934	-2.05	-1.00	1968	0.38	0.02
1901	-0.82	-0.56	1935	-0.40	-0.88	1969	0.38	0.11
1902	-0.27	-0.54	1936	-1.14	-0.59	1970	-0.44	0.18
1903	-0.56	-0.40	1937	0.30	-0.32	1971	0.35	0.33
1904	-1.21	-0.06	1938	0.45	-0.16	1972	0.53	0.52
1905	1.16	0.43	1939	-1.47	0.00	1973	1.47	0.59
1906	1.62	0.75	1940	0.54	0.26	1974	-0.28	0.47
1907	0.75	0.71	1941	1.71	0.40	1975	1.46	0.24
1908	0.26	0.35	1942	0.34	0.31	1976	-1.61	0.10
1909	0.69	-0.07	1943	-1.18	0.19	1977	0.54	0.17
1910	-2.29	-0.29	1944	0.44	0.26	1978	0.51	0.32
1911	0.24	-0.17	1945	1.14	0.40	1979	1.07	0.39
1912	0.59	0.11	1946	0.58	0.39	1980	-0.49	0.48
1913	0.50	0.32	1947	-0.36	0.27	1981	0.03	0.78
1914	-0.23	0.36	1948	0.38	0.16	1982	2.19	1.17
1915	1.30	0.20	1949	0.23	0.10	1983	2.15	1.33
1916	0.35	-0.10	1950	-0.29	-0.03	1984	0.89	1.12
1917	-2.44	-0.27	1951	0.82	-0.31	1985	0.50	0.72
1918	0.41	-0.13	1952	-1.62	-0.69	1986	0.62	0.27
1919	0.57	0.18	1953	-0.83	-1.05	1987	-0.03	-0.14
1920	0.90	0.36	1954	-1.69	-1.24	1988	-1.51	-0.31
1921	-0.25	0.36	1955	-1.03	-1.15	1989	-0.62	-0.09
1922	0.39	0.22	1956	-2.37	-0.77	1990	1.17	0.38
1923	1.22	-0.03	1957	1.41	-0.29	1991	0.92	0.79
1924	-1.74	-0.28	1958	0.13	0.00	1992	1.04	0.98
1925	-0.79	-0.28	1959	-0.03	0.01	1993	1.42	0.98
1926	0.34	-0.08	1960	-0.42	-0.13	1994	0.46	0.90
1927	1.09	0.02	1961	0.22	-0.32	1995	0.85	0.82
1928	-0.74	-0.15	1962	-0.51	-0.51			

Source: U.S. Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC), *Climate Variations Bulletin,* Vol. 7 (DOC, NOAA, NCDC, Asheville, NC, December 1995).

Notes: The U.S. national precipitation index is computed from data from the Cooperative Station Network. The contiguous United States is divided into 344 climate divisions. The monthly precipitation for all stations within each division is averaged to compute a divisional monthly precipitation. The divisional precipitation values are standardized using the gamma distribution over the 1931-90 period. The divisional standardized precipitation index values are then weighted by area to compute a national precipitation index value. A national annual value is computed from the monthly national values. The annual index values are then normalized over the period of record.

Table 36. Severe to Extreme Drought and Wetness in the Conterminous United States, 1896-1995

Year	Severe to extreme drought	Severe to extreme wetness	Year	Severe to extreme drought	Severe to extreme wetness	Year	Severe to extreme drought	Severe to extreme wetness
	% area			*% area*			*% area*	
1896	5.4	7.9	1930	12.9	5.3	1964	20.7	3.2
1897	4.0	6.4	1931	30.0	5.3	1965	7.6	13.7
1898	9.0	4.2	1932	10.2	9.5	1966	10.0	5.8
1899	8.6	2.4	1933	13.6	3.2	1967	7.3	5.2
1900	15.7	5.4	1934	48.8	0.6	1968	3.9	7.6
1901	19.8	3.4	1935	23.4	3.1	1969	0.9	10.8
1902	24.7	5.7	1936	24.7	2.3	1970	0.9	4.4
1903	7.9	11.8	1937	19.6	5.2	1971	5.2	8.7
1904	13.7	7.3	1938	9.3	6.0	1972	4.8	13.3
1905	6.9	17.7	1939	19.4	2.9	1973	3.2	31.2
1906	1.1	22.7	1940	22.2	2.2	1974	4.9	16.1
1907	0.9	26.4	1941	11.6	26.0	1975	0.5	20.8
1908	2.1	12.8	1942	4.2	26.0	1976	6.9	9.2
1909	4.4	16.0	1943	4.2	10.0	1977	22.7	4.7
1910	14.2	5.4	1944	5.9	7.6	1978	2.8	14.0
1911	18.3	3.8	1945	2.7	17.0	1979	1.1	21.9
1912	0.5	14.3	1946	3.4	9.7	1980	5.1	11.6
1913	3.3	13.8	1947	4.7	11.6	1981	13.1	4.5
1914	6.1	14.3	1948	6.1	9.3	1982	1.1	17.5
1915	3.8	24.1	1949	4.8	6.2	1983	0.0	36.0
1916	0.5	26.8	1950	8.4	9.6	1984	2.2	26.3
1917	8.5	14.8	1951	12.3	14.6	1985	2.9	21.0
1918	13.3	1.4	1952	12.7	10.3	1986	4.4	15.1
1919	5.2	11.3	1953	19.9	4.1	1987	7.8	16.5
1920	1.4	18.4	1954	39.5	2.9	1988	22.2	5.8
1921	2.8	6.4	1955	29.4	1.5	1989	18.7	6.9
1922	4.1	3.0	1956	37.0	5.0	1990	19.0	7.2
1923	4.4	8.1	1957	15.5	10.5	1991	9.2	9.0
1924	11.6	8.2	1958	2.7	18.1	1992	10.8	18.3
1925	16.7	0.7	1959	11.1	4.5	1993	1.2	35.1
1926	9.6	4.6	1960	12.3	7.1	1994	6.9	14.8
1927	5.3	15.9	1961	14.6	7.7	1995	1.6	24.9
1928	5.6	12.3	1962	4.4	5.9			
1929	6.8	2.0	1963	18.4	2.0			

Source: U.S. Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC), *Climate Variations Bulletin,* Vol. 7 (DOC, NOAA, NCDC, Asheville, NC, December 1995).

Notes: This table presents the average annual values of the percent area experiencing severe to extreme drought and wet conditions based on the Palmer Drought Severity Index (PDSI). PDSI is based on a water balance model that consists of a hydrologic accounting between water supply and demand. The index values range from negative (indicating drought), to zero (near normal conditions), to positive (wet spell). The index has been calculated on a monthly basis for the contiguous United States since 1896.

Table 37. U.S. Water Use by Source and End-use Sector, 1900-1990

Year	Source: Ground water	Source: Surface water	End-use sector: Public supply	Rural domestic & livestock	Irrigation	Thermoelectric utility	Other industrial	Total
	billions of gallons per day							
1900	na	na	3.0	2.0	20.0	5.0	10.0	40.0
1910	na	na	5.0	2.2	39.0	7.0	14.0	67.2
1920	na	na	6.0	2.4	56.0	9.0	18.0	91.4
1930	na	na	8.0	2.9	60.0	18.0	21.0	109.9
1940	na	na	10.0	3.1	71.0	23.0	29.0	136.1
1945	na	na	12.0	3.4	80.0	31.5	35.0	161.9
1950	34.0	150.0	14.0	3.6	89.0	40.0	37.0	183.6
1955	47.6	198.0	17.0	3.6	110.0	72.0	39.0	241.6
1960	50.4	221.0	21.0	3.6	110.0	100.0	38.0	272.6
1965	60.5	253.0	24.0	4.0	120.0	130.0	46.0	324.0
1970	69.0	303.0	27.0	4.5	130.0	170.0	47.0	378.5
1975	83.0	329.0	29.0	4.9	140.0	200.0	45.0	418.9
1980	83.9	361.0	34.0	5.6	150.0	210.0	45.0	444.6
1985	73.7	320.0	37.0	7.8	140.0	190.0	31.0	405.8
1990	80.6	327.2	38.5	7.9	137.0	195.0	29.9	408.8

Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970*, Series J 92-103 (GPO, Washington, DC, 1975).

W.B. Solley, R.R. Pierce and H.A. Perlman, *Estimated Water Use in the United States in 1990*, Circular 1081 (U.S. Department of the Interior, Geological Survey, Reston, VA, 1993) and earlier reports in this series.

Note: na=not available.

Table 38. Designated-use Support in Surface Waters of the United States, 1994

Designated-use support	Rivers and streams	Lakes, ponds and reservoirs	Estuaries
	miles	*acres*	*square miles*
Fully supporting	352,828	8,598,603	15,426
Threatened	43,454	2,184,198	1,651
Partially supporting	135,679	4,845,390	7,261
Not supporting	83,739	1,505,946	2,439
Not attainable	105	16	71
Total surface waters assessed	615,806	17,134,153	26,847
Total surface waters not assessed	2,932,932	23,691,911	7,541
Total surface waters	3,548,738	40,826,064	34,388

Source: U.S. Environmental Protection Agency (EPA), Office of Water (OW), *National Water Quality Inventory: 1994 Report to Congress, Appendixes,* EPA841-R-95-006 (EPA, OW, Washington, DC, 1995).

Table 39. Trends in U.S. Stream Water Quality, 1980-1989

Water quality indicators	NASQAN* stations analyzed	Flow-adjusted concentrations		
		Upward trend	Downward trend	No trend
	number of stations			
Dissolved solids	340	28	46	266
Nitrate	344	22	27	295
Total phosphorus	410	19	92	299
Suspended sediments	324	5	37	282
Dissolved oxygen	424	38	26	360
Fecal coliform	313	10	40	263

Source: R.A. Smith, R.B. Alexander and K.J. Lanfear, “Stream Water Quality in the Conterminous United States -- Status and Trends of Selected Indicators During the 1980’s,” In: *National Water Summary 1990-91, Hydrologic Events and Stream Water Quality*, R.W. Paulson, E.B. Chase, J.S. Williams and D.W. Moody, Compilers, Water Supply Paper 2400 (U.S. Department of the Interior, Geological Survey, Reston, VA, 1993), Figures 38-43.

Notes: *Analyses were made on data from the U.S. Geological Survey’s National Stream Quality Accounting Network (NASQAN) stations. Data for total phosphorus cover the period 1982-1989.

Table 40. Ambient Water Quality in U.S. Rivers and Streams: Violation Rates, 1975-1994

Year	Fecal coliform bacteria	Dissolved oxygen	Total phosphorus	Total cadmium, dissolved	Total lead, dissolved
	percent of all measurements exceeding national water quality criteria				
1975	36	5	5	*	*
1976	32	6	5	*	*
1977	34	11	5	*	*
1978	35	5	5	*	*
1979	34	4	3	4	13
1980	31	5	4	1	5
1981	30	4	4	1	3
1982	33	5	3	1	2
1983	34	4	3	1	5
1984	30	3	4	<1	<1
1985	28	3	3	<1	<1
1986	24	3	3	<1	<1
1987	23	2	3	<1	<1
1988	22	2	4	<1	<1
1989	30	3	2	<1	<1
1990	26	2	3	<1	<1
1991	15	2	2	<1	<1
1992	28	2	2	<1	<1
1993	31	1	2	na	na
1994	29	<1	4	na	na

Source: U.S. Geological Survey, unpublished, Reston, VA, 1995.

Notes: Violation levels are based on the following U.S. Environmental Protection Agency water quality criteria: fecal coliform bacteria—above 200 cells per 100 ml; dissolved oxygen—below 5 mg per liter; total phosphorus—above 1.0 mg per liter; cadmium, dissolved—above 10 ug per liter; lead, dissolved—above 50 ug per liter. *base figure too small to meet statistical standards for reliability of derived figures. na=not available.

Table 41. Estimated Phosphorus Loadings to the Great Lakes, 1976-1991

Year	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
	metric tons				
1976	3,550	6,656	4,802	18,480	12,695
1977	3,661	4,666	3,763	14,576	8,935
1978	5,990	6,245	5,255	19,431	9,547
1979	6,619	7,659	4,881	11,941	8,988
1980	6,412	6,574	5,307	14,855	8,579
1981	3,412	4,091	3,481	10,452	7,437
1982	3,160	4,084	4,689	12,349	8,891
1983	3,407	4,515	3,978	9,880	6,779
1984	3,642	3,611	3,452	12,874	7,948
1985	2,864	3,956	5,758	11,216	7,083
1986	3,059	4,981	4,210	11,118	9,561
1987	1,949	3,298	2,909	8,381	7,640
1988	2,067	2,907	3,165	7,841	6,521
1989	2,323	4,360	3,227	8,568	6,728
1990	1,750	3,006	2,639	12,899	8,542
1991	2,709	3,478	4,460	11,113	10,475

Source: Great Lakes Water Quality Board, *Great Lakes Water Quality Surveillance Subcommittee Report to the International Joint Commission*, United States and Canada, (International Joint Commission, Windsor, ON, Canada, biennial).

Notes: The 1978 Great Lakes Water Quality Agreement set target loadings for each lake (in metric tons per year): Lake Superior 3,400; Lake Michigan 5,600; Lake Huron 4,360; Lake Erie 11,000; and Lake Ontario 7,000. Data do not include loadings to the St. Lawrence River.

Table 42. Oil Polluting Incidents Reported In and Around U.S. Waters, 1970-1994

Year	Number	Volume	Year	Number	Volume
	thousands	*million gallons*		*thousands*	*million gallons*
1970	3.71	15.25	1983	7.92	8.38
1971	8.74	8.84	1984	8.26	19.01
1972	9.93	18.81	1985	6.17	8.47
1973	9.01	15.25	1986	4.99	4.28
1974	9.99	15.72	1987	4.84	3.61
1975	9.30	21.52	1988	5.00	6.59
1976	9.42	18.52	1989	6.61	13.48
1977	9.46	8.19	1990	8.18	7.97
1978	10.64	10.86	1991	10.41	2.16
1979	9.83	20.89	1992	4.49	1.88
1980	8.38	12.60	1993	8.97	2.08
1981	7.81	8.92	1994	9.44	19.51
1982	7.48	10.34			

Source: U.S. Department of Transportation, United States Coast Guard, Response Division, G-MRO, Oil Spill Database, unpub lished, Washington, DC, 1996.

Table 43. Shellfish Bed Closures in the U.S. Gulf of Mexico by State, 1985-1995

Year	1985	1990	1995
	thousands of harvested-limited acres		
Florida	610	841	736
Alabama	297	315	408
Mississippi	280	157	113
Louisiana	1,619	1,509	1,359
Texas	376	840	691

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Ocean Assessments Division, Strategic Assessment Branch, National Shellfish Register, unpublished, Rockville, MD, 1996.

Notes: Harvest-limited acres are shellfish growing waters that are not available for direct marketing at all times. There may be several reasons why an area is classified as harvest-limited, including water quality problems, lack of funding for complete surveying and monitoring, conservation measures, and other management/administrative actions.

Table 44. Status of Stock Levels of U.S. Fisheries, 1992-1994

Fishery	Current status relative to the level producing LTPY				
	Below	Near	Above	Unknown	Total
	number of species				
Northeast demersals	19	3	2	1	25
Northeast pelagics	1	2	3	0	6
Atlantic anadromous	4	0	1	0	5
Northeast invertebrates	0	3	2	1	6
Atlantic highly migratory pelagics	4	4	0	2	10
Atlantic sharks	1	0	1	1	3
Atlantic/Gulf coastal migratory pelagics	1	3	0	3	7
Atlantic/Gulf reef fish	9	2	0	17	28
Southeast drum and croaker	4	0	0	3	7
Southeast menhaden	0	2	0	0	2
Southeast/Caribbean invertebrates	3	6	0	5	14
Pacific coast salmon	2	3	0	0	5
Alaska salmon	1	1	3	0	5
Pacific coast and Alaska pelagics	3	4	0	0	7
Pacific coast groundfish	6	4	4	5	19
Western Pacific invertebrates	1	0	0	0	1
Western Pacific bottomfish*	3	3	0	0	6
Pacific highly migratory pelagics	2	12	0	1	15
Alaska groundfish	6	8	8	3	25
Alaska shellfish	3	0	1	1	5
Subtotal	73	60	25	43	201
Nearshore species	10	14	0	50	74
Total assessed species	83	74	25	93	275

Source: U.S. Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), *Our Living Oceans, Report on the Status of U.S. Living Marine Resources, 1995*, NOAA Tech. Memo., NMFS-F/SPO-19 (DOC, NOAA, NMFS, Washington, DC, 1996).

Notes: LTPY is long-term potential yield or the maximum long-term average catch that can be achieved from the resource. This term is analogous to the concept of maximum sustainable yield. Stock level relative to LTPY is a measure of stock status. The present abundance level of the stock is compared with the level of abundance which on average would support the LTPY harvest. This level is expressed as below, near, above, or unknown relative to the abundance level that would produce LTPY. Demersal=bottom-dwelling fishes such as flounders, skates, and dogfish. Pelagic=mid-water fishes such as blue fish, anchovies, sardines, and squids. Anadromous=fishes which ascend rivers to spawn, such as salmon, shad, and striped bass. Invertebrates=lobsters, clams, scallops, shrimp, etc. Highly migratory=high-seas (oceanic) fishes such as tunas, swordfish, and billfishes. Coastal migratory=fishes that range from the shore to the outer edge of the U.S. continental shelf, such as king and Spanish mackeral, dolphin fish, and cobia. Reef fish=fishes that prefer coral reefs, artificial structures, and other hard bottom areas, such as snappers, groupers, and amberjacks. Reef fish also include tilefishes that prefer sand bottom areas. *also includes armorhead.

Table 45. Waterborne Disease Outbreaks and Cases in the United States, 1971-1994

Year	Water supply system: Community	Non-community	Individual	Total	Total cases
	number of outbreaks				*number*
1971	8	8	4	20	5,184
1972	9	19	2	30	1,650
1973	6	16	3	25	1,762
1974	11	9	5	25	8,356
1975	6	16	2	24	10,879
1976	9	23	3	35	5,068
1977	14	18	2	34	3,860
1978	10	19	3	32	11,435
1979	24	13	8	45	9,841
1980	26	20	7	53	20,045
1981	14	18	4	36	4,537
1982	26	15	3	44	3,588
1983	30	9	4	43	21,036
1984	12	5	10	27	1,800
1985	7	14	1	22	1,946
1986	10	10	2	22	1,569
1987	8	6	1	15	22,149
1988	6	10	1	16	2,169
1989	6	6	1	13	2,670
1990	6	7	2	15	1,748
1991	2	13	0	15	12,960
1992	6	10	3	19	4,504
1993	9	4	5	18	404,190
1994	5	5	2	12	649

Source: M.H. Kramer, B.L. Herwaldt, G.F. Craun, R.L. Calderon and D.D. Juranek, "Surveillance for Waterborne-Disease Outbreaks - United States, 1993-1994," In: *CDC Surveillance Summaries,* April 12, 1996, Morbidity and Mortality Weekly Report 42(SS-5) (U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, Atlanta, GA), pp. 7-8, and earlier reports.

Notes: The number of waterborne disease outbreaks and the number of affected people (=cases) reported to the Centers for Disease Control and Prevention and to the U.S. Environmental Protection Agency represents a fraction of the total number that occur. Therefore, these data should not be used to draw firm conclusions about the true incidence of waterborne disease outbreaks.

Table 46. U.S. Wetlands by Type, Mid-1950s, Mid-1970s, and Mid-1980s

Wetlands type	Mid-1950s	Mid-1970s	Mid-1980s
		million acres	
Estuarine wetlands	5.59	5.53	5.47
Palustrine marshes	33.07	24.31	24.53
Palustrine shrub wetlands	11.00	15.51	15.35
Palustrine forested wetlands	55.09	55.15	51.75
Other palustrine wetlands	2.70	5.35	6.14
Total wetland acreage	107.45	105.85	103.24

Source: T.E. Dahl and C.E. Johnson, *Status and Trends of Wetlands in the Conterminous United States, 1970s to 1980s,* Table 2, p. 8 (U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC, 1991) and earlier reports.

Table 47. Wetlands Losses by Current State Boundaries, 1780s-1980s

State	Total surface area of state	Wetlands area 1780s	Wetlands area 1980s	Wetlands losses
	million acres			*%*
Alabama	33.03	7.57	3.78	50
Alaska	375.30	170.20	170.00	<1
Arizona	72.90	0.93	0.60	36
Arkansas	33.99	9.85	2.76	72
California	101.56	5.00	0.45	91
Colorado	66.72	2.00	1.00	50
Connecticut	3.21	0.67	0.18	74
Delaware	1.32	0.48	0.22	54
Florida	37.48	20.33	11.04	46
Georgia	37.68	6.84	5.30	23
Hawaii	4.12	0.06	0.05	12
Idaho	53.47	0.88	0.39	56
Illinois	36.10	8.21	1.25	85
Indiana	23.23	5.60	0.75	87
Iowa	36.03	4.00	0.42	89
Kansas	52.65	0.84	0.44	48
Kentucky	25.85	1.57	0.30	81
Louisiana	31.05	16.19	8.78	46
Maine	21.26	6.46	5.20	20
Maryland	6.77	1.65	0.44	73
Massachusetts	5.28	0.82	0.59	28
Michigan	37.26	11.20	5.58	50
Minnesota	53.80	15.07	8.70	42
Mississippi	30.54	9.87	4.07	59
Missouri	44.60	4.84	0.64	87
Montana	94.17	1.15	0.84	27
Nebraska	49.43	2.91	1.91	35
Nevada	70.75	0.49	0.24	52

See next page for continuation of table.

Table 47. Wetlands Losses by Current State Boundaries, 1780s-1980s (continued)

State	Total surface area of state	Wetlands area 1780s	Wetlands area 1980s	Wetlands losses
	million acres			%
New Hampshire	5.95	0.22	0.20	9
New Jersey	5.02	1.50	0.92	39
New Mexico	77.87	0.72	0.48	33
New York	31.73	2.56	1.03	60
North Carolina	33.66	11.09	5.69	49
North Dakota	45.23	4.93	2.49	49
Ohio	26.38	5.00	0.48	90
Oklahoma	44.75	2.84	0.95	67
Oregon	62.07	2.26	1.39	38
Pennsylvania	29.01	1.13	0.50	56
Rhode Island	0.78	0.10	0.07	37
South Carolina	19.88	6.41	4.66	27
South Dakota	49.31	2.74	1.78	35
Tennessee	27.04	1.94	0.79	59
Texas	171.10	16.00	7.61	52
Utah	54.35	0.80	0.56	30
Vermont	6.15	0.34	0.22	35
Virginia	26.12	1.85	1.07	42
Washington	43.64	1.35	0.94	31
West Virginia	15.48	0.13	0.10	24
Wisconsin	35.94	9.80	5.33	46
Wyoming	62.66	2.00	1.25	38

Source: T.E. Dahl, *Wetlands Losses in the United States 1780s to 1980s, Report to Congress* (U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC, 1991).

Table 48. U.S. Wetlands Conversions, 1954-1992

Post-conversion land use	1954-1974[1]	1974-1983[2]	1982-1992[3]
	thousands of acres per year (average)		
Cropland	600.0	237.5	30.9
Urban use	55.0	14.1	88.6
Other uses	35.0	171.7	36.6
Total	690.0	423.2	156.1
	percent of average annual conversion		
Cropland	87.0	56.1	19.8
Urban use	8.0	3.3	56.7
Other uses	5.1	40.6	23.5
Total	100.0	100.0	100.0

Sources: [1]Frayer, W.E., T.J. Monahan, D.C. Bowden and F.A. Graybill, *Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950's to 1970's* (U.S. Department of the Interior, Fish and Wildlife Service, Fort Collins, CO, 1983).

[2]T.E. Dahl and C.E. Johnson, *Status and Trends of Wetlands in the Conterminous United States, 1970s to 1980s,* Table 2, p. 8 (U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC, 1991).

[3]U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), *Wetlands Values and Trends*, NRCS/RCA (Resource Conservation Act) Issue Brief 4 (USDA, NRCS, Washington, DC, 1995).

Notes: Data for 1954-1974 and 1974-1983 exclude Alaska and Hawaii. Data for 1982-1992 include only rural, nonfederal land; exclude Alaska. Other includes forests, rangeland, and deepwater habitat.

Terrestrial Resources

Table 49. Land Use and Ownership in the United States, 1900-1992

	Land use					Ownership	
Year	Crop-land	Grazing land	Forest-land	Other land	Total	Private & other public	Federal
	million acres					%	
1900	319	1,044	366	175	1,904	52.7	47.3
1910	347	814	562	181	1,904	68.5	31.5
1920	402	750	567	185	1,904	73.8	26.2
1930	413	708	607	176	1,904	74.0	26.0
1945	451	660	602	193	1,905	73.7	26.3
1949	478	631	606	189	1,904	73.5	26.5
1954	465	632	615	191	1,904	73.5	26.5
1959	458	633	728	452	2,271	61.0	39.0
1964	444	640	732	450	2,266	60.4	39.6
1969	472	604	723	465	2,264	66.5	33.5
1974	465	598	718	483	2,264	66.5	33.5
1978	471	587	703	503	2,264	67.2	32.9
1982	469	597	655	544	2,265	67.9	32.2
1987	464	591	648	562	2,265	68.1	31.9
1992	460	591	648	564	2,263	71.3	28.7

Sources: A.B. Daugherty, *Major Uses of Land in the United States: 1992*, Table 1, p. 4, Agricultural Economic Report No. 723 (GPO, Washington, DC, 1995) and earlier reports in this series.

U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States* (GPO, Washington, DC, annual).

Notes: Prior to 1959, excludes Alaska and Hawaii. Other changes in total land area result from refinements in measuring techniques. Federal includes original public-domain lands vested in the U.S. government by virtue of its sovereignty as well as lands acquired by the U.S. government by purchase, condemnation, and gift. Historical estimates are based on imperfect data. Other land includes rural transportation areas, areas used primarily for recreation and wildlife purposes, various public installations and facilities, farmsteads and farm roads, urban areas, areas in miscellaneous uses not inventoried, marshes, open swamps, bare rock areas, desert, tundra, and other land generally having low value for agricultural purposes. Land-use and land-ownership estimates are not strictly comparable. Totals may not agree with sum of components due to independent rounding.

Table 50. Special Uses of Land in the United States, 1945-1992

Land use	1945	1949	1959	1969	1974	1978	1982	1987	1992
					million acres				
Transportation	22.6	22.9	25.2	26.0	26.3	26.6	26.7	25.7	25.2
Parks & wildlife	22.6	27.6	46.9	81.3	87.5	98.0	211.0	224.9	228.9
National defense	24.8	21.5	31.2	25.6	25.0	24.9	24.0	20.9	20.5
Urban	15.0	18.3	27.2	31.0	34.8	44.6	50.2	56.6	58.9
Farmsteads	15.1	15.1	11.4	10.3	8.1	8.4	8.0	7.1	6.2
Total	100.0	105.4	141.9	174.2	181.7	202.5	319.9	335.2	393.5

Source: A.B. Daugherty, *Major Uses of Land in the United States: 1992*, Table 14, p. 17, Agricultural Economic Report No. 723 (GPO, Washington, DC, 1995) and earlier reports in this series.

Note: Categories of special-use lands are a subset of those listed as other in Table 49.

Table 51. Number of Farms and Land in Farms in the United States, 1900-1992

	Farm size									
	1 - 49 acres		50 - 499 acres		500 - 999 acres		1,000 + acres		Total	
Year	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
					millions					
1900	1.93	49	3.37	520	0.10	68	0.05	200	5.74	837
1910	2.25	49	3.93	570	0.13	84	0.05	167	6.37	870
1920	2.31	59	3.93	580	0.15	100	0.07	221	6.45	960
1925	2.42	57	3.75	550	0.14	97	0.06	224	6.37	928
1930	2.36	56	3.69	550	0.16	109	0.08	277	6.30	992
1935	2.69	59	3.86	540	0.17	114	0.09	310	6.81	1,023
1940	2.29	50	3.55	540	0.16	112	0.10	366	6.10	1,068
1945	2.25	47	3.32	520	0.17	119	0.11	460	5.86	1,146
1950	1.97	39	3.12	500	0.18	126	0.12	495	5.39	1,160
1954	1.70	32	2.76	460	0.19	132	0.13	531	4.78	1,155
1959	1.06	22	2.32	410	0.20	137	0.14	555	3.71	1,124
1964	0.82	17	1.98	360	0.21	145	0.15	585	3.16	1,107
1969	0.64	14	1.73	320	0.22	148	0.15	578	2.73	1,060
1974	0.51	11	1.44	273	0.21	142	0.16	590	2.31	1,024
1978	0.54	12	1.34	256	0.21	147	0.16	600	2.26	1,015
1982	0.64	13	1.24	233	0.20	141	0.16	600	2.24	987
1987	0.60	12	1.12	212	0.20	139	0.17	602	2.09	965
1992	0.56	11	1.01	190	0.19	129	0.17	615	1.93	945

Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970* (GPO, Washington, DC, 1975).

--, *Census of Agriculture for 1992, Vol. I: Geographic Area Series, Part 51 United States Summary and State Data*, Table 8, p. 18, AC92-A-51 (GPO, Washington, DC, 1994) and earlier census reports.

Table 52. Major Uses of U.S. Cropland, 1945-1995

Year	Cropland used for crops: Harvested	Cropland used for crops: Failed	Cropland used for crops: Cultivated summer fallow	Idle cropland	Cropland pasture	Total	Cropland diverted from production
	million acres						
1945	336	9	18	40	47	454	na
1949	352	9	26	22	67	478	na
1954	339	13	28	19	66	465	na
1959	317	10	31	33	66	457	22.5
1964	292	6	37	52	57	444	55.0
1969	286	6	41	51	88	472	57.5
1974	322	8	31	21	83	465	2.7
1978	330	7	32	26	76	471	18.3
1982	347	5	31	21	65	469	11.1
1987	293	6	32	68	65	464	76.2
1992	306	8	24	56	67	460	54.9
1995	304	7	22	na	na	na	50.0

Sources: U.S. Department of Agriculture (USDA), Economic Research Service (ERS), *AREI Updates: 1995 Cropland Use* (USDA, ERS, Washington, DC, 1995).

U.S. Department of Commerce, Bureau of the Census, *Census of Agriculture for 1992, Vol. I: Geographic Area Series, Part 51 United States Summary and State Data*, Table 7, p. 17, AC92-A-51 (GPO, Washington, DC, 1994) and earlier census reports.

Notes: na=not available except for years coinciding with Census of Agriculture. Excludes Alaska and Hawaii. Cropland diversions occur under federal farm programs such as annual commodity programs, Conservation Reserve Program, and Wetlands Reserve Program.

Table 53. Cropland Tillage Practices Used in U.S. Field Crop Production, 1989-1995

	Conventional tillage	Reduced tillage	Conservation tillage
	million acres (percent of planted acres)		
1989	137.3 (49.09%)	70.7 (25.26%)	71.7 (25.65%)
1990	136.7 (48.67%)	71.0 (25.27%)	73.2 (26.07%)
1991	129.8 (46.14%)	72.3 (25.71%)	79.2 (28.14%)
1992	120.8 (42.70%)	73.4 (25.94%)	88.7 (31.35%)
1993	107.9 (38.78%)	73.2 (26.30%)	97.2 (34.92%)
1994	111.4 (39.25%)	73.2 (25.76%)	99.3 (34.98%)
1995	109.7 (39.33%)	70.1 (25.18%)	98.9 (35.47%)

Source: Conservation Technology Information Center (CTIC), *National Crop Residue Management Survey Annual Report* (CTIC, West Lafayette, IN, 1996).

Notes: Definitions of tillage practices are based on the use of specific tillage implements and their residue incorporation rates. Conventional tillage is practiced with or without moldboard plow and leaves less than 15 percent residue after planting. Reduced tillage leaves 15-30 percent residue after planting. Conservation tillage leaves over 30 percent residue after planting. Conservation tillage includes no till (the soil is left undisturbed prior to planting, except for nutrient injection, and planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row openers, disk openers, inrow chisels, or rototillers), ridge till (the soil is left undisturbed prior to planting, except for nutrient injection, and planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners; residue is left on the surface between ridges), and mulch till (the surface is disturbed before planting but 30 percent or more residue remains after planting).

Table 54. Erosion on U.S. Cropland, 1982-1992

Year	Sheet and rill erosion		Wind erosion	
	billion tons per year	*tons per acre per year*	*billion tons per year*	*tons per acre per year*
1982	1.7	4.1	1.4	3.3
1987	1.5	3.7	1.3	3.2
1992	1.2	3.1	0.9	2.5

Source: U.S. Department of Agriculture, National Resource Conservation Service (NRCS), *Summary Report 1992 National Resources Inventory* (USDA, NRCS, Washington, DC, 1995).

Table 55. U.S. Agricultural Productivity Indexes, 1960-1993

	Farm input				Farm output			Total
Year	Purchased input	Labor	Capital	Total	Crops	Live-stock	Total	produc-tivity
	index (1982=100)							
1960	77	186	86	99	55	77	63	64
1961	75	181	85	97	56	80	65	66
1962	77	179	84	97	56	81	65	67
1963	79	174	84	98	58	83	67	69
1964	78	164	84	96	56	86	67	70
1965	78	160	85	95	60	83	68	72
1966	84	149	85	96	59	84	68	71
1967	83	142	88	95	62	87	71	75
1968	82	137	88	94	63	87	72	77
1969	85	135	88	95	65	87	73	77
1970	86	133	88	95	63	90	73	77
1971	84	131	90	94	70	92	78	83
1972	86	129	89	95	70	93	78	83
1973	89	129	92	97	75	94	81	84
1974	90	120	95	96	68	92	77	80
1975	87	120	95	95	78	87	81	86
1976	92	118	97	98	77	92	83	85
1977	90	114	97	96	84	93	88	91
1978	103	110	98	101	87	93	89	88
1979	109	106	99	104	95	95	95	91
1980	111	102	102	105	86	99	91	87
1981	106	102	101	103	99	101	100	97
1982	100	100	100	100	100	100	100	100
1983	101	95	94	97	78	102	88	91
1984	99	95	95	97	97	101	99	103
1985	96	91	94	94	102	104	103	109
1986	94	85	90	91	97	104	100	110
1987	94	84	86	89	98	107	102	115
1988	89	86	84	86	86	109	95	111
1989	89	85	84	86	99	109	103	120
1990	96	85	83	89	106	111	108	121
1991	97	87	83	90	104	114	108	121
1992	101	82	82	90	115	116	116	129
1993	104	81	81	90	101	117	108	119

Source: U.S. Department of Agriculture, Economic Research Service, *Agricultural Outlook* (USDA, ERS, Washington, DC, monthly).

Notes: Purchased input includes chemicals, fuels, electricity, feed, seed, and livestock purchases; contract labor and custom machine services; machine and building maintenance and repair; irrigation from public sellers of water; and miscellaneous farm production items. Labor includes both hired and self-employed labor. Capital includes durable equipment and real estate. Livestock output includes meat animals, dairy products, poultry, eggs, wool, mohair, horses, mules, goats, sheep, rabbits, fur animals, aquaculture, honey, and beeswax. Crop outputs include food grains, feed grains, oil crops, sugar crops, cotton, cottonseed, vegetables, fruit trees, nut trees, tobacco, floriculture, ornamentals, Christmas trees, mushrooms, legume seeds, grass seeds, hops, mint, broomcorn, popcorn, hemp, and flax. Productivity=output/input.

Table 56. U.S. Farm Fuel Use, 1974-1994

Year	Gasoline	Diesel	Liquefied petroleum gas
		billion gallons	
1974	3.7	2.6	1.4
1975	4.5	2.4	1.0
1976	3.9	2.8	1.2
1977	3.8	2.9	1.1
1978	3.6	3.2	1.3
1979	3.4	3.2	1.1
1980	3.0	3.2	1.1
1981	2.7	3.1	1.0
1982	2.4	2.9	1.1
1983	2.3	3.0	0.9
1984	2.1	3.0	0.9
1985	1.9	2.9	0.9
1986	1.7	2.9	0.7
1987	1.5	3.0	0.6
1988	1.6	2.8	0.6
1989	1.6	3.2	0.6
1990	1.5	2.7	0.6
1991	1.4	2.8	0.6
1992	1.6	3.1	0.9
1993	1.4	3.3	0.7
1994	1.4	3.5	0.9

Sources: U.S. Department of Agriculture (USDA), Economic Research Service (ERS), *AREI Updates: Farm Energy*, Table 2, p. 2 (USDA, ERS, Washington, DC, 1995).

Notes: Excludes Alaska and Hawaii. Excludes fuel used for household and personal business. Data are based on USDA, National Agricultural Statistics Service, Farm Production Expenditures Survey data.

Table 57. U.S. Commercial Fertilizer Use, 1960-1995

Year	Total quantity	Active ingredients			
		Nitrogen	Phosphate	Potash	Total
	million tons	*million tons*			
1960	24.9	2.7	2.6	2.2	7.5
1961	25.6	3.0	2.6	2.2	7.8
1962	26.6	3.4	2.8	2.3	8.4
1963	28.8	3.9	3.1	2.5	9.5
1964	30.7	4.4	3.4	2.7	10.5
1965	31.8	4.6	3.5	2.8	10.9
1966	34.5	5.3	3.9	3.2	12.4
1967	37.1	6.0	4.3	3.6	14.0
1968	38.7	6.8	4.4	3.8	15.0
1969	38.9	6.9	4.7	3.9	15.5
1970	39.6	7.5	4.6	4.0	16.1
1971	41.1	8.1	4.8	4.2	17.2
1972	41.2	8.0	4.9	4.3	17.2
1973	43.3	8.3	5.1	4.6	18.0
1974	47.1	9.2	5.1	5.1	19.3
1975	42.5	8.6	4.5	4.4	17.6
1976	49.2	10.4	5.2	5.2	20.8
1977	51.6	10.6	5.6	5.8	22.1
1978	47.5	10.0	5.1	5.5	20.6
1979	51.5	10.7	5.6	6.2	22.6
1980	52.8	11.4	5.4	6.2	23.1
1981	54.0	11.9	5.4	6.3	23.7
1982	48.7	11.0	4.8	5.6	21.4
1983	41.8	9.1	4.1	4.8	18.1
1984	50.1	11.1	4.9	5.8	21.8
1985	49.1	11.5	4.7	5.6	21.7
1986	44.1	10.4	4.2	5.1	19.7
1987	43.0	10.2	4.0	4.8	19.1
1988	44.5	10.5	4.1	5.0	19.6
1989	44.9	10.6	4.1	4.8	19.6
1990	47.7	11.1	4.3	5.2	20.6
1991	47.3	11.3	4.2	5.0	20.5
1992	48.8	11.5	4.2	5.0	20.7
1993	49.1	11.4	4.4	5.1	20.9
1994	52.3	12.6	4.5	5.3	22.4
1995	50.7	11.7	4.4	5.1	21.3

Sources: Tennessee Valley Authority, Environmental Research Center, *Commercial Fertilizers, 1994* (TVA, Oak Ridge, TN, 1995), and earlier issues.

The Association of American Plant Food Control Officials (AAPFCO), *Commercial Fertilizers, 1995* (AAPFCO, Lexington, KY, 1996).

U.S. Department of Agriculture, Economic Research Service, *AREI UPDATES: Nutrient Use and Management*, Table 1, p. 2 (USDA, ERS, Washington, DC, 1995).

Notes: Quantity refers to total fertilizer materials. Fertilizer use estimates for 1960-1984 are based on USDA data; those for 1985-1994 are TVA estimates. The 1995 data are from AAPFCO. Includes fertilizer use on farms, lawns, golf courses, home gardens, and other nonfarm lands. Includes Puerto Rico.

Table 58. U.S. Commercial Pesticide Use by Sector and Type, 1979-1993

Year	Agriculture				Industry, commercial, & government			
	Herbicides	Insecticides	Fungicides	Total	Herbicides	Insecticides	Fungicides	Total
	million pounds of active ingredients							
1979	488	302	90	840	84	38	18	140
1980	445	306	95	846	82	47	18	147
1981	456	309	95	860	86	48	19	153
1982	430	295	90	815	86	48	19	153
1983	445	185	103	733	105	40	20	165
1984	545	200	105	850	105	40	20	165
1985	525	225	111	861	115	40	21	176
1986	500	210	110	820	125	45	25	195
1987	505	179	130	814	115	45	40	200
1988	510	185	150	845	120	45	40	205
1989	520	151	135	806	110	45	40	195
1990	516	173	145	834	103	42	38	183
1991	496	175	147	817	108	44	39	191
1992	511	181	147	839	110	43	40	193
1993	481	171	159	811	112	44	41	197

Year	Home & garden				Total			
	Herbicides	Insecticides	Fungicides	Total	Herbicides	Insecticides	Fungicides	Total
	million pounds of active ingredients							
1979	28	38	12	77	560	378	120	1,058
1980	28	42	12	82	555	395	125	1,075
1981	28	48	12	85	570	405	126	1,101
1982	28	48	12	88	544	391	121	1,056
1983	25	30	10	65	575	255	133	963
1984	25	30	10	65	675	270	135	1,080
1985	30	35	10	75	670	300	142	1,112
1986	30	40	11	81	655	395	146	1,096
1987	25	36	12	73	645	260	182	1,087
1988	30	38	12	80	660	268	202	1,130
1989	25	30	14	78	655	226	189	1,070
1990	25	30	14	69	644	245	197	1,086
1991	25	30	14	69	628	249	200	1,077
1992	26	31	14	71	647	255	201	1,103
1993	27	32	14	73	620	247	214	1,081

Source: U.S. Environmental Protection Agency (EPA), Office of Pesticide Programs (OPP), Biological and Economic Analysis Division (BEAD), *Pesticide Industry Sales and Usage: 1992 and 1993 Market Estimates*, Tables 13, p. 26, and Table 14, pp. 27-29 (EPA, OPP, BEAD, Washington, DC, 1994).

Notes: Estimates for total fungicide use also include other pesticides. Totals may not agree with sum of components due to independent rounding.

Table 59. Irrigated U.S. Farmland, Selected Years, 1890-1987, and Annually, 1988-1995

Year	Seventeen Western states	Other states	Total
		million acres	
1890	3.5	0.1	3.5
1900	7.5	0.3	7.8
1910	11.3	0.4	11.7
1920	13.9	0.5	14.5
1930	14.1	0.6	14.7
1940	17.2	0.7	18.0
1950	24.3	1.5	25.8
1959	30.7	2.4	33.2
1964	33.2	3.9	37.1
1969	34.8	4.3	39.1
1974	36.6	4.6	41.2
1978	43.2	7.2	50.3
1982	41.3	7.7	49.0
1987	37.5	8.9	46.4
1988	38.9	9.7	48.6
1989	40.0	9.5	49.5
1990	39.4	9.8	49.2
1991	39.9	10.1	50.0
1992	39.1	10.3	49.4
1993	39.6	10.2	49.8
1994	40.8	11.0	51.8
1995	41.2	10.8	52.0

Sources: U.S. Department of Agriculture (USDA), Economic Research Service (ERS), *Agricultural Resources and Environmental Indicators* (USDA, ERS, Washington, DC, 1994).

U.S. Department of Commerce, Bureau of the Census. *Census of Agriculture for 1992, Vol. I: Geographic Area Series, Part 51 United States Summary and State Data*, Table 9, p. 18, AC92-A-51 (GPO, Washington, DC, 1994) and earlier census reports.

Notes: Seventeen Western states include Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. Data for 1890-1982, 1987, and 1992 are from the Census of Agriculture. Data for other years are estimates constructed from data provided by the USDA, National Agricultural Statistics Service (NASS).

Table 60. Condition of U.S. Nonfederal Rangeland, 1963-1992, and Bureau of Land Management Rangeland, 1936-1994

Rangeland	Nonfederal					Bureau of Land Management				
condition	1963	1977	1982	1987	1992	1936	1966	1975	1986	1994
	% rangeland acreage									
Excellent	5	12	4	3	6	2	2	2	4	5
Good	15	28	30	30	34	14	17	15	30	31
Fair	40	42	45	47	44	48	52	50	41	37
Poor	40	18	16	14	15	36	30	33	18	13
Unclassified	na	na	5	6	1	na	na	na	na	14

Sources: U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), *National Resources Inventory* (USDA, NRCS, Washington, DC, 1977, 1982, 1987, and 1992).

U.S. Department of the Interior (DOI), Bureau of Land Management (BLM), *Public Land Statistics* (DOI, BLM, Washington, DC, annual) and updates by agency.

Notes: na=not available. Range condition is the present state of the vegetation of a range site in relation to the climax (natural potential) plant community for that site. It is expressed as the degree of similarity of present vegetation to the climax plant community: Excellent=76-100% similarity; Good=51-75% similarity; Fair=26-50% similarity; and Poor=0-25% similarity. Unclassified includes rangeland for which data and estimates are not available. Data are updated annually to reflect new information and changes in range condition classes. NRI and BLM data are not strictly comparable because of different survey methodologies. The 1992 NRI data are preliminary pending statistical validation.

Table 61. Timberland in the United States by Ownership, 1952-1992

Year	Farmer and other private	Forest industry	National forests	Other public	Total
			million acres		
1952	304.5	59.0	94.7	50.7	508.9
1962	307.5	61.4	96.8	49.3	515.1
1977	285.3	68.9	88.7	49.5	491.1
1987	283.6	70.3	85.2	45.8	484.9
1992	287.6	70.5	84.7	46.8	489.6

Source: D.S. Powell, J.L. Faulkner, D.R. Darr, Z. Zhu and D.W. MacCleery, *Forest Statistics of the United States, 1992*, General Technical Report RM-234 (U.S. Department of Agriculture, Forest Service, Washington, DC, 1993).

Table 62. Annual Net Growth and Removals of U.S. Growing Stock, 1952-1991, and Volume of U.S. Growing Stock, 1952-1992

	Net growth and removals of growing stock									
	Farmer and other private		Forest industry		National forests		Other public		Total	
Year	Net Growth	Re-movals	Net Growth	Re-movals	Net Growth	Re-movals	Net Growth	Re-movals	Net Growth	Re-movals
					billion cubic feet					
1952	8.1	6.9	2.6	3.3	2.1	1.1	1.2	0.6	13.9	11.9
1962	9.5	6.4	3.2	3.0	2.5	1.9	1.6	0.7	16.7	12.0
1976	12.6	6.8	4.2	4.2	3.1	2.1	2.0	1.1	21.9	14.2
1986	12.1	8.2	4.3	5.4	3.4	2.3	2.3	1.2	22.1	16.0
1991	12.1	8.0	4.3	5.3	3.3	2.0	1.9	1.0	21.6	16.3

	Volume of growing stock									
	Farmer and other private		Forest industry		National forests		Other public		Total	
Year	Soft-wood	Hard-wood	Soft-wood	Hard-wood	Soft-wood	Hard-wood	Soft-wood	Hard-wood	Soft-wood	Hard-wood
					billion cubic feet					
1952	94.8	133.7	77.4	20.3	204.4	13.6	55.2	16.5	431.8	184.1
1962	104.3	152.5	76.1	25.4	213.7	17.2	55.7	20.7	449.8	215.8
1977	125.3	185.8	74.5	32.3	208.1	21.6	59.0	26.5	467.0	266.1
1986	136.6	220.8	72.8	35.3	186.3	25.1	57.3	31.4	452.9	312.6
1992	143.4	242.3	71.0	34.8	185.6	25.6	50.0	33.0	449.9	335.7

Source: D.S. Powell, J.L. Faulkner, D.R. Darr, Z. Zhu and D.W. MacCleery, *Forest Statistics of the United States, 1992*, General Technical Report RM-234 (U.S. Department of Agriculture, Forest Service, Washington, DC, 1993).

Table 63. U.S. Production of Roundwood Equivalent of End Product, 1950-1991

Year	Lumber	Plywood & veneer	Pulp products	Fuel	Miscel-laneous	Total
			billion cubic feet			
1950	5.9	0.3	1.5	2.3	0.8	10.8
1951	5.8	0.4	1.8	2.2	0.7	11.0
1952	5.8	0.4	1.8	2.0	0.7	10.8
1953	5.7	0.5	1.9	1.9	0.7	10.7
1954	5.6	0.5	2.0	1.8	0.7	10.6
1955	5.8	0.6	2.2	1.7	0.7	11.0
1956	5.9	0.6	2.5	1.7	0.6	11.3
1957	5.1	0.6	2.4	1.6	0.6	10.2
1958	5.2	0.6	2.2	1.5	0.6	10.0
1959	5.7	0.7	2.4	1.4	0.6	10.8
1960	5.1	0.7	2.6	1.3	0.6	10.2
1961	4.9	0.8	2.5	1.2	0.6	10.0
1962	5.1	0.8	2.6	1.1	0.6	10.2
1963	5.4	0.9	2.7	1.1	0.7	10.6
1964	5.6	1.0	2.9	1.0	0.7	11.2
1965	5.7	1.0	3.1	0.9	0.8	11.5
1966	5.6	1.0	3.2	0.8	0.8	11.5
1967	5.3	1.0	3.2	0.8	0.9	11.2
1968	5.5	1.1	3.4	0.7	1.0	11.8
1969	5.4	1.1	3.6	0.6	1.0	11.6
1970	5.2	1.0	3.8	0.5	1.0	11.6
1971	5.4	1.2	3.6	0.5	0.9	11.5
1972	5.5	1.3	3.5	0.5	1.1	11.9
1973	5.7	1.3	3.8	0.5	1.2	12.4
1974	5.1	1.1	4.2	0.5	1.1	12.1
1975	4.9	1.2	3.5	0.6	1.0	11.1
1976	5.6	1.4	3.8	0.6	1.2	12.5
1977	5.9	1.4	3.6	1.0	1.2	13.2
1978	6.2	1.5	3.7	1.5	1.2	14.1
1979	6.1	1.4	4.1	2.2	1.4	15.2
1980	5.3	1.2	4.4	3.1	1.2	15.2
1981	4.8	1.2	4.1	3.2	0.9	14.3
1982	4.6	1.1	4.0	3.4	1.1	14.3
1983	5.4	1.4	4.2	3.2	1.1	15.3
1984	5.8	1.4	4.4	3.6	1.2	16.3
1985	5.7	1.4	4.2	3.4	1.2	16.0
1986	6.5	1.5	4.5	3.1	1.2	17.0
1987	7.0	1.7	4.7	3.1	1.4	17.8
1988	6.9	1.6	4.7	3.4	1.5	18.2
1989	6.8	1.6	5.0	3.4	1.6	18.3
1990	6.5	1.6	5.1	3.3	1.5	18.0
1991	6.5	1.6	5.1	3.3	1.4	17.9

Source: U.S. Department of Agriculture, Forest Service, *U.S. Timber Production, Trade, Consumption, and Price Statistics, 1960-1988*, Table 4, p. 13 (USDA, FS, Washington, DC, 1991) and updates by agency.

Note: Miscellaneous=log and pulp chip exports and other products not specified.

Table 64. Logging Residues from U.S. Growing Stock and Timber Product Output from U.S. Nongrowing Stock, 1952-1991

Year	Logging residues		Output from nongrowing stock	
	Softwood	Hardwood	Softwood	Hardwood
	% of timber product removals from growing stock		*% of timber supplies*	
1952	9.8	22.2	10.4	20.9
1962	9.6	20.7	10.0	18.5
1970	10.0	19.7	7.0	13.9
1976	8.4	17.1	6.9	14.0
1986	9.0	13.2	11.5	38.5
1991	7.5	12.0	11.9	37.5

Source: R.W. Haynes, D.M. Adams and J.R. Mills, *The 1993 RPA Timber Assessment Update*, Table 7, p. 16, and Table 8, p. 17 (U.S. Department of Agriculture, Forest Service, Washington, DC, 1995).

Notes: Logging residues are lower quality material, such as small stem, chunks, and low-quality stems. Declining amounts of residues reflect increased stumpage prices, improved logging technology, and increased demand for wood products. Timber supplies from nongrowing stock include salvable dead trees, rough and rotten trees, tops and limbs, defective sections of growing stock trees in urban areas, along fence rows, and on forested lands other than timberlands. Output from these sources has been greatly influenced by markets for pulpwood and fuelwood since the late 1970s.

Table 65. U.S. Forest Fire Damage and Tree Planting, 1930-1995

Year	Forest fire damage	Tree planting	Year	Forest fire damage	Tree planting
	million acres			million acres	
1930	52.3	0.14	1972	2.6	1.68
1940	25.9	0.52	1973	1.9	1.75
1950	15.5	0.50	1974	2.9	1.60
1951	10.8	0.45	1975	1.8	1.93
1952	14.2	0.52	1976	5.1	1.89
1953	10.0	0.71	1977	3.2	1.98
1954	8.8	0.81	1978	3.9	2.09
1955	8.1	0.78	1979	3.0	2.06
1956	6.6	0.89	1980	5.3	2.27
1957	3.4	1.14	1981	4.8	2.35
1958	3.3	1.53	1982	2.4	2.37
1959	4.2	2.12	1983	5.1	2.45
1960	4.5	2.14	1984	3.0	2.55
1961	3.0	1.76	1985	5.2	2.70
1962	4.1	1.37	1986	3.2	2.75
1963	7.1	1.33	1987	5.0	3.03
1964	4.2	1.31	1988	5.7	3.39
1965	2.7	1.29	1989	3.5	3.02
1966	4.6	1.28	1990	4.6	2.86
1967	4.7	1.37	1991	na	2.56
1968	4.2	1.44	1992	na	2.55
1969	6.7	1.43	1993	na	2.42
1970	3.3	1.60	1994	na	2.78
1971	4.3	1.69	1995	na	2.42

Sources: U.S. Department of Agriculture, Forest Service, Wildfire Statistics, unpublished, Washington, DC, annual.

--, *U.S. Forest Planting Report* (USDA, FS, Washington, DC, annual).

Notes: Tree planting refers to acres planted in seedlings and direct seeded. Year refers to fiscal year. na=not available prior to statistical validation. Annual forest fire damage for the years 1991-1995 is estimated to be between 2 and 7 million acres.

Table 66. U.S. Forestland Damaged by Insects, 1968-1995

Year	Spruce budworm	Western spruce budworm	Gypsy moth	Mountain pine beetle	Southern pine beetle
			million acres		
1968	1.3	5.3	0.1	na	na
1969	1.2	4.6	0.3	na	na
1970	2.0	4.0	1.0	na	na
1971	1.6	4.8	1.9	na	na
1972	2.8	5.5	1.4	na	na
1973	4.2	4.4	1.8	na	na
1974	10.8	5.5	0.8	na	na
1975	9.2	5.3	0.5	na	na
1976	9.1	5.8	0.9	na	na
1977	10.3	6.5	1.6	na	na
1978	7.7	5.2	1.3	4.0	na
1979	6.6	5.0	0.6	4.4	15.0
1980	6.6	4.0	5.0	4.7	12.1
1981	4.5	5.5	12.9	4.7	0.9
1982	4.2	8.7	8.2	4.2	7.3
1983	6.5	11.0	2.4	3.6	11.4
1984	6.1	10.6	1.0	3.3	na
1985	5.2	12.8	1.7	3.3	15.5
1986	1.0	13.2	2.4	3.5	26.4
1987	0.8	8.0	1.3	2.4	13.8
1988	0.3	6.1	0.7	2.2	7.9
1989	0.2	3.1	3.0	1.6	5.3
1990	0.2	4.6	7.3	0.9	4.2
1991	0.1	7.2	4.2	0.6	10.7
1992	0.1	4.6	3.1	15.8	14.3
1993	0.1	0.5	1.8	0.8	10.4
1994	1.0	0.5	0.9	0.4	5.3
1995	0.8	0.5	1.4	0.6	21.7

Sources: U.S. Department of Agriculture (USDA), Forest Service (FS), *Forest Insect and Disease Conditions in the United States, 1979-1983* (USDA, FS, Washington, DC, 1985).

--, *Forest Insect and Disease Conditions in the United States* (USDA, FS, Washington, DC, annual from 1986).

Notes: na=not available. Acreage for spruce budworm from 1991 forward includes spruce budworm in Alaska since it is the same species of budworm as in the eastern United States (i.e., it is not the western spruce budworm). Acreage for mountain pine beetle in 1992 includes 15.2 million acres in California not previously reported.

Pollution Prevention

Table 67. U.S. Municipal Solid Waste Trends, 1960-1994

Year	Gross discards	Recovery for recycling	Net discards	Com-bustion	Discards to landfills	Per capita waste generation
	million tons					lbs/person/day
1960	87.8	5.9	81.9	27.0	55.3	2.67
1970	121.9	8.6	113.3	25.1	89.5	3.29
1980	151.4	14.5	136.9	13.7	124.3	3.67
1990	198.0	32.9	165.1	31.9	132.3	4.33
1994	209.1	49.3	159.8	32.5	127.3	4.40

Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. *Characterization of Municipal Solid Waste in the United States: 1995 Update,* Table 26, p. 91 and Table 38, p. 117 (EPA, Washington, DC, 1996).

Table 68. U.S. Municipal Solid Waste Trends by Waste Type, 1960-1994

Year	Paper		Glass		Metals*		Aluminum		Plastics	
	Gener-ation	Re-covery	Gener-ation	Re-covery	Gener-ation	Re-covery	Gener-ation	Re-covery	Gener-ation	Re-covery
	million tons									
1960	29.98	5.08	6.68	0.10	10.11	0.50	0.36	**	0.36	**
1970	44.31	6.77	12.75	0.16	13.56	0.47	0.85	0.01	3.07	**
1980	55.16	11.74	14.99	0.75	12.89	0.91	1.77	0.31	7.74	0.20
1990	72.72	20.23	13.11	2.63	13.54	2.44	2.85	1.01	16.89	0.37
1994	81.30	28.73	13.27	3.11	12.73	4.52	3.06	1.15	19.84	0.93

Year	Rubber and leather		Textiles		Wood		Food		Yard	
	Gener-ation	Re-covery	Gener-ation	Re-covery	Gener-ation	Re-covery	Gener-ation	Re-covery	Gener-ation	Re-covery
	million tons									
1960	2.03	0.32	1.73	0.01	3.01	**	12.20	**	20.00	**
1970	3.27	0.25	2.00	0.01	4.22	**	12.80	**	23.20	**
1980	4.49	0.13	2.61	0.03	7.44	**	13.00	**	27.50	**
1990	6.25	0.37	5.15	0.57	12.31	0.39	13.20	**	35.00	4.20
1994	6.37	0.45	6.56	0.77	14.59	1.43	14.07	0.48	30.60	7.00

Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. *Characterization of Municipal Solid Waste in the United States: 1995 Update,* Table 1, p. 26 and Table 2, p. 27 (EPA, Washington, DC, 1996).

Notes: *ferrous and nonferrous metals. **negligible (less than 50, 000 tons or 0.05 percent).

Table 69. U.S. Inventory of Low-level Nuclear Waste, 1962-1995, High-level Nuclear Waste, 1980-1995, and Spent Nuclear Fuel, 1980-1995

	Low-level wastes at commercial disposal sites				
Year	Cumulative volume	Cumulative radioactivity	Year	Cumulative volume	Cumulative radioactivity
	million m3	*million curies*		*million m3*	*million curies*
1962	0.002	na	1979	0.676	4.539
1963	0.008	0.042	1980	0.768	4.547
1964	0.020	0.204	1981	0.852	4.483
1965	0.034	0.273	1982	0.929	4.568
1966	0.049	0.355	1983	1.007	4.732
1967	0.071	0.428	1984	1.083	4.954
1968	0.091	0.529	1985	1.160	5.282
1969	0.112	0.687	1986	1.213	5.059
1970	0.138	0.855	1987	1.265	4.924
1971	0.169	2.000	1988	1.306	4.793
1972	0.208	2.287	1989	1.352	5.284
1973	0.255	2.732	1990	1.384	4.979
1974	0.309	2.754	1991	1.423	5.272
1975	0.367	3.040	1992	1.472	5.708
1976	0.442	3.268	1993	1.495	5.709
1977	0.514	3.765	1994	1.519	5.841
1978	0.593	4.383	1995	1.543	5.944

	High-level nuclear waste at DOE/defense and commercial sites			Spent nuclear fuel at commercial sites	
Year	Cumulative volume	Cumulative decayed radioactivity	Year	Cumulative volume	Cumulative radioactivity
	thousand m3	*million curies*		*metric tons initial heavy metal*	*million curies*
1980	329.7	1,362.6	1980	6,558	10,137
1981	339.3	1,628.5	1981	7,692	10,552
1982	342.0	1,369.4	1982	8,690	10,400
1983	352.7	1,299.7	1983	9,952	12,088
1984	363.5	1,355.2	1984	11,291	13,222
1985	357.1	1,459.5	1985	12,684	14,228
1986	365.9	1,419.0	1986	14,139	15,308
1987	381.4	1,303.1	1987	15,844	17,292
1988	384.9	1,206.7	1988	17,497	18,207
1989	381.1	1,113.9	1989	19,410	20,209
1990	398.5	1,050.8	1990	21,547	22,910
1991	396.5	1,007.4	1991	23,406	22,825
1992	398.3	1,081.2	1992	25,697	26,136
1993	403.5	1,045.3	1993	27,929	27,516
1994	378.4	958.8	1994	29,811	26,661
1995	371.7	916.7	1995	32,200	30,200

Source: U.S. Department of Energy, *Integrated Data Base Report - 1994: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics* (DOE, Washington, DC, 1995).

Table 70. U.S. Superfund Inventory and NPL Sites, 1980-1995

Year	Superfund	NPL
	number of sites, cumulative	
1980	8,689	0
1981	13,893	0
1982	14,697	160
1983	16,023	551
1984	18,378	547
1985	22,238	864
1986	24,940	906
1987	27,274	967
1988	29,809	1,195
1989	31,650	1,254
1990	33,371	1,236
1991	35,108	1,245
1992	36,869	1,275
1993	38,169	1,321
1994	39,099	1,360
1995	15,622	1,374

Source: U.S. Environmental Protection Agency, unpublished, Washington, DC, 1996.

Notes: NPL=National Priorities List. The 1995 data reflect the removal of over 24,000 sites from the Superfund inventory as part of EPA's Brownfields initiatives.

Table 71. U.S. Production of Selected Ozone-depleting Chemicals, 1958-1994

Year	CFC-11	CFC-12	HCFC-22	CFC-113	CH_3CCl_3
	thousand metric tons of CFC-11 equivalent				
1958	22.9	59.6	0.76	0.0	0.0
1959	27.4	71.3	0.83	0.0	0.0
1960	32.8	75.5	0.91	1.6	0.0
1961	41.2	78.7	1.03	2.4	0.0
1962	56.6	94.3	1.12	3.2	0.0
1963	63.6	98.6	1.23	3.6	0.0
1964	67.4	103.4	1.34	4.3	0.0
1965	77.3	123.1	1.46	5.1	0.0
1966	77.3	129.9	1.59	5.8	0.0
1967	82.7	140.5	1.78	7.6	13.7
1968	92.7	147.7	1.96	9.1	14.6
1969	108.2	166.8	2.14	10.9	15.6
1970	110.9	170.3	2.28	13.1	16.6
1971	117.0	176.7	2.55	15.6	17.4
1972	135.9	199.2	2.80	18.2	18.2
1973	151.4	221.7	3.09	21.4	19.0
1974	154.7	221.1	3.21	23.2	19.9
1975	122.3	178.3	2.99	24.8	20.8
1976	116.2	178.3	3.85	29.7	24.8
1977	96.4	162.3	4.07	36.2	28.8
1978	87.9	148.4	4.67	41.0	29.2
1979	75.8	133.3	4.78	47.0	32.5
1980	71.7	133.8	5.16	36.7	31.4
1981	73.8	147.6	5.71	38.6	27.9
1982	63.7	117.0	3.95	40.0	27.0
1983	73.1	134.3	5.35	42.2	26.6
1984	83.9	152.7	5.76	60.2	30.6
1985	79.7	136.9	5.34	65.8	39.4
1986	91.6	146.2	6.15	69.2	29.6
1987	89.7	151.9	6.23	72.3	31.5
1988	113.0	187.7	7.54	79.2	32.8
1989	83.3	141.2	7.24	80.4	35.5
1990	61.0	94.6	6.94	55.9	36.4
1991	44.9	71.3	7.13	47.2	29.2
1992	45.5	73.9	7.48	28.5	31.4
1993	32.8	83.7	6.61	11.4	20.5
1994	na	57.5	6.93	na	na

Source: U.S. International Trade Commission, *Synthetic Organic Chemicals, United States Production and Sales* (GPO, Washington, DC, annual).

Notes: CFC-11=Trichlorofluoromethane. CFC-12=Dichlorodifluoromethane. HCFC-22= Chlorodifluoromethane. CFC-113=Trichlorotrifluoroethane. CH_3CCL_3=Trichloroethane or methyl chloroform.

Table 72. U.S. Toxics Release Inventory Releases and Transfers, 1988-1995

	1988	1992	1993	1994
	billion pounds			
Releases				
Air Emissions	2.253	1.560	1.385	1.341
Fugitive air	0.686	0.441	0.379	0.350
Point source air	1.567	1.119	1.006	0.991
Surface water	0.177	0.196	0.203	0.047
Underground injection	0.626	0.367	0.295	0.307
On-site land releases	0.481	0.328	0.274	0.282
Total releases	3.536	2.450	2.157	1.977
Transfers				
To recycling	na	2.609	2.057	2.234
To energy-recovery	na	0.431	0.447	0.463
To treatment	0.396	0.257	0.255	0.290
To POTWs	0.297	0.226	0.186	0.180
To disposal	0.437	0.217	0.267	0.281
To other	0.042	0.013	0.002	0.004
Total transfers	1.173	3.752	3.213	3.451
Total releases and transfers	4.709	6.202	5.370	5.428

Source: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, *1994 Toxics Release Inventory: Public Data Release*, EPA/745-R-96-002 (EPA, Washington, DC, 1996).

Table 73. U.S. Toxics Release Inventory by Industry, 1988-1994

Industry	1988	1992	1993	1994
	million pounds			
Food	9.083	11.876	12.035	10.332
Tobacco	1.234	0.588	0.625	0.962
Textile	34.263	19.086	17.598	15.884
Apparel	0.922	1.296	0.994	1.318
Lumber	31.071	30.033	29.801	31.708
Furniture	61.376	53.184	54.003	50.558
Paper	227.692	199.101	179.821	218.562
Printing	60.697	40.433	35.915	34.180
Chemical	1,322.843	991.275	874.385	700.662
Petroleum	67.689	61.724	50.891	43.789
Plastics	146.553	121.075	111.009	111.568
Leather	11.927	7.226	4.447	3.594
Stone/clay/glass	27.114	14.254	14.334	12.403
Primary metals	496.230	341.208	304.643	293.822
Fabr. metals	131.777	100.591	88.633	86.071
Machinery	59.615	32.951	26.538	23.495
Electrical equip.	115.881	47.066	32.888	28.995
Transportation	191.020	125.293	123.826	119.695
Measure/photo.	49.926	29.051	22.478	15.749
Miscellaneous	28.564	16.888	15.248	13.712
Multiple codes	446.596	191.819	137.189	142.919
No codes	13.977	13.628	20.056	16.937
Total	3,536.050	2,449.644	2,157.355	1,976.912

Source: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, *1994 Toxics Release Inventory: Public Data Release*, EPA/745-R-96-002 (EPA, Washington, DC, 1996).

Table 74. U.S. Toxics Release Inventory by State, 1988 and 1994

State	1988	1994	Change 1988-1994	
	million pounds			%
Alabama	110.190	88.256	-21.935	-19.9
Alaska	6.203	1.667	-4.536	-73.1
Arizona	66.057	30.482	-35.575	-53.9
Arkansas	40.676	32.123	-8.553	-21.0
California	97.587	35.042	-62.545	-64.1
Colorado	13.765	3.744	-10.021	-72.8
Connecticut	32.538	10.148	-22.390	-68.8
Delaware	7.825	4.132	-3.694	-47.2
District of Columbia	<0.001	0.024	0.023	4,658.2
Florida	96.972	82.542	-14.520	-15.0
Georgia	81.661	45.248	-36.412	-44.6
Hawaii	0.935	0.512	-0.423	-45.3

See next page for continuation of table.

Table 74. U.S. Toxics Release Inventory by State, 1988 and 1994 (continued)

State	1988	1994	Change 1988-1994	
	million pounds			%
Idaho	7.898	2.422	-5.476	-69.3
Illinois	118.263	86.493	-31.770	26.9
Indiana	169.719	70.231	-99.489	-58.6
Iowa	36.349	22.592	-13.757	-37.8
Kansas	104.567	17.657	-86.910	-83.1
Kentucky	82.349	30.368	-51.981	-63.1
Louisiana	435.022	120.017	-315.006	-72.4
Maine	16.017	7.472	-8.545	-53.3
Maryland	19.587	12.267	-7.319	-37.4
Massachusetts	27.009	8.579	-18.430	-68.2
Michigan	98.792	79.027	-19.765	-20.0
Minnesota	54.772	19.699	-35.073	-64.0
Mississippi	94.357	112.958	18.602	19.7
Missouri	87.441	45.252	-42.188	-48.2
Montana	35.719	46.428	10.709	30.0
Nebraska	13.889	8.148	-5.741	-41.3
Nevada	2.316	3.009	0.693	29.9
New Hampshire	12.287	2.362	-9.925	-80.8
New Jersey	36.677	12.827	-23.850	-65.0
New Mexico	30.252	17.140	-13.112	-43.3
New York	95.609	33.387	-62.222	-65.1
North Carolina	125.148	79.652	-45.496	-36.4
North Dakota	1.131	0.926	-0.245	-18.1
Ohio	166.274	98.556	-67.718	-40.7
Oklahoma	34.085	15.018	-19.067	-55.9
Oregon	17.600	15.460	-2.140	-12.2
Pennsylvania	99.845	47.589	-52.256	-52.3
Puerto Rico	12.368	8.962	-3.405	-27.5
Rhode Island	6.351	2.879	-3.472	-54.7
South Carolina	61.847	44.786	-17.061	-27.6
South Dakota	2.314	1.954	-0.360	-15.6
Tennessee	159.648	146.698	-12.950	-8.1
Texas	310.984	213.061	-97.924	-31.5
Utah	134.108	70.975	-63.134	-47.1
Vermont	1.598	0.611	-0.987	-61.8
Virgin Islands	1.848	0.961	-0.887	-48.0
Virginia	115.321	46.243	-69.077	-59.9
Washington	26.133	22.140	-3.993	-15.3
West Virginia	33.152	19.324	-13.829	-41.7
Wisconsin	50.777	30.272	-20.505	-40.4
Wyoming	42.221	18.683	-23.538	-55.7
Total	3,536.050	1,976.912	-1,559.138	-44.1

Source: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, *1994 Toxics Release Inventory: Public Data Release*, EPA/745-R-96-002 (EPA, Washington, DC, 1996).

Table 75. Contaminant Levels in Herring Gull Eggs from Great Lakes Colonies, 1974-1995

	Lake Superior				
Year	DDE	Dieldrin	Mirex	HCB	PCBs
	parts per million in whole egg samples, wet weight				
1974	16.59	0.51	1.04	0.26	62.08
1975	23.10	0.38	0.96	0.18	76.24
1977	11.92	0.38	0.33	0.24	55.22
1978	9.64	0.39	0.28	0.12	41.57
1979	6.83	0.60	0.26	0.14	58.74
1980	3.67	0.34	0.13	0.08	25.58
1981	5.74	0.44	0.14	0.12	33.84
1982	6.29	0.39	0.37	0.08	34.74
1983	3.17	0.33	0.15	0.05	21.42
1984	2.94	0.36	0.12	0.05	16.91
1985	3.13	0.32	0.11	0.05	15.89
1986	3.22	0.34	0.11	0.05	14.10
1987	2.52	0.20	0.10	0.04	12.35
1988	2.94	0.34	0.06	0.05	13.43
1989	2.50	0.34	0.07	0.05	15.09
1990	2.64	0.30	0.06	0.03	11.62
1991	3.60	0.27	0.07	0.04	14.09
1992	3.69	0.40	0.07	0.05	13.95
1993	4.09	0.19	0.08	0.03	15.70
1994	2.39	0.15	0.10	0.03	12.30
1995	2.49	0.11	0.08	0.02	11.15

	Lake Michigan				
Year	DDE	Dieldrin	Mirex	HCB	PCBs
	parts per million in whole egg samples, wet weight				
1976	33.40	0.82	0.36	0.14	118.42
1977	29.25	0.68	0.14	0.24	107.80
1978	22.36	0.87	0.21	0.12	90.74
1980	12.17	0.70	0.10	0.09	57.83
1982	15.86	0.81	0.09	0.09	65.41
1983	6.46	0.61	0.05	0.05	30.27
1984	7.85	0.53	0.09	0.06	31.47
1985	6.98	0.47	0.12	0.05	31.94
1986	7.48	0.38	0.07	0.07	27.25
1987	3.95	0.33	0.06	0.04	16.58
1988	5.04	0.55	0.03	0.04	19.14
1989	4.74	0.54	0.04	0.04	21.00
1990	8.12	0.54	0.06	0.05	32.19
1991	10.52	0.34	0.12	0.05	31.27
1992	6.71	0.41	0.04	0.04	20.25
1993	na	na	na	na	na
1994	10.10	0.34	0.08	0.05	32.85
1995	6.38	0.19	0.05	0.03	23.30

See next page for continuation of table.

Table 75. Contaminant Levels in Herring Gull Eggs from Great Lakes Colonies, 1974-1995 (continued)

Year	Lake Huron				
	DDE	Dieldrin	Mirex	HCB	PCBs
	parts per million in whole egg samples, wet weight				
1974	17.40	0.50	1.34	0.38	71.01
1975	14.03	0.36	0.51	0.21	42.67
1977	16.17	0.54	0.44	0.36	70.28
1978	6.53	0.22	0.21	0.11	32.38
1979	2.30	0.30	0.19	0.10	28.66
1980	2.71	0.24	0.11	0.07	20.41
1981	3.82	0.24	0.26	0.07	25.39
1982	4.43	0.28	0.48	0.08	34.29
1983	2.74	0.22	0.15	0.05	18.28
1984	2.56	0.22	0.34	0.07	19.95
1985	2.77	0.30	0.22	0.06	16.90
1986	2.05	0.21	0.12	0.05	12.00
1987	1.32	0.22	0.08	0.02	8.33
1988	1.40	0.22	0.07	0.04	8.83
1989	1.57	0.20	0.09	0.03	10.19
1990	1.86	0.14	0.11	0.03	11.34
1991	1.97	0.16	0.11	0.03	10.00
1992	2.36	0.16	0.05	0.05	10.20
1993	3.18	0.19	0.06	0.03	10.95
1994	2.19	0.13	0.10	0.03	11.25
1995	1.60	0.10	0.06	0.03	8.95

Year	Lake Erie				
	DDE	Dieldrin	Mirex	HCB	PCBs
	parts per million in whole egg samples, wet weight				
1974	7.13	0.35	0.64	0.29	72.46
1975	7.41	0.33	0.32	0.19	62.30
1977	7.49	0.40	0.45	0.37	68.70
1978	4.29	0.24	0.20	0.09	44.43
1979	3.10	0.25	0.17	0.11	48.44
1980	2.98	0.21	0.18	0.09	46.38
1981	3.90	0.22	0.25	0.09	56.49
1982	3.07	0.25	0.13	0.08	58.89
1983	2.39	0.20	0.17	0.05	37.31
1984	3.23	0.33	0.22	0.06	46.20
1985	2.83	0.19	0.14	0.06	38.41
1986	2.77	0.23	0.14	0.06	33.35
1987	1.77	0.14	0.12	0.03	23.16
1988	2.07	0.17	0.10	0.05	27.50
1989	2.69	0.17	0.18	0.05	39.21
1990	2.01	0.10	0.11	0.03	30.09
1991	2.12	0.08	0.07	0.02	26.55
1992	1.68	0.13	0.05	0.04	24.45
1993	1.49	0.10	0.07	0.02	21.70
1994	1.55	0.08	0.08	0.03	22.90
1995	1.21	0.08	0.07	0.03	23.55

See next page for continuation of table.

Table 75. Contaminant Levels in Herring Gull Eggs from Great Lakes Colonies, 1974-1995 (continued)

	Lake Ontario				
Year	DDE	Dieldrin	Mirex	HCB	PCBs
	parts per million in whole egg samples, wet weight				
1974	22.30	0.47	6.99	0.58	152.37
1975	22.80	0.29	4.70	0.33	143.11
1977	14.88	0.39	2.48	0.80	102.50
1978	10.65	0.26	1.59	0.32	72.43
1979	8.94	0.21	1.89	0.21	69.60
1980	7.62	0.19	1.65	0.17	56.43
1981	11.00	0.28	2.67	0.24	78.90
1982	10.04	0.28	3.05	0.16	62.90
1983	4.78	0.18	1.43	0.08	42.59
1984	6.26	0.21	1.87	0.12	51.11
1985	6.02	0.15	1.47	0.07	35.58
1986	4.41	0.16	1.10	0.07	27.86
1987	2.60	0.13	0.68	0.04	16.48
1988	4.25	0.15	0.82	0.07	23.53
1989	5.28	0.22	1.15	0.07	32.45
1990	3.36	0.10	0.64	0.03	18.44
1991	3.53	0.14	0.58	0.03	17.05
1992	5.01	0.13	0.77	0.05	21.20
1993	5.27	0.13	0.82	0.04	21.05
1994	3.83	0.13	0.80	0.04	19.70
1995	2.23	0.05	0.57	0.02	13.60

Source: Environment Canada, Canadian Wildlife Service, Canada Centre for Inland Waters, Organochlorine Contaminant Concentrations in Herring Gull Eggs from Great Lakes Colonies, unpublished, Burlington, ON, 1996.

Notes: DDE=Derivative of Dichloro-diphenyl-trichloro ethane (DDT). HCB=Hexachlorobenzene. PCBs=Polychlorinated biphenyls. Data are not available for: Lake Superior in 1976; Lake Michigan in 1979, 1981 and 1993; Lake Huron in 1976; Lake Erie in 1976; and Lake Ontario in 1976.

Table 76. Pesticide Residues in U.S. Domestic Surveillance Food Samples by Commodity Group, 1978-1994

Year	Commodity group						
	Grains & grain products	Milk, dairy products & eggs	Fish, shellfish & meats	Fruits	Vegetables	Other	Total
	% of samples with residues found						
1978	54	43	80	48	34	42	47
1979	54	47	81	58	35	47	49
1980	52	36	71	53	40	36	46
1981	43	32	77	56	37	34	44
1982	42	34	72	49	36	32	41
1983	42	32	61	52	41	31	43
1984	54	31	75	38	33	31	37
1985	52	22	65	36	34	22	35
1986	60	21	68	57	39	48	44
1987	57	24	73	50	37	37	42
1988	49	19	72	51	35	28	40
1989	44	13	65	44	32	20	35
1990	46	9	68	49	38	21	40
1991	42	22	42	51	32	19	36
1992	39	6	52	49	31	19	35
1993	34	6	47	30	61	17	36
1994	39	7	41	56	34	12	37

Source: Food and Drug Administration, "Pesticide Program Residues Monitoring 1994," *J. Assoc. Off. Anal. Chem*. Vol. 78 (Washington, DC: FDA, 1995), and earlier issues.

Notes: Domestic food samples are collected as close as possible to the point of production. Fresh produce is analyzed as the unwashed whole, raw commodity. Although a percentage of samples contain pesticide residues, the percent of samples with over-tolerance residues (as set by EPA) is low. Between 1973 and 1986; 3 percent of samples were classed as violative; since 1987, less than 1 percent were violative.

Energy

Table 77. Proven Reserves of Liquid and Gaseous Hydrocarbons in the United States, 1977-1994

Year	Crude oil	Natural gas	Natural gas liquids
	billion barrels	*trillion cubic feet*	*billion barrels*
1977	31.8	207.4	na
1978	31.4	208.0	6.8
1979	29.8	201.0	6.6
1980	29.8	199.0	6.7
1981	29.4	201.7	7.1
1982	27.9	201.5	7.2
1983	27.7	200.5	7.9
1984	28.4	197.5	7.6
1985	28.4	193.4	7.9
1986	26.9	191.6	8.2
1987	27.3	187.2	8.1
1988	26.8	168.0	8.2
1989	26.5	167.1	7.8
1990	26.3	169.3	7.6
1991	24.7	167.1	7.5
1992	23.7	165.0	7.5
1993	23.0	162.4	7.2
1994	22.5	163.8	7.2

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 4.10, p. 129, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

Table 78. U.S. Energy Production by Source, 1960-1995

Year	Coal	Crude oil & NPGL	Natural gas	Hydroelectric power	Nuclear	Geothermal & other renewables	Total
				quadrillion Btu			
1960	10.82	16.39	12.66	1.61	0.01	<0.01	41.49
1961	10.45	16.76	13.10	1.66	0.02	<0.01	41.99
1962	10.90	17.11	13.72	1.82	0.03	<0.01	43.58
1963	11.85	17.68	14.51	1.77	0.04	<0.01	45.85
1964	12.52	17.96	15.30	1.89	0.04	<0.01	47.72
1965	13.06	18.40	15.78	2.06	0.04	<0.01	49.34
1966	13.47	19.56	17.01	2.06	0.06	<0.01	52.17
1967	13.83	20.83	17.94	2.35	0.09	0.01	55.04
1968	13.61	21.63	19.07	2.35	0.14	0.01	56.81
1969	13.86	21.98	20.45	2.65	0.15	0.01	59.10
1970	14.61	22.91	21.67	2.63	0.24	0.01	62.07
1971	13.19	22.57	22.28	2.82	0.41	0.01	61.29
1972	14.09	22.64	22.21	2.86	0.58	0.03	62.42
1973	13.99	22.06	22.19	2.86	0.91	0.04	62.06
1974	14.07	21.04	21.21	3.18	1.27	0.05	60.84
1975	14.99	20.10	19.64	3.15	1.90	0.07	59.86
1976	15.65	19.59	19.48	2.98	2.11	0.08	59.89
1977	15.76	19.78	19.57	2.33	2.70	0.09	60.22
1978	14.91	20.68	19.49	2.94	3.02	0.06	61.10
1979	17.54	20.39	20.08	2.93	2.78	0.09	63.80
1980	18.60	20.50	19.91	2.90	2.74	0.11	64.76
1981	18.38	20.46	19.70	2.76	3.01	0.12	64.42
1982	18.64	20.50	18.32	3.27	3.13	0.10	63.96
1983	17.25	20.57	16.59	3.53	3.20	0.13	61.28
1984	19.72	21.12	18.01	3.39	3.55	0.17	65.96
1985	19.33	21.23	16.98	2.97	4.15	0.21	64.87
1986	19.51	20.53	16.54	3.07	4.47	0.23	64.35
1987	20.14	19.89	17.14	2.63	4.91	0.25	64.95
1988	20.74	19.54	17.60	2.33	5.66	0.24	66.10
1989	21.35	18.28	17.85	2.77	5.68	0.22	66.13
1990	22.46	17.74	18.36	2.99	6.16	3.05	70.75
1991	21.59	18.01	18.23	2.94	6.58	3.07	70.41
1992	21.59	17.58	18.38	2.57	6.61	3.23	69.96
1993	20.22	16.90	18.58	2.84	6.52	3.25	68.32
1994	22.07	16.49	19.26	2.64	6.84	3.31	70.62
1995	21.91	16.27	19.23	3.17	7.19	3.40	71.16

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 1.2, p. 7, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

Notes: NGPL=Natural gas plant liquids. Hydroelectric power includes hydroelectric pumped storage. Other renewables include electricity produced from wood, waste, wind, photovoltaic, and solar thermal sources. There is a discontinuity in this time series between 1989 and 1990 due to expanded coverage of nonelectric utility use of renewable energy beginning in 1990. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 79. U.S. Coal Production by Rank, Mining Method, and Location, 1960-1995

	Rank				Mining method		Location		
Year	Bituminous	Sub-bituminous	Lignite	Anthracite	Underground	Surface	West	East	Total
	million tons								
1960	415.5	i	i	18.8	292.6	141.7	21.3	413.0	434.3
1961	403.0	i	i	17.4	279.6	140.9	21.8	398.6	420.4
1962	422.1	i	i	16.9	287.9	151.1	21.4	417.6	439.0
1963	458.9	i	i	18.3	309.0	168.2	23.7	453.5	477.2
1964	487.0	i	i	17.2	327.7	176.5	25.7	478.5	504.2
1965	512.1	i	i	14.9	338.0	189.0	27.4	499.5	527.0
1966	533.9	i	i	12.9	342.6	204.2	28.0	518.8	546.8
1967	552.6	i	i	12.3	352.4	212.5	28.6	536.0	564.9
1968	545.2	i	i	11.5	346.6	210.1	29.7	527.0	556.7
1969	547.2	8.3	5.0	10.5	349.2	221.7	33.3	537.7	571.0
1970	578.5	16.4	8.0	9.7	340.5	272.1	44.9	567.8	612.7
1971	521.3	22.2	8.7	8.7	277.2	283.7	51.0	509.9	560.9
1972	556.8	27.5	11.0	7.1	305.0	297.4	64.3	538.2	602.5
1973	543.5	33.9	14.3	6.8	300.1	298.5	76.4	522.1	598.6
1974	545.7	42.2	15.5	6.6	278.0	332.1	91.9	518.1	610.0
1975	577.5	51.1	19.8	6.2	293.5	361.2	110.9	543.7	654.6
1976	588.4	64.8	25.5	6.2	295.5	389.4	136.1	548.8	684.9
1977	581.0	82.1	28.2	5.9	266.6	430.6	163.9	533.3	697.2
1978	534.0	96.8	34.4	5.0	242.8	427.4	183.0	487.2	670.2
1979	612.3	121.5	42.5	4.8	320.9	460.2	221.4	559.7	781.1
1980	628.8	147.7	47.2	6.1	337.5	492.2	251.0	578.7	829.7
1981	608.0	159.7	50.7	5.4	316.5	507.3	269.9	553.9	823.8
1982	620.2	160.9	52.4	4.6	339.2	499.0	273.9	564.3	838.1
1983	568.6	151.0	58.3	4.1	300.4	481.7	274.7	507.4	782.1
1984	649.5	179.2	63.1	4.2	352.1	543.9	308.3	587.6	895.9
1985	613.9	192.7	72.4	4.7	350.8	532.8	324.9	558.7	883.6
1986	620.1	189.6	76.4	4.3	360.4	529.9	325.9	564.4	890.3
1987	636.6	200.2	78.4	3.6	372.9	545.9	336.8	581.9	918.8
1988	638.1	223.5	85.1	3.6	382.2	568.1	370.7	579.6	950.3
1989	659.8	231.2	86.4	3.3	393.8	586.9	381.7	599.0	980.7
1990	693.2	244.3	88.1	3.5	424.5	604.5	398.9	630.2	1,029.1
1991	650.7	255.3	86.5	3.4	407.2	588.8	404.7	591.3	996.0
1992	651.9	252.1	90.1	3.5	407.2	590.3	409.0	588.6	997.5
1993	576.7	274.9	89.5	4.3	351.1	594.4	429.2	516.2	945.4
1994	640.3	300.5	88.1	4.6	399.1	634.4	467.2	566.3	1,033.5
1995	611.1	328.4	86.1	4.1	370.0	659.7	487.5	542.2	1,029.7

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 7.2, p. 213, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

Notes: i=included in bituminous coal. Location refers to east and west of the Mississippi River. Totals may not agree with components due to independent rounding. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 80. U.S. Petroleum Production and Imports, 1942-1995

Year	Production: Crude oil	Production: NGPL	Production: Total	Total imports	Year	Production: Crude oil	Production: NGPL	Production: Total	Total imports
	million barrels per day					*million barrels per day*			
1942	3.80	0.23	4.03	0.03	1969	9.24	1.59	10.83	3.17
1943	4.12	0.24	4.37	0.38	1970	9.64	1.66	11.30	3.42
1944	4.60	0.27	4.97	0.12	1971	9.46	1.69	11.16	3.93
1945	4.69	0.31	5.00	0.20	1972	9.44	1.75	11.18	4.74
1946	4.75	0.32	5.07	0.24	1973	9.21	1.74	10.95	6.26
1947	5.09	0.36	5.45	0.27	1974	8.77	1.69	10.46	6.11
1948	5.53	0.40	5.94	0.35	1975	8.37	1.63	10.01	6.06
1949	5.05	0.43	5.48	0.65	1976	8.13	1.61	9.74	7.31
1950	5.41	0.50	5.91	0.85	1977	8.24	1.62	9.86	8.81
1951	6.16	0.56	6.72	0.84	1978	8.71	1.57	10.27	8.36
1952	6.27	0.61	6.87	0.95	1979	8.55	1.58	10.14	8.46
1953	6.46	0.65	7.11	1.03	1980	8.60	1.58	10.17	6.91
1954	6.34	0.69	7.03	1.05	1981	8.57	1.61	10.18	6.00
1955	6.81	0.77	7.58	1.25	1982	8.65	1.55	10.20	5.11
1956	7.15	0.80	7.95	1.44	1983	8.69	1.56	10.25	5.05
1957	7.17	0.81	7.98	1.57	1984	8.88	1.63	10.51	5.44
1958	6.71	0.81	7.52	1.70	1985	8.97	1.61	10.58	5.07
1959	7.05	0.88	7.93	1.78	1986	8.68	1.55	10.23	6.22
1960	7.04	0.93	7.96	1.81	1987	8.35	1.60	9.94	6.68
1961	7.18	0.99	8.17	1.92	1988	8.14	1.62	9.76	7.40
1962	7.33	1.02	8.35	2.08	1989	7.61	1.55	9.16	8.06
1963	7.54	1.10	8.64	2.12	1990	7.36	1.56	8.91	8.02
1964	7.61	1.16	8.77	2.26	1991	7.42	1.66	9.08	7.63
1965	7.80	1.21	9.01	2.47	1992	7.17	1.70	8.87	7.89
1966	8.30	1.28	9.58	2.57	1993	6.85	1.74	8.58	8.62
1967	8.81	1.41	10.22	2.54	1994	6.66	1.73	8.39	9.00
1968	9.10	1.51	10.60	2.84	1995	6.53	1.76	8.29	8.83

Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970*, Series M 143, 138 (GPO, Washington, DC, 1975).

U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 5.1, p. 141, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

Notes: Crude oil includes lease condensate. NGPL=Natural gas plant liquids. Imports for years 1941-1949 include crude petroleum products only. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 81. U.S. Natural Gas Production, 1960-1995

Year	Well with-drawals	Repres-suring	Nonhydro-carbon gas removal	Vented or flared	Marketed production	Extraction loss	Total pro-duction
				trillion cubic feet			
1960	15.09	1.75	na	0.56	12.77	0.54	12.23
1961	15.46	1.68	na	0.52	13.25	0.59	12.66
1962	16.04	1.74	na	0.43	13.88	0.62	13.25
1963	16.97	1.84	na	0.38	14.75	0.67	14.08
1964	17.54	1.65	na	0.34	15.55	0.72	14.82
1965	17.96	1.60	na	0.32	16.04	0.75	15.29
1966	19.03	1.45	na	0.38	17.21	0.74	16.47
1967	20.25	1.59	na	0.49	18.17	0.78	17.39
1968	21.33	1.49	na	0.52	19.32	0.83	18.49
1969	22.68	1.46	na	0.53	20.70	0.87	19.83
1970	23.79	1.38	na	0.49	21.92	0.91	21.01
1971	24.09	1.31	na	0.28	22.49	0.88	21.61
1972	24.02	1.24	na	0.25	22.53	0.91	21.62
1973	24.07	1.17	na	0.25	22.65	0.92	21.73
1974	22.85	1.08	na	0.17	21.60	0.89	20.71
1975	21.10	0.86	na	0.13	20.11	0.87	19.24
1976	20.94	0.86	na	0.13	19.96	0.85	19.10
1977	21.10	0.93	na	0.17	20.03	0.86	19.16
1978	21.31	1.18	na	0.15	19.97	0.85	19.12
1979	21.88	1.25	na	0.17	20.47	0.81	19.66
1980	21.87	1.37	0.20	0.13	20.18	0.78	19.40
1981	21.59	1.31	0.22	0.10	19.96	0.77	19.18
1982	20.27	1.39	0.21	0.09	18.58	0.76	17.82
1983	18.66	1.46	0.22	0.09	16.88	0.79	16.09
1984	20.27	1.63	0.22	0.11	18.30	0.84	17.47
1985	19.61	1.92	0.33	0.09	17.27	0.82	16.45
1986	19.13	1.84	0.34	0.10	16.86	0.80	16.06
1987	20.14	2.21	0.38	0.12	17.43	0.81	16.62
1988	21.00	2.48	0.46	0.14	17.92	0.82	17.10
1989	21.07	2.48	0.36	0.14	18.10	0.78	17.31
1990	21.52	2.49	0.29	0.15	18.59	0.78	17.81
1991	21.75	2.77	0.28	0.17	18.53	0.83	17.70
1992	22.13	2.97	0.28	0.17	18.71	0.87	17.84
1993	22.73	3.10	0.41	0.23	18.98	0.89	18.10
1994	23.61	3.33	0.41	0.23	19.64	0.89	18.75
1995	23.79	3.66	0.36	0.14	19.62	0.91	18.71

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 6.2, p. 191, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

Notes: Extraction loss refers to volume reduction resulting from the removal of natural gas plant liquids. Total production refers to dry natural gas. Beginning in 1965, all volumes are shown on a pressure base of 14.73 p.s.i.a. at 60 degrees F. Totals may not agree with sum of components due to independent rounding. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 82. U.S. Production of Electricity by Prime Mover, 1960-1995

Year	Fossil-fired steam: Coal	Fossil-fired steam: Natural gas	Fossil-fired steam: Petro-leum	Internal combus-tion & gas turbine	Nuclear power	Hydro-electric	Geo-thermal & other	Total
	billion kilowatt-hours							
1960	403	158	48	4	1	146	<1	756
1961	422	169	49	5	2	152	<1	794
1962	450	184	49	5	2	169	<1	855
1963	494	202	52	5	3	166	<1	917
1964	526	220	57	5	3	177	<1	984
1965	571	222	65	5	4	194	<1	1,055
1966	613	251	79	5	6	195	1	1,144
1967	630	265	89	5	8	222	1	1,214
1968	685	304	104	9	13	222	1	1,329
1969	706	333	138	14	14	250	1	1,442
1970	704	361	174	22	22	248	1	1,532
1971	713	360	206	28	38	266	1	1,613
1972	771	361	253	36	54	273	2	1,750
1973	848	323	296	36	83	272	2	1,861
1974	828	304	279	38	114	301	3	1,867
1975	853	288	273	28	173	300	3	1,918
1976	944	284	302	29	191	284	4	2,038
1977	985	292	338	34	251	220	4	2,124
1978	976	290	345	36	276	280	3	2,206
1979	1,075	311	290	32	255	280	4	2,247
1980	1,162	326	238	28	251	276	6	2,286
1981	1,203	325	202	25	273	261	6	2,295
1982	1,192	291	144	16	283	309	5	2,241
1983	1,259	261	141	17	294	332	6	2,310
1984	1,342	284	117	17	328	321	9	2,416
1985	1,402	279	97	16	384	281	11	2,470
1986	1,386	236	133	15	414	291	12	2,487
1987	1,464	258	115	18	455	250	12	2,572
1988	1,541	236	144	22	527	223	12	2,704
1989	1,554	245	151	29	529	265	11	2,784
1990	1,560	246	113	22	577	280	11	2,808
1991	1,551	246	108	22	613	276	10	2.825
1992	1,576	246	86	21	619	240	10	2,797
1993	1,639	229	96	25	610	269	10	2,883
1994	1,636	260	86	36	640	244	9	2,911
1995	1,653	268	56	44	673	296	6	2,995

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 8.4, p. 237, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

Notes: Production refers to electric utility net generation of electricity for distribution. Hydroelectric power includes hydroelectric pumped storage. Other includes wood, waste, photovoltaic, and solar thermal energy. Totals may not agree with sum of components due to independent rounding. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 83. U.S. Nuclear Power Plant Operations, 1958-1995

Year	Operable nuclear generating units	Net generation of electricity	Year	Operable nuclear generating units	Net generation of electricity
	number of units	*billion kilowatt-hours*		*number of units*	*billion kilowatt-hours*
1958	1	0.2	1977	65	250.9
1959	1	0.2	1978	70	276.4
1960	3	0.5	1979	68	255.2
1961	3	1.7	1980	70	251.1
1962	5	2.3	1981	74	272.7
1963	6	3.2	1982	77	282.8
1964	6	3.3	1983	80	293.7
1965	6	3.7	1984	86	327.6
1966	8	5.5	1985	95	383.7
1967	10	7.7	1986	100	414.0
1968	11	12.5	1987	107	455.3
1969	14	13.9	1988	108	527.0
1970	18	21.8	1989	110	529.4
1971	21	38.1	1990	111	576.9
1972	29	54.1	1991	111	612.6
1973	39	83.5	1992	109	618.8
1974	48	114.0	1993	109	610.3
1975	54	172.5	1994	109	640.4
1976	61	191.1	1995	109	673.4

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 9.2, p. 261, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

Notes: Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 84. Net U.S. Energy Imports by Source, 1960-1995

Year	Coal	Natural gas (dry)	Petroleum	Other	Total
			quadrillion Btu		
1960	-1.02	0.15	3.57	0.04	2.74
1965	-1.37	0.44	5.01	- 0.02	4.06
1966	-1.35	0.47	5.21	- 0.01	4.32
1967	-1.35	0.50	4.91	- 0.02	4.04
1968	-1.37	0.58	5.73	- 0.02	4.90
1969	-1.53	0.70	6.42	- 0.02	5.56
1970	-1.93	0.77	6.92	- 0.04	5.72
1971	-1.54	0.88	8.07	<0.005	7.41
1972	-1.53	0.97	9.83	0.05	9.32
1973	-1.42	0.98	12.98	0.14	12.68
1974	-1.57	0.91	12.66	0.19	12.19
1975	-1.74	0.90	12.51	0.08	11.75
1976	-1.57	0.92	15.20	0.09	14.65
1977	-1.40	0.98	18.24	0.20	18.02
1978	-1.00	0.94	17.06	0.33	17.32
1979	-1.70	1.24	16.93	0.27	16.75
1980	-2.39	0.96	13.50	0.18	12.25
1981	-2.92	0.86	11.38	0.33	9.65
1982	-2.77	0.90	9.05	0.28	7.46
1983	-2.01	0.89	9.08	0.36	8.31
1984	-2.12	0.79	9.89	0.40	8.96
1985	-2.39	0.90	8.95	0.41	7.87
1986	-2.19	0.69	11.53	0.36	10.38
1987	-2.05	0.94	12.53	0.49	11.91
1988	-2.45	1.22	14.01	0.37	13.15
1989	-2.57	1.28	15.33	0.14	14.18
1990	-2.70	1.46	15.29	0.03	14.08
1991	-2.77	1.67	14.22	0.25	13.36
1992	-2.59	1.94	14.96	0.33	14.64
1993	-1.78	2.25	16.40	0.32	17.18
1994	-1.69	2.52	17.26	0.49	18.58
1995	-2.14	2.63	16.95	0.42	17.86

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 1.4, p. 11, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

Notes: Net imports=imports minus exports. Other includes coal coke and small amounts of electricity transmitted across U.S. borders with Canada and Mexico. Totals may not agree with sum of components due to independent rounding. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 85. U.S. Energy Consumption by Sector, 1960-1995

Year	Residential	Industrial	Transportation	Total
		quadrillion Btu		
1960	13.04	20.16	10.60	43.80
1961	13.44	20.25	10.77	44.46
1962	14.27	21.04	11.23	46.53
1963	14.71	21.95	11.66	48.32
1964	15.23	23.27	12.00	50.50
1965	16.03	24.22	12.43	52.68
1966	17.06	25.50	13.10	55.66
1967	18.10	25.72	13.75	57.57
1968	19.23	26.90	14.86	61.00
1969	20.59	28.10	15.50	64.19
1970	21.71	28.63	16.09	66.43
1971	22.59	28.57	16.72	67.89
1972	23.69	29.86	17.71	71.26
1973	24.14	31.53	18.60	74.28
1974	23.72	30.70	18.12	72.54
1975	23.90	28.40	18.25	70.55
1976	25.02	30.24	19.10	74.36
1977	25.39	31.08	19.82	76.29
1978	26.09	31.39	20.61	78.09
1979	25.81	32.61	20.47	78.90
1980	26.65	30.61	19.69	75.96
1981	25.24	29.24	19.51	73.99
1982	25.63	26.14	19.07	70.85
1983	25.63	25.75	19.13	70.52
1984	26.48	27.86	19.80	74.14
1985	26.70	27.22	20.07	73.98
1986	26.80	26.63	20.81	74.30
1987	27.62	27.83	21.45	76.89
1988	28.92	28.99	22.30	80.22
1989	29.40	29.35	22.56	81.33
1990	29.43	32.10	22.62	84.17
1991	30.10	31.76	22.19	84.05
1993	29.80	32.90	22.54	82.26
1993	30.88	33.17	22.97	87.03
1994	31.07	34.17	23.67	88.90
1995	32.07	34.47	24.06	90.62

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 2.1, p. 39, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

Table 86. U.S. Energy Consumption per Capita, 1950-1995

Year	Total energy consumption per capita	End-use energy consumption per capita	Year	Total energy consumption per capita	End-use energy consumption per capita
	million Btu			million Btu	
1950	219	194	1973	351	285
1951	230	205	1974	340	273
1952	226	199	1975	327	261
1953	228	201	1976	342	272
1954	218	191	1977	347	274
1955	235	206	1978	352	276
1956	240	210	1979	351	275
1957	236	206	1980	335	259
1958	232	202	1981	322	246
1959	238	206	1982	305	231
1960	244	212	1983	301	226
1961	243	210	1984	314	236
1962	250	216	1985	310	232
1963	256	220	1986	308	231
1964	264	226	1987	316	237
1965	272	232	1988	326	246
1966	285	241	1989	328	246
1967	292	246	1990	338	256
1968	306	257	1991	333	252
1969	319	266	1992	334	255
1970	327	270	1993	338	258
1971	328	270	1994	341	261
1972	340	278	1995	345	264

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 1.5, p. 13, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

Notes: End-use energy consumption is total energy consumption less losses incurred in the generation, transmission, and distribution of electricity, less power plant electricity use, and less unaccounted for electrical system energy losses. Per capita data are based upon the resident population of the 50 states and the District of Columbia, estimated for July 1 of each year, except for April decennial census years when April 1 data are used. Previous-year data may have been revised. Current-year data are preliminary and may be revised in future publications.

Table 87. U.S. Energy Consumption per Dollar of Gross Domestic Product, 1959-1995

Year	Petroleum & natural gas	Other energy	Total	Year	Petroleum & natural gas	Other energy	Total
	thousand Btu per chained (1992) $				*thousand Btu per chained (1992) $*		
1959	14.03	5.02	19.05	1978	12.90	4.48	17.38
1960	14.28	5.08	19.37	1979	12.50	4.56	17.06
1961	14.35	4.90	19.25	1980	11.84	4.63	16.47
1962	14.20	4.80	19.00	1981	10.98	4.68	15.66
1963	14.14	4.78	18.92	1982	10.54	4.78	15.32
1964	13.91	4.78	18.68	1983	9.86	4.81	14.66
1965	13.57	4.76	18.33	1984	9.65	4.78	14.43
1966	13.53	4.66	18.19	1985	9.15	4.73	13.88
1967	13.77	4.57	18.33	1986	8.91	4.63	13.53
1968	14.05	4.50	18.55	1987	8.96	4.65	13.61
1969	14.47	4.48	18.95	1988	9.00	4.68	13.68
1970	15.15	4.46	19.61	1989	8.84	4.58	13.42
1971	15.15	4.24	19.40	1990	8.61	5.10	13.71
1972	15.08	4.23	19.31	1991	8.63	5.20	13.83
1973	14.70	4.34	19.04	1992	8.59	5.06	13.65
1974	14.19	4.46	18.66	1993	8.56	5.07	13.63
1975	13.63	4.62	18.25	1994	8.49	4.97	13.46
1976	13.60	4.62	18.22	1995	8.43	5.01	13.45
1977	13.33	4.50	17.83				

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 1.7, p. 17, DOE/EIA-0035(95) (GPO, Washington, DC, 1996).

Notes: See Table 9 for chained (1992) dollars of Gross Domestic Product. Current-year data are preliminary and may be revised in future publications.

Table 88. U.S. Consumption of Renewable Energy Resources, 1990-1995

Year	Conventional hydroelectric power	Geo-thermal power	Biofuels	Solar energy	Wind energy	Total
			quadrillion Btu			
1990	3.102	0.338	2.632	0.067	0.024	6.163
1991	3.181	0.347	2.642	0.068	0.027	6.265
1992	2.852	0.367	2.788	0.068	0.030	6.106
1993	3.138	0.381	2.784	0.069	0.031	6.403
1994	2.958	0.381	2.852	0.068	0.036	6.296
1995	3.462	0.362	2.941	0.074	0.041	6.879

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 10.1a, p. 265, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

Notes: Hydroelectricity generated by pumped storage is not included in renewable energy estimates. Conventional hydroelectric power includes electricity net imports from Canada that are derived from hydroelectric energy. Geothermal power includes electricity imports from Mexico that are derived from geothermal energy. Biofuels are fuelwood, wood byproducts, municipal solid waste, manufacturing process waste, and alcohol fuels. Solar energy includes photovoltaic energy. Wind energy includes only grid-connected electricity; excludes direct heat applications.

Table 89. Estimates of U.S. Energy Intensity by Sector, Selected Years, 1977-1994

Year	Residential	Commercial	Manufacturing	Transportation: Passenger automobiles	Transportation: Freight trucks
	million Btu per household	*thousand Btu per sq. ft.*	*thous. Btu per 1987 $ value of shipments*	*thous. Btu per vehicle-mile*	*thous. Btu per vehicle-mile*
1977	na	na	6.0	9.11	14.16
1978	138	na	5.8	8.96	14.06
1979	126	115.0	5.7	8.73	13.98
1980	114	na	5.5	8.13	13.46
1981	114	na	5.4	7.89	13.39
1982	103	na	4.9	7.56	13.10
1983	na	98.2	4.7	7.31	13.14
1984	105	na	4.5	7.03	13.07
1985	na	na	4.4	6.88	13.12
1986	na	86.6	4.2	6.85	13.08
1987	101	na	4.2	6.52	13.01
1988	na	na	4.3	6.30	12.79
1989	na	91.6	4.3	6.16	12.49
1990	98	na	4.3	5.95	12.17
1991	na	na	4.4	5.77	11.84
1992	na	80.9	na	5.77	11.94
1993	104	na	na	5.95	11.05
1994	na	na	na	5.83	11.16

Sources: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1995*, Table 2.4, p. 45, Table 2.9, p. 55, and Table 2.20, p. 77, DOE/EIA-0384(95) (GPO, Washington, DC, 1996).

U.S. Department of Energy (DOE), Oak Ridge National Laboratory (ORNL), *Transportation Energy Data Book: Edition 16*, Table 2.16, p. 2-17, and Table 2.17, p. 2-18, ORNL-6898 (DOE, ORNL, Oak Ridge, TN, 1996).

Transportation

Table 90. U.S. Passenger-Miles of Travel, 5-Year Intervals, 1960-1990, and Annually, 1991-1994

Year	Highway	Transit	Rail	Air	Total
		thousands of passenger-miles			
1960	1,498.25	na	17.06	33.40	1,548.71
1965	1,768.86	na	13.26	57.63	1,839.74
1970	2,116.94	na	6.18	117.54	2,240.66
1975	2,387.46	na	3.93	147.40	2,538.79
1980	2,630.35	39.85	4.50	219.07	2,893.78
1985	2,931.30	39.58	4.83	290.14	3,265.84
1990	3,271.26	41.14	6.06	358.87	3,677.33
1991	3,649.61	40.70	6.27	350.69	4,047.27
1992	3,783.45	40.24	6.09	365.46	4,195.24
1993	3,847.85	39.63	6.20	372.43	4,266.10
1994	3,937.76	na	5.92	398.13	4,341.82

Source: U.S. Department of Transportation (DOT), Bureau of Transportation Statistics (BTS), *National Transportation Statistics 1996*, Table 6, p. 72 (DOT, BTS, Washington, DC, 1996).

Table 91. U.S. Ton-Miles of Freight, 5-Year Intervals, 1960-1990, and Annually, 1991-1994

Year	Intercity truck	Rail	Air	Water	Oil pipeline
			thousands of ton-miles		
1960	285.00	572.31	0.55	413.34	233.00
1965	359.00	697.88	1.35	489.80	306.39
1970	412.00	764.81	2.19	596.20	461.00
1975	454.00	754.25	3.47	565.98	507.00
1980	555.00	918.96	4.53	na	588.20
1985	610.00	876.98	5.16	na	564.30
1990	735.00	1,033.97	9.06	833.54	584.10
1991	758.00	1,038.88	8.86	848.40	578.50
1992	815.00	1,066.87	9.82	856.69	588.80
1993	861.00	1,109.31	10.68	789.66	592.90
1994	908.00	1,200.70	11.69	814.92	608.00

Source: U.S. Department of Transportation (DOT), Bureau of Transportation Statistics (BTS), *National Transportation Statistics 1996*, Table 7, p. 74 (DOT, BTS, Washington, DC, 1996).

Table 92. U.S. Vehicle-Miles of Travel and Fuel Consumption, 1966-1994

Year	Automobiles		Motorcycles		Buses		Other 2-axle, 4-tire vehicles		Trailer combin-ation truck	
	thous. vmt/y	*vmt/g*	*thous. vmt/y*	*vmt/g*	*thous. vmt/y*	*vmt/g*	*thous. vmt/y*	*vmt/g*	*thous. vmt/y*	*vmt/g*
1966	9.92	14.11	1.28	50.00	14.06	5.42	8.08	9.70	35.99	4.78
1967	10.10	14.07	1.16	50.00	13.69	5.38	7.88	9.83	37.36	4.79
1968	10.14	13.87	1.04	50.00	14.00	5.43	8.38	9.86	38.15	4.77
1969	10.16	13.62	1.02	50.00	13.23	5.42	8.36	9.82	38.46	4.76
1970	10.27	13.52	1.06	50.00	12.04	5.54	8.68	10.01	38.82	4.78
1971	10.42	13.54	1.08	50.00	12.07	5.68	9.08	10.22	40.49	4.90
1972	10.52	13.40	1.15	50.00	13.14	5.79	9.53	10.34	42.34	5.01
1973	10.26	13.30	1.19	50.00	13.63	5.86	9.78	10.51	44.37	5.06
1974	9.61	13.42	1.10	50.00	12.72	5.89	9.45	10.97	42.37	5.22
1975	9.69	13.52	1.13	50.00	13.10	5.75	9.83	11.21	41.32	5.40
1976	9.79	13.53	1.22	50.00	13.08	5.98	10.13	11.20	40.56	5.21
1977	9.88	13.80	1.29	50.00	11.87	5.98	10.61	11.44	44.92	5.22
1978	9.84	14.04	1.47	50.00	11.65	5.95	10.97	11.62	46.95	5.20
1979	9.40	14.41	1.59	50.00	11.29	5.97	10.80	11.80	48.32	5.21
1980	9.14	15.46	1.79	50.00	11.46	5.95	10.44	12.33	48.47	5.41
1981	9.19	15.94	1.83	50.00	11.48	5.92	10.24	12.51	54.82	5.33
1982	9.43	16.69	1.72	50.00	10.41	5.93	10.28	12.84	52.69	5.28
1983	9.48	17.14	1.57	50.00	8.92	5.92	10.50	12.82	53.49	5.19
1984	9.56	17.83	1.60	50.00	7.95	5.85	11.15	12.93	57.73	5.23
1985	9.56	18.20	1.67	50.00	8.22	5.84	11.02	12.86	56.73	5.21
1986	9.61	18.27	1.79	50.00	8.54	5.84	11.17	12.85	58.50	5.21
1987	9.88	19.20	1.93	50.00	8.83	5.89	11.59	12.88	60.63	5.22
1988	10.12	19.87	2.19	50.00	8.88	5.93	11.85	13.40	61.07	5.27
1989	10.33	20.31	2.34	50.00	9.05	5.96	11.98	13.77	60.00	5.45
1990	10.55	21.02	2.24	50.00	9.12	6.39	11.99	14.15	59.81	5.52
1991	10.76	21.69	2.20	50.00	9.10	6.65	12.10	14.54	60.46	5.65
1992	11.10	21.68	2.35	50.00	8.93	6.57	12.10	14.28	59.89	5.60
1993	11.76	21.04	2.49	50.00	9.36	6.47	10.29	15.72	64.79	5.82
1994	11.84	21.48	2.76	50.00	9.57	6.58	10.28	15.64	67.11	5.87

Source: U.S. Department of Transportation (DOT), Federal Highway Administration (FHWA), *Highway Statistics*, Table VM-1 (DOT, FHWA, Washington, DC, annual).

Notes: thous. vmt/y=thousand vehicle-miles of travel per year per vehicle. vmt/g=average vehicle-miles of travel per gallon of fuel consumed. Prior to 1993, other 2-axle, 4-tire vehicles refers to light weight trucks. For 1993 and beyond, this category also includes some minivans and sport/utility vehicles which were previously included in the passenger automobile category.

Table 93. U.S. Personal Travel per Household, Driver, and Mode, 1969, 1977, 1983, and 1990

Characteristics of personal travel	Unit	Year 1969	1977	1983	1990
Persons per household	*number*	3.16	2.83	2.69	2.56
Licensed drivers per household	*number*	1.65	1.69	1.72	1.75
Vehicles per household	*number*	1.16	1.59	1.68	1.77
Daily vehicle trips per household	*number*	3.83	3.95	4.07	4.66
Daily vehicle miles per household	*miles*	34.01	32.97	32.16	41.37
Average vehicle occupancy rate	*persons/vehicle*	na	1.90	1.70	1.60
Home to work	*persons/vehicle*	na	1.30	1.30	1.10
Family & personal business	*persons/vehicle*	na	2.00	1.80	1.80
Shopping	*persons/vehicle*	na	2.10	1.80	1.70
Social & recreation	*persons/vehicle*	na	2.40	2.10	2.10
Average vehicle trip length	*miles*	8.90	8.40	7.90	9.00
Home to work	*miles*	9.40	9.10	8.50	11.00
Family & personal business	*miles*	6.50	6.80	6.70	7.40
Shopping	*miles*	4.40	5.00	5.30	5.10
Social & recreation	*miles*	13.10	10.30	10.50	11.80
Vacation	*miles*	160.00	77.90	113.90	114.90
Average distance to work	*miles*	9.90	9.20	9.90	10.60
by automobile	*miles*	9.40	9.20	9.90	10.40
by truck	*miles*	14.20	10.60	11.40	13.00
by bus	*miles*	8.70	7.20	8.60	9.30
Average annual travel per driver	*1,000 miles*	8.69	9.92	10.29	13.13
by male drivers	*1,000 miles*	11.35	13.40	13.96	16.64
by female drivers	*1,000 miles*	5.41	5.94	6.38	9.53
Average annual personal travel*	*1,000 miles*	7.66	9.47	9.14	10.42
by private vehicle	*1,000 miles*	na	8.15	7.52	9.18
by public vehicle	*1,000 miles*	na	0.25	0.24	0.24
by other mode	*1,000 miles*	na	1.06	1.37	0.97

Sources: U.S. Department of Transportation (DOT), Federal Highway Administration (FHWA), *1990 Nationwide Personal Transportation Study: Summary of Travel Trends* (DOT, FHWA, Washington, DC, 1992).

--, *1990 NPTS Databook: Nationwide Personal Transportation Study*, Vol. I (DOT, FHWA, Washington, DC, 1993).

--, *1990 NPTS Databook: Nationwide Personal Transportation Study*, Vol. II (DOT, FHWA, Washington, DC, 1995).

Notes: *per person. Household vehicles include automobiles, station wagons, and vanbuses/mini-buses, and, except for 1969, light pickups and other light trucks. Household vehicles are those that are owned, leased, rented, or company owned and left at home to be regularly used by household members. They also include vehicles used solely for business purposes or business-owned vehicles if left at home and used for the home-to-work trip (e.g., taxicabs and police cars). Average vehicle trip length for 1969 is for automobiles only. Family and personal business includes vehicle trips to shop, pickup or deposit passengers, shoe repair, haircuts, etc. Social/recreation includes vehicle trips to visit relatives and friends, go to a movie or play, attend or participate in a sporting event, etc. Private vehicle modes of travel include automobile, van, pick-up truck, and motorcycle. Public transportation includes bus, commuter rail, subway, elevated rail, streetcar, and trolley. Other includes airplane, Amtrak, taxi, school bus, moped, bicycle, and, except for 1969, walking.

Table 94. Journey-To-Work Mode for U.S. Working Population, 1960-1990

Mode of transportation	Year 1960	1970	1980	1990
	U.S. working population, in millions			
Private vehicle	42.99	61.96	83.02	101.29
Public transit	7.81	6.51	6.01	5.89
Walked to work	6.42	5.69	5.41	4.49
Worked at home	4.66	2.69	2.18	3.41
Total	61.87	76.85	96.62	115.07
	percent of U.S. working population			
Private vehicle	69.48	80.63	85.92	88.02
Public transit	12.62	8.48	6.22	5.12
Walked to work	10.37	7.40	5.60	3.90
Worked at home	7.54	3.49	2.26	2.96

Source: U.S. Department of Commerce, Bureau of the Census, *Census of Population and Housing* for 1960, 1970, 1980, and 1990 (GPO, Washington, DC, decennial).

Table 95. Congestion on U.S. Urban Interstate Highways, 1975-1994

Year	Peak-hour travel time under congested conditions	Peak-hour miles traveled under congested conditions	Average daily vehicles per lane
	percent		*thousands*
1975	41	23	na
1978	48	29	na
1980	52	28	na
1982	53	28	na
1984	55	30	9.99
1986	63	37	10.79
1988	67	42	11.68
1990	69	45	12.26
1992	70	46	12.38
1994	68	45	12.81

Source; U.S. Department of Transportation (DOT), Federal Highway Administration (FHWA), *Highway Statistics 1994,* Chart "Urban Interstate Congestion Trends," p. V-58 (DOT, FHWA, Washington, DC, 1995).

Note: Congestion refers to the volume-to-service ratio equal to or greater than 0.80.

Part IV
Appendix
NEPA Case Law and Statistical Tables

Appendix

SELECTED 1994 NEPA CASE LAW

Standing

Sierra Club v. Robertson, 28 F.3d 753 (8th Cir. 1994). The Sierra Club and State of Arkansas sought judicial review of the Forest Service's Amended Land and Resource Management Plan (LRMP) for the Ouachita National Forest in west-central Arkansas and southeast Oklahoma. The plaintiffs first sought a preliminary injunction barring two sales proposed under the plan, on the grounds that the Forest Service improperly denied them the right to an administrative review. After their motion was denied by the district court, the plaintiffs again moved for a preliminary injunction, arguing that the timber sales violated both the National Forest Management Act (NFMA), which requires the Forest Service to take into account the multiple uses and sustained yield of the products and services of national forests in preparing LRMPs, and NEPA, and were arbitrary and capricious. After again being denied, the plaintiffs sought judicial review of the plan itself as violative of NFMA and NEPA. The district court granted the Forest Service summary judgment, finding that the plan satisfied the directives of both NFMA and NEPA.

The Eighth Circuit affirmed the district court's denial of a preliminary injunction with respect to the two proposed sales. The court further refused to grant the plaintiffs standing to challenge the Forest Service's plan and dismissed the suit. In finding that the plaintiffs lacked standing to sue, the court first cited the three requirements to establish standing under the 1992 Supreme Court decision, *Lujan v. Defenders of Wildlife*, 112 S.Ct. 2130 (1992): (1) the plaintiff must have suffered an "injury in fact;" (2) there must be a causal connection between the injury and the conduct complained of that is "fairly . . . trace[able] to the challenged conduct of the defendant;" and (3) it must be "likely," as opposed to merely "speculative," that the injury is redressable by a decision favorable to the plaintiff.

The court found that the claim failed on the first injury in fact component of standing. It concurred with the Forest Service's characterization of the Ouachita LRMP as "a general planning tool," which "provides guidelines and approved methods by which forest management decisions are to be made," but which does not "dictate that any particular site-specific action causing environmental injury must occur." Because several events must transpire before an environmental change can come about under an LRMP—including proposal of a site-specific action, subjection of that proposal to NFMA and NEPA analysis, and adoption of the action by the Forest Service—standing would not be granted to challenge the plan per se.[21]

Roadless Areas

Smith v. U.S. Forest Service, 33 F.3d 1072 (9th Cir. 1994). The Forest Service awarded the Gatorson timber sale to a logging company operating in the Colville National Forest in Washington State. The Forest Service had prepared an EIS for the forest plan for the Colville National Forest, and subsequently issued a final EA for the Gatorson Sale, with a finding of no significant impact beyond that addressed in the Forest Plan EIS.

Plaintiff Smith, a frequent recreational user of the area affected by the sale, sued the Forest Service and logging company seeking to enjoin the sale on the grounds that the EA was inadequate. Smith argued first that the area affected by the sale contained in excess of 5,000 acres of roadless land that the Forest Service never considered for classification as wilderness, as required by the Washington State Wilderness Act (WSWA). Second, Smith argued that the EA was inadequate under NEPA in its failure to address the effect of the sale on a separate tract of 6,000 acres, part of which was inventoried by the Forest Service under the Wilderness Act of 1964.

The district court entered summary judgment for the defendants, holding that the Forest Service was not acting in an arbitrary and capricious manner when it decided that the uninventoried tract in excess of 5,000 acres was actually two smaller tracts of land, divided by a jeep trail. The court further held that the WSWA barred its review of the agency's decision with respect to the second tract, since a reviewing court has jurisdiction only over uninventoried areas of greater than 5,000 acres.

The Ninth Circuit upheld the first portion of the district court's holding, finding that the factual record supported a conclusion that the Forest Service was not arbitrary and capricious in its decision that the jeep trail rendered the first area roaded. Because of the existence of the jeep trail, the Service properly concluded that the area was actually two roadless areas of less than 5,000 acres each. The court reversed, however, the second part of the district court's holding. It found that the EA was inadequate in its failure to consider the effect of the sale on the neighboring 6,000 acres, even though it had been partially inventoried. The court found that, though judicial review over the wilderness designation might have been precluded under the WSWA, under that act and NEPA, the court retained jurisdiction over the roadless determination and decision not to consider the area in its EA. The court held that the Service should have at least considered the "no action" alternative to development of the parcel. Under the WSWA, judicial review of the wilderness option is only foreclosed for first-generation forest plans. However, the wilderness option for inventoried land "may be revisited in second-generation forest plans," at which time the decision becomes justiciable. Therefore, the court stated:

> *Clearly, under the WSWA, the agency is not required to preserve any [congressionally] released roadless area for wilderness consideration in second-generation Forest Plans… But the possibility of future wilderness classification triggers, at the very least, an obligation on the part of the agency to disclose the fact that development will affect a 5,000 acre roadless area.*

Because in a second-generation Plan the area might be designated as wilderness, the Forest Service should have included discussion of the "no action" alternative in its EA.

Further, because the roadless character of an area has environmental significance, the Forest Service should have examined the potential impact of the sale on the roadless area in its EA. The 6,000 acre area considered in the EA did not include "the remaining thousands of acres of roadless land . . . to the west of [the 6,000 acres] that will no longer be part of a 5,000 acre roadless expanse [after the sale]." In remanding the case, the court refused to find that, though "the decision to harvest timber in a 5,000 acre roadless area is environmentally significant," an EIS is per se required under such circumstances.

Forest Management Plans

Seattle Audubon Society v. Lyons, 871 F.Supp. 1291 (W.D.Wash. 1994). In April, 1993, a conference was held in Portland, Oregon, attended by the President, Vice President, and other government officials and representative stakeholders, as the first step in a massive effort by the executive branch to meet the legal and scientific needs of forest management in the Pacific Northwest. The conference resulted in the formation of three working groups, including the Forest Ecosystem Management Assessment Team (FEMAT), organized to conduct a conservation and management assessment of all federal forests within the range of the Northern Spotted Owl. FEMAT, an interagency, interdisciplinary team, was asked to "develop a set of options for management of all federal forests within the owl's range that would comply with existing laws, maintain biological diversity, provide for sustainable levels of timber harvest, and support rural economies and communities."

Based on the FEMAT report, which winnowed down from an initial fifty-four identified alternatives, ten alternatives chosen for final intensive review, and finally one recommended alternative, the Secretaries of Agriculture and the Interior adopted a management plan for an area including forests in northern California, Oregon, and Washington. The Secretaries directed the Forest Service and the Bureau of Land Management

(BLM), in conjunction with other relevant federal agencies, to prepare a joint draft supplemental EIS (DSEIS) to accompany the plan. After incorporating and conducting further research based on the more than 100,000 comments received after publication of the DSEIS, the Secretaries issued a final SEIS (FSEIS). Additional comments received on the FSEIS were responded to in the Record of Decision (ROD) accompanying the Secretaries' decision to incorporate the recommendations of the FEMAT report into the management plan.

The forest management plan adopted pursuant to the FEMAT report contains four main components: (1) reserve areas in which logging and other ground-disturbing activities are generally prohibited to protect the ecosystem and conserve the spotted owl and other species; (2) unreserved areas designated as "matrix," in which timber harvest may proceed subject to compliance with environmental laws; (3) an aquatic conservation strategy which contains a system of key watersheds where activities are restricted to conserve aquatic species; and (4) a monitoring and evaluation program. In addition, six percent of lands are allocated as adaptive management areas for experimentation in areas near communities affected by the reduction in timber sales. Altogether, the plan protects about eighty percent of late successional old-growth trees from programmed timber harvest; makes provisions for protection of the owl and the marbled murrelet, both threatened species, as well as other species; and provides provisions for protection of the aquatic ecosystem, water quality, and fish habitat.

Following the adoption of the plan, twelve environmental organizations, including the Seattle Audubon Society, sued the Secretaries seeking invalidation of the plan or injunctive relief against its implementation under NEPA, the National Forest Management Act (NFMA), and the Administrative Procedures Act (APA). The Northwest Forest Resource Council (NFRC), an association of loggers, mill owners, and others in the timber industry, also sued under a variety of statutes.

After rejecting a wide spectrum of claims brought by the various plaintiffs, the district court found in favor of the federal defendants, holding that none of the claims and arguments would justify invalidation of the plan or a remand to the agencies. Rather, the court held that the Secretaries and the respective federal agencies had acted reasonably, and not arbitrarily or capriciously, in adopting the plan based on FEMAT's report. The following discussion addresses a selection of the plaintiffs' claims.

The court rejected an argument by NFRC that the agencies acted improperly by adopting an ecosystem planning approach. The court first noted that: "The agencies for years had operated independently and sometimes in conflict. In the current plan they have cooperated and have analyzed not just individual species but ecosystems." Noting that NFMA "requires planning for the entire biological community - not for one species alone," that "[b]oth agencies must comply with NEPA," and that "the ESA requires federal agencies to carry out their administrative programs so as to conserve listed species and the ecosystems on which they depend . . . there is no way the agencies could comply with the environmental laws without planning on an ecosystem basis."

The court also found that the so-called "viability provision," promulgated by the Secretary of Agriculture pursuant to NFMA, was valid and properly applied. The provision requires that: "Fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area." The court found the provision compatible with the objective of NFMA that forests be maintained for multiple use. It further held that the Secretaries did not act arbitrarily or capriciously in finding that the FEMAT report-based plan was properly based on the viability provision, as well as on NFMA more broadly. The court gave further support to the ecosystem approach in finding that the Secretaries could divide the planning process into two stages—the overall plan and specific projects within the overall forest. It stated: "To require planning be done only on an individual forest basis would be unrealistic."

The court went on to uphold the FSEIS against a number of NEPA challenges. It held that the FSEIS was in compliance with NEPA with respect to: (1) NEPA's basic EIS standards that an EIS provide the decisionmaker with useful information, as well as provide the public with a chance for meaningful participation; (2) agency objectivity, finding that though there was a clear early preference for the alternative ultimately chosen, a "thorough and fair analysis of the ten alternatives was made;" (3) use of the FEMAT report, since there was sufficient representation by federal agents within FEMAT such that independent verification of its findings before their adoption was not necessary; (4) the range of alternatives considered, which included a broad enough spectrum of possibilities, including an appropriate "no action" alternative; (5) provision of adequate protection for the northern spotted owl, the marbled murrelet, and aquatic and other land-based species, safeguarded by the monitoring procedures established by the plan; (6) adequate acknowledgment as to where there was incomplete data in the plan; (7) sufficient discussion of the cumulative impacts of the plan, including those in federal forests, those on non-federal land, and those arising from non-federal actions; (8) the extent to which any irretrievable commitments of resources had been made; (9) discussion of mitigation measures included, and monitoring to insure that the objectives of the plan were being met and conditions were not significantly changing; (10) discussion of the impacts of timber harvest on water and air quality, and on climate change; (11) the economic effects of the plan; (12) the funding necessary for carrying out the plan; and (13) the incorporation into the FSEIS and ROD of public comments.

After finding the FSEIS adequate on all of the foregoing grounds, the court granted summary judgment to the federal defendants, refusing to invalidate or remand the plan. The district court's decision was upheld by the Court of Appeals for the Ninth Circuit. 80 F.3d 1401 (9th Cir. 1996).

Range of Alternatives

Natural Resources Defense Council, Inc. v. U.S. Dept. of Navy, 857 F.Supp. 734 (C.D.Cal. 1994). The National Marine Fisheries Service (NMFS) promulgated a regulation that authorized the taking of marine mammals over a five-year period as a result of a United States Navy weapons-testing program which would involve the underwater detonation of explosives in an area off of the California coast known as the Outer Sea Test Range (OSTR). The Navy planned to proceed with a specific weapons test, the ship-shock trial of the U.S.S. John Paul Jones, pursuant to a Letter of Authorization issued by NMFS pursuant to the regulation. Prior to promulgation of its regulation, NMFS prepared an EA, which found no significant impact on the environment resulting from its proposed regulation. After receiving a comment that alternatives to the regulation should have been considered in the EA, NMFS issued a supplemental EA with discussion of alternative sites within and outside of the OSTR. The Navy issued a separate EA concluding that no significant impact on the environment was likely to result from the U.S.S. John Paul Jones test.

The Natural Resources Defense Council (NRDC) sought a preliminary injunction against both the implementation of the NMFS regulation and the specific Navy test authorized by NMFS. NRDC claimed that the challenged regulation and authorization letter violated the Marine Mammal Protection Act (MMPA) and NEPA. Specifically, NRDC argued that NMFS and the Navy failed to adequately consider possible alternative sites for the planned test and other weapons testing.

In granting the preliminary injunction against both the regulation and the particular test proposed by the Navy, the district court found that NMFS failed to adequately consider alternative sites in determining that a test in the planned area would cause the "least practicable adverse impact" on marine mammal species, as required by the MMPA. The MMPA establishes a general "moratorium" of the "taking and importation" of "marine mammals." The Secretary of Commerce may permit the "incidental" taking of marine mammals over a period of time not exceeding five years if the taking will have a "negligible impact" on the species affected and regulations are prescribed setting forth "the least practicable adverse impact" on the species. Under NEPA, agencies are required to consider a reasonable range of alternatives to their proposed actions. Therefore, NMFS should have considered alternatives, in addition to the "no action" alternative, in conjunction with the proposal of its regulation. With respect to the particular test to be undertaken by the Navy, NRDC had identified offshore areas with lower population densities than those present in the test area proposed by the Navy.

Because NRDC had demonstrated a "near-certain probability of success in showing a NEPA violation," and failure to issue the injunction would likely result in irreparable harm to marine species, the court granted NRDC's motion for a preliminary injunction.

NEPA Disclosure Requirements

Conservation Law Foundation, Inc. v. Dept. of Air Force, 864 F.Supp. 265 (D.N.H. 1994). Pursuant to the Base Closure and Realignment Act (BCRA), the Commission on Base Realignment and Closure decided to close the Pease Air Force Base within the boundaries of the Town of Newington and Portsmouth, New Hampshire. The United States Air Force (USAF) proposed transferring the base to a local development authority for development into an international trade hub. The USAF issued a final EIS on the Disposal and Reuse of Pease Air Force Base, which included a response to EPA concerns about the extent to which development at the closed base would effect ozone problems in southern New Hampshire. The EIS concluded that development would impair the ability of the state to achieve the proper ozone precursor reductions mandated by the 1990 Clean Air Act (CAA) amendments. Accordingly, the Pease Development Authority (PDA), EPA and the New Hampshire Department of Environmental Services entered into a Memorandum of Understanding (MOU) addressing the EPA's air quality concerns by requiring a surface transportation study, a traffic model, a master transportation plan, and a carbon monoxide analysis. The USAF incorporated the MOU into the Record of Decision (ROD), following comments on the final EIS.

The Conservation Law Foundation (CLF) filed a citizen suit pursuant to the CAA, alleging violations of NEPA and its regulations against the USAF, and violations of the CAA against the USAF and EPA. PDA was granted a motion to intervene as a defendant, and the CLF suit was consolidated with an action brought by the Town of Newington alleging violations of NEPA, CERCLA, the Federal Facilities Agreement, and the CAA. Specifically related to NEPA, the CLF claimed that the EIS failed to address: (1) the full scope of the environmental costs and benefits relative to ozone precursor emissions; (2) relevant studies on carbon monoxide; (3) the impact on neighboring Maine's ozone levels; (4) alternative air quality mitigation measures; and (5) the impact on surrounding wetlands.

With respect to the NEPA claims, the district court held that the BCRA, which contains a sixty day time limit during which challenges to base closure decisions may be made under NEPA, does not place any time limits on NEPA claims which assert challenges to actions subsequent to the base closure, rather than related to the base closure itself. Thus, the action was allowed to stand. The court found further that the USAF violated NEPA by failing to discuss conformity of its proposed action with the CAA in the final EIS, or issuing a supplemental EIS to discuss the issue. Instead, the USAF had responded improperly to the EPA concerns about air quality by entering into an MOU later incorporated into the ROD. Because NEPA requires that an EIS contain all relevant environmental information in order to allow public comment prior to a final agency decision, reliance on the MOU, which contained post-EIS air quality studies, though sufficiently in compliance with the CAA, was improper for NEPA purposes. Rather, a supplemental EIS containing the air quality information should have been prepared and subject to public comment. The court directed the USAF to prepare a supplemental EIS addressing the issues identified by CLF.

GATT and NEPA

Public Citizen v. Kantor, 864 F.Supp. 208 (D.D.C. 1994). In the third case of its type, Public Citizen sought injunctive and declaratory relief requiring the United States Trade Representative (USTR) and the Office of the United States Trade Representative (OTR) to prepare an EIS for the Uruguay Round of negotiations on the General Agreement on Tariffs and Trade (GATT). The plaintiff further sought to require adoption by the OTR of "methods and procedures" to insure future compliance with NEPA. Two prior cases in the D.C. circuit seeking to compel the USTR and OTR to prepare EISs for the Uruguay Round and the North American Free Trade Agreement (NAFTA) were resolved in favor of the government. Both resulted in a finding that the Administrative Procedures Act (APA), which is the statutory basis for citizen actions against federal defendants under NEPA, did not apply to the international agreements, because APA review requires "final agency action," which is not met where Congress provides that only the President may take final action. *Public Citizen v. United States Trade Representative*, 782 F.Supp. 139 (D.D.C.) aff'd on other grounds, 970 F.2d 916 (D.C.Cir. 1992); *Public Citizen v. United States Trade Representative*, 822 F.Supp. 21 (D.D.C.), rev'd, 5 F.3d 549 (D.C.Cir. 1993), cert. denied, 114 S.Ct. 685 (1994).[22]

The court held that in this case, as in the two before, though the agency's role is closely bound with that of the President in conducting international trade negotiation, "[u]ntil submitted the agreement remained a moving target subject to alteration by the President," and "[e]ven after submission, the legislation is not the result of 'final agency action.'" Thus, the Uruguay Round falls outside of the scope of the APA, and is not subject to judicial review on NEPA grounds. Under the same reasoning, the court refused to compel the OTR to implement procedures for conducting environmental review of trade negotiations. The court wrote that the "possibility of future harm to members of plaintiff organizations is too speculative given the 'uncertainty not only about the precise terms of any final agreements, but, more fundamentally, about whether there will ever be final agreements at all.'" Finally, the court rejected an argument by Public Citizen that the USTR and OTR should be required to prepare an EIS for the Uruguay Round under the Mandamus Act, which provides courts with the "extraordinary" remedy to "compel an officer or employee of the United States or any agency thereof to perform a duty owed to the plaintiff" where no other statutory basis for suit exists. The court felt that uncertainty about whether the Mandamus Act forms the basis of a substantive right, whether the United States waived its sovereign immunity not to be sued in passing the Act, and whether plaintiffs could establish standing, required it to reject Public Citizen's motion.

SELECTED 1995 NEPA CASE LAW

Standing

Sierra Club v. Marita, 46 F.3d 606 (7th Cir. 1995). Plaintiff environmental organizations brought a suit seeking to enjoin timber harvesting, road construction or reconstruction, and the creation of wildlife openings at the Nicolet and Chequamegon National Forests in northern Wisconsin under the forest management plans developed by the Forest Service for those areas. The plaintiff groups claimed that the Service violated NEPA, the National Forest Management Act (NFMA), and the Multiple Use-Sustained Yield Act (MUSYA), by failing to properly consider certain ecological principles of biological diversity.

Specifically, the plaintiffs argued that the Forest Service should have employed the science of conservation biology in drafting the management plans. Conservation biology is an approach which predicts that biological diversity can only be maintained if a given habitat is sufficiently large so that populations within that habitat will remain viable in the event of disturbances. Because the plans for the two forests divided up large tracts of forest into a "patchwork" of different habitats and uses, the plaintiffs argued that sustainability could not be maintained within these "patches" unless each were sufficiently large so as to extend across an entire landscape or regional ecosystem. Failure to employ conservation biology principles in assigning plots as different habitats, according to the groups, constituted a violation of the Forest Service's mandate to manage the forests for sustainability of multiple uses, taking into consideration the environmental impacts of plans, under NEPA, NFMA, and MUSYA.

The Service argued that the plaintiffs lacked standing to challenge the management plans without attacking any specific action under the plans. It further argued that, because no specific action had yet taken place under the plan, it was not ripe for judicial review. The district court held that the plaintiffs had standing to challenge the forest management plan, and that it was ripe for review. The court granted summary judgment for the Service, however, on the merits of the case, holding that because of the uncertain nature of the application of many theories of conservation biology, the Service had not erred in failing to apply it, and so had not violated NEPA, NFMA, or MUSYA.

The Court of Appeals for the Seventh Circuit upheld the findings of the district court. The court first held that forest management plans, because they "speak in mandatory terms," themselves specify and implement particular actions. The court stated that, like zoning requirements: "The plans clearly require certain projects to be undertaken and indicate what their effects may be . . . That 'the Service has yet to actually inflict the injury through the development of site-specific projects does not render the injury "conjectural" or "speculative" and therefore does not deprive plaintiffs of standing to challenge the plan.'" Applying standing requirements under NEPA, the court found that, "[o]nce the plan has passed administrative review, the procedural injury has been inflicted . . . [and] [t]o the extent that the Sierra Club suffered a procedural injury, it is directly tied to an underlying, particularized interest." Thus, the plaintiffs had met the requirements for standing established under *Lujan v. Defenders of Wildlife*, 112 S.Ct. 2130 (1992).[23] Finally, the court felt that "[w]aiting until an actual timber sale occurs under the plan will not clarify the presentation of issues; arguments over the plans' sufficiency as a whole or the procedures followed in developing the plans with regard to diversity are as concrete now as they will ever become." Following the same line of reasoning, the court held that the plans were ripe for judicial review.

The court went on to reject the Sierra Club's claims that the Service should have employed conservation biology in developing the forest management plans. The court agreed with the plaintiffs that NFMA and MUSYA require "Forest Service planners to treat the wildlife resource as a controlling, co-equal factor in forest management and, in particular, as a substantive limitation on timber production," and that under NEPA "the Service is required to 'utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences.'" However, the court concurred with the district court, holding that "conservation biology is not a necessary element of diversity analysis insofar as the regulations do not dictate that the service analyze diversity in any specific way." Further, the court believed that the methodology which the Forest Service chose to utilize was neither irrational nor arbitrary and capricious. Rather, though "NFMA's diversity provisions do substantively limit the Forest Service's ability to sacrifice diversity in [trade-offs among competing interests], and NEPA does require that decisions regarding diversity comply with certain procedural requirements," the Service in the two management plans "neither ignored nor abused those limits." Accordingly, summary judgment for the Forest Service was affirmed.

Cumulative Impacts

Oregon Natural Resources Council v. Marsh, 52 F.3d 1485 (9th Cir. 1995). In 1962, Congress authorized the Army Corps of Engineers to build three dams in southern Oregon's Rogue River Basin. The Corps completed the first two, and was one-third through the construction of the last, the Elk Creek Project, when this litigation was initiated. The Oregon Natural Resources Council (ONRC) sought to enjoin the construction of the dam, alleging in part that the Corps had violated NEPA by failing to prepare adequate documentation of the likely environmental effects in its supplemental EIS for the Elk Creek dam. In particular, the ONRC argued that the Corps had failed to consider the cumulative impacts of the dam, in conjunction with the previous two, on populations of wild coho salmon and steelhead trout which pass through those portions of the Rogue River designated as Wild and Scenic under the Wild and Scenic Rivers Act, and of which Elk Creek is a tributary.

Prior to this case, the Ninth Circuit reversed a district court decision not to grant the injunction, holding that the Corps must consider the cumulative impacts of the third dam. The Corps prepared a second supplemental EIS, which formed the basis of this case. In the second EIS, the Corps discussed the cumulative impacts on two specific water quality factors—temperature and turbidity—and their effects on fish and fisheries production. The Corps argued that the Ninth Circuit's earlier decision only mandated a discussion of those two issues, in addition to those issued raised during its scoping process. The ONRC argued, conversely, that the Corps should have considered a much broader range of cumulative impacts, including the effects on the spawning and rearing habitat of the coho salmon and steelhead trout located in Elk Creek.

The Ninth Circuit agreed with the ONRC, and held that the Corps must prepare an additional, third supplemental EIS discussing the impact of the Elk Creek Project in conjunction with the two earlier dams, "with regard not just to those factors specifically identified by us, but to all environmental factors essential to an informed agency decision." The court refused to hold that the partially constructed dam need be demolished on the basis of its decision, only that a supplemental EIS containing a complete discussion of cumulative impacts must be prepared before construction might proceed.

Circuit Judge Rymer concurred in the majority's opinion to the extent that it denied the ONRC relief in the form of removing or modifying the dam. He dissented, however, on the issue of cumulative impacts, finding that the Corps had made an adequate discussion of the impacts of the dam in conjunction with the two existing dams. Judge Rymer believed that, because the Corps failed to identify issues relevant to water quality other than turbidity and temperature in its scoping process, the detailed discussion in the second supplemental EIS of those two issues was adequate.

Significant New Circumstances

Alaska Wilderness Recreation & Tourism Ass'n v. Morrison, 67 F.3d 723 (9th Cir. 1995). After the Alaska Pulp Company (APC) closed its mill in Sitka, Alaska, the Forest Service terminated its 50-year timber sales contract, set to expire in 2011, with APC. Following cancellation of the sales contract, the Forest Service decided to offer some of the uncut timber formerly reserved for APC for sale to the Ketchikan Pulp Company (KPC), another timber company with a 50-year contract, set to expire in 2004. Additional uncut timber would be periodically offered for sale to other lumber companies. The Forest Service completed an EIS for the entire Tongass National Forest, which contains the APC timber in question, at the time it prepared its forest plan for the area. In addition, site-specific EISs were prepared for the uncut APC areas. After cancellation of the APC contract, the Forest Service prepared brief supplemental evaluations, concluding that because the forest plan "direction and need for timber and timber-related jobs had not changed," the conditions underlying the initial EISs were not significantly altered, and thus no new EISs were required under NEPA or the Alaska National Interest Lands Conservation Act (ANILCA).

A coalition of environmental groups, tourist associations, native communities and fishing interests sought to enjoin the harvest of the uncut APC timber. The groups argued that the cancellation of the contract presented the Forest Service with alternatives to the sale of the timber not available when the contract with APC was in existence. The district court denied the plaintiffs' motion, agreeing with the Forest Service that "the new circumstances created by the cancellation of the APC contract [were] not 'significant' because the contract was, in the district court's words, 'but a means to an end—supporting a timber harvest in the Forest consistent with the objectives of the [Tongass Land Management Plan].'" Thus, though NEPA requires that agencies prepare supplemental EISs whenever "significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts" arise, such was not the case here, and no new EIS need be filed.

The Ninth Circuit disagreed with the findings of the district court, first issuing an emergency temporary injunction, and then extending the injunction while the case was remanded for a determination whether the injunction should continue pending the Forest Service's compliance with NEPA and ANILCA.

In so holding, the court agreed with the plaintiffs' contention that the cancellation of the contract presented the Forest Service with the opportunity to consider a broader range of viable alternatives for the relevant areas than was available when the timber was contracted for harvesting to APC. The previous EISs "took into account other needs and uses only to the extent that they permitted contract requirements to be met." The cancellation represented "an event requiring serious and detailed evaluation by the Forest Service," and the Service's "decision not to reconsider land use alternatives in an EIS after providing public notice and conducting proceedings in keeping with the requirements of NEPA and ANILCA was not reasonable."

The court rejected arguments by the Forest Service that the Tongass Timber Reforms Act (TTRA), which amended ANILCA, required the Forest Service to make its primary mission seeking to meet market demand for timber, finding instead that TTRA gave the Forest Service enhanced flexibility in meeting market demand, while not relieving the Service of compliance with other statutory law, including NEPA and ANILCA.

Three days after the filing of the court's opinion, Congress enacted the Emergency Supplemental Appropriations for Additional Disaster Assistance for Anti-Terrorism Initiatives, which included a rider stating that EISs prepared for a timber sale "shall be deemed sufficient if the Forest Service sells the timber to an alternate buyer," and specifically referencing the areas subject to controversy in this case. The court found, however, that the rider:

> *offers no new statutory basis on which to analyze the matter at issue here: the cancellation of a preexisting timber sales contract on the EIS process. Consideration of alternatives is the 'heart' of the public decision-making process which culminates in the EIS . . . There is not the slightest indication that Congress intended . . . to vitiate the EIS process by eliminating the consideration of alternatives requirements of NEPA and ANILCA.*

Critical Habitat Designation

Douglas County v. Babbitt, 48 F.3d 1495 (9th Cir. 1995). In a case of first impression, the Ninth Circuit held that NEPA does not apply to a decision by the Secretary of the Interior to designate critical habitat for an endangered or threatened species under the Endangered Species Act (ESA).

Following litigation brought by environmental groups, *Northern Spotted Owl v. Hodel*, 716 F.Supp. 479 (W.D.Wash. 1988), the Secretary listed the Northern Spotted Owl as an threatened species under Section 4 of the ESA. The Secretary put off designating the owl's critical habitat until information had been gathered. The Secretary ultimately issued a final designation of critical habitat consisting of over six million acres of federal land. At the time of the designation, the Secretary concluded that an EIS need not be prepared, pursuant to a Department of Interior policy that determinations made under Section 4 of the ESA were not subject to NEPA.

Douglas County filed suit seeking declaratory and injunctive relief, alleging that the Secretary failed to comply with NEPA in designating a critical habitat. The Secretary in turn charged that Douglas County lacked standing to bring the action. The district court granted the county standing, and granted summary judgment on behalf of the county, finding that NEPA was applicable to the Secretary's designation of critical habitat.

The Ninth Circuit agreed with the district court that the county had standing to bring suit. Based on claims by the county that land management practices on federal land could affect adjacent county-owned land, the County had described "concrete, plausible interests, within NEPA's zone of concern for the environment, which underlie the County's asserted procedural interests."

The court went on to hold, however, that NEPA does not apply to the designation of a critical habitat. After rejecting Douglas County's assertion that absent an irreconcilable statutory conflict between

NEPA and the ESA, NEPA must be complied with, the court laid out three primary reasons underlying its holding. First, the court found that ESA procedures have displaced NEPA requirements and made "the NEPA procedure seem 'superfluous.'" Further, the mandate under the ESA that the Secretary must designate any area without which the species would become extinct conflicts with the requirements of NEPA since "in cases where extinction is at issue, the Secretary has no discretion to consider the environmental impact of his or her action." The court believed that the procedural requirements of the ESA would provide adequate safeguards against the exercise of "unchecked discretion" by the Secretary.

Second, the court found that NEPA does not require an EIS for actions that preserve, or do not alter, the natural physical environment. The court believed the designation of critical habitat prevents human interference with the environment, and NEPA only applies to human actions to effect change on the environment.

Finally, the court found that the ESA furthers the goals of NEPA in its own right, without requiring the preparation of an EIS. Relying on the Sixth Circuit's analysis in Pacific Legal Foundation, the court placed its finding on four bases: (1) the ESA's purpose would be frustrated by application of NEPA to the designation process because the ESA prevents the Secretary from considering environmental impact other than those directly related to the preservation of the species in that process; (2) similarly, NEPA would not be furthered by application to the ESA because the Secretary does not have the discretion to consider factors not listed in the ESA when making a designation; (3) the purpose of NEPA, preserving the human environment, is furthered by the ESA; and (4) the legislative histories of both acts indicate that Congress did not intend that the Secretary prepare an EIS prior to making a critical habitat designation.

Accordingly, the Ninth Circuit remanded the case for consideration of whether the injunction granted by the district court should remain in place in light of its ruling that NEPA does not apply to critical habitat designation decisions.

Significant Impacts

Friends of Fiery Gizzard v. Farmers Home Administration, 61 F.3d 501 (6th Cir. 1995). Environmental groups brought an action seeking to enjoin a proposed water impoundment and treatment project in Tennessee until the Farmers Home Administration (FHA) had prepared an EIS. The district court denied the groups' application, finding that where a project will have no significant adverse effects on the human environment, the fact that people served by the project would enjoy the benefit of an improved water supply did not mean that the agency needed to prepare a full EIS for the project.

The Sixth Circuit affirmed the district court's decision, holding that the conclusion of the EA prepared for the project, that it would have a purely beneficial impact on the environment, justified the decision by the FHA not to prepare an EIS. The FHA prepared an EA when the reservoir site was proposed, concluding that, because the only likely impacts of the project would be to enhance "the living environment of the residents of the area," there would be no significant impact on the environment requiring the preparation of an EIS. The crux of the Sixth Circuit's opinion upholding the FHA's conclusion not to prepare an EIS turned on its decision that the FHA's finding that a positive impact on the environment did not implicate the EIS requirement was correct. Where no significant adverse environmental impacts would accompany the beneficial impacts of the proposed project, "the agency was free to dispense with a full-scale [EIS]."

ENDNOTES

[21] This case should be compared to *Sierra Club v. Marita*, 46F.3d 606 (7th Cir. 1995), which granted standing to the environmental group in its challenge of the Forest Service's forest management plans for the Nicolet and Chequamegon National Forests in Wisconsin, holding that forest management plans are justiciable in a reviewing court.

[22] The first of these two cases, addressing the USTR's decision not to prepare an environmental analysis under NEPA for the Uruguay Round and NAFTA, appears at 23 *Environmental Quality* 157, (1992). The second, which appears at 24 *Environmental Quality* (1993) 362, addressed NEPA and NAFTA.

[23] See discussions of *Lujan's* standing requirements under discussion of *Sierra Club v. Robertson*, 28 F.3d 753 (8th Cir. 1994).

Environmental Impact Statements Filed
by Federal Agencies, 1994

Agency	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Agriculture	172	104	102	89	59	65	117	118	75	68	89	138	145	129	156	108
Commerce	54	53	36	25	14	24	10	8	9	3	5	8	13	12	14	11
Defense	1	1	1	1	1	0	0	0	2	0	0	0	0	1	0	4
Air Force	8	3	7	4	6	5	7	8	9	6	11	19	20	19	19	21
Army	40	9	14	3	6	5	5	2	10	8	9	9	21	14	7	13
COE	182	150	186	127	119	116	106	91	76	69	40	48	45	56	37	53
Navy	11	9	10	6	4	9	8	13	9	6	4	19	9	6	13	18
Energy	28	45	21	24	19	14	4	13	11	9	6	11	2	15	13	26
EPA	84	71	96	63	67	42	16	18	19	23	25	31	16	4	12	8
GSA	13	11	13	8	1	0	4	0	1	3	0	4	3	15	6	8
HUD	170	140	140	93	42	13	15	18	6	2	7	5	7	2	1	3
Interior	126	131	107	127	146	115	105	98	110	117	61	68	64	79	71	98
Transportation	277	189	221	183	169	147	126	110	101	96	80	100	87	129	90	125
TVA	9	6	4	0	2	1	0	1	0	0	0	3	0	3	3	1
Other	98	44	76	55	22	21	26	15	17	20	23	18	24	29	23	35
TOTAL:	1,273	966	1,033	808	677	577	549	521	455	430	370	477	456	513	465	532

1993 Environmental Impact Statements Filed with the Environmental Protection Agency by Federal Agencies

Agency	Totals by Subject Matter	Totals
Department of Agriculture		156
Natural Gas and Oil: Driling and Exploration	4	
Forestry and Range Management	104	
Comprehensive Management Plans	1	
Parks, Recreation Areas, Wilderness Areas, National Seashores	13	
Land Acquisition or Disposal, Management/ Jurisdiction Transfer	10	
Watershed Protection and Flood Control	7	
Pesticides, Hebicides Use	6	
Other Water Projects	1	
Mining	1	
Mining (Non-Energy)	5	
Railroads	1	
Road Improvements	2	
Miscellaneous Information	1	
Department of Commerce		14
Wetlands, Estuary, and Ocean Use (Sanctuary, Disposal, etc.)	3	
Fisheries	7	
Wildlife Refuges, Fish Hatcheries	4	
Department of the Air Force		19
Military Installations (Conventional, Chemical, Nuclear, etc.)	17	
Nuclear Development (e.g., Fuel, Reactors)	1	
Aircraft, Ships, and Vehicles	1	
Department of the Army		7
Military Installations (Conventional, Chemical, Nuclear, etc.)	3	
Defense Systems	2	
Buildings for Federal Use	1	
Space Programs	1	
Department of the Navy		13
Military Installations (Conventional, Chemical, Nuclear, etc.)	12	
Dredge and Fill	1	

1993 Environmental Impact Statements Filed with the Environmental Protection Agency by Federal Agencies *(continued)*

Agency	Totals by Subject Matter	Totals
Department of the Army, Corps of Engineers		37
Military Installations (Conventional, Chemical, Nuclear, etc.)	1	
Beach Erosion, Hurricane Protection, River/Lake Bank Stabilization	4	
Navigation	5	
Dredge and Fill	4	
Watershed Protection and Flood Control	8	
Other Water Projects	7	
Fisheries	1	
Multi-Purpose Impoundments	1	
Pesticides and Herbicides Disposal	1	
Road Improvements	2	
Mining (Non-Energy)	1	
Mining	1	
Municipal and Industrial Water Supply Systems (Not Multi-Purpose Impoundments)	1	
Department of Energy		13
Power Facilities: Transmission	4	
Power Facilities: Fossil	1	
Power Facilities: Hydroelectric	1	
Power Facilities: Conservation and Other	1	
Natural Gas and Oil: Transportation, Pipeline, Storage	2	
Natural Gas and Oil: Drilling and Exploration	1	
Radioactive Waste Disposal	2	
Nuclear Development (e.g., Fuel, Reactors)	1	
Environmental Protection Agency		12
Sewage Treatment and Sewage Facilities	1	
Wetlands, Estuary, and Ocean Use (Sanctuary, Disposal, etc.)	5	
Industrial Wastewater Facilities, Mining Pollution Control	1	
Emission Standards	1	
Power Facilities: Fossil	1	
Natural Gas and Oil: Drilling and Exploration	3	
General Service Administration		6
Buildings for Federal Use	4	
Road Improvements	2	

1993 Environmental Impact Statements Filed with the Environmental Protection Agency by Federal Agencies *(continued)*

Agency	Totals by Subject Matter	Totals
Department of Housing and Urban Development		1
Buildings, Federally Licensed or Assisted (Including Production Facilities)	1	
Department of Health and Human Services		2
Buildings for Federal Use	2	
Department of the Interior		71
Buildings, Federally Licensed or Assisted (Including Production Facilities)	3	
Natural Gas and Oil: Drilling and Exploration	6	
Natural Gas and Oil: Transportation, Pipeline, Storage	1	
Municipal and Industrial Water Supply System (Not Multi–Purpose Impoundments)	3	
Multi–Purpose Impoundments	1	
Navigation	2	
Land Acquisition or Disposal, Management Jurisdiction Transfer	3	
Parks, Recreation Areas, Wilderness Areas, National Seashores	19	
Forestry and Range Management	13	
Mining (Non–Energy)	7	
Comprehensive Resource Management	2	
Other Water Projects	1	
Wildlife Refuges, Fish Hatcheries	5	
Nuclear Development (e.g., Fuel, Reactors)	1	
Power Facilities: Transmission	1	
Wetlands, Estuary, and Ocean Use (Sanctuary, Disposal, etc.)	1	
Miscellaneous Information	1	
Hazardous and Toxic Substance Disposal	1	
Nuclear Regulatory Commission		3
Power Facilities: Nuclear	1	
Radioactive Waste Disposal	1	
Tennessee Valley Authority		3
Pesticides, Herbicides Use	1	
Miscellaneous Information	1	
Comprehensive Resource Management	1	

1993 Environmental Impact Statements Filed with the
Environmental Protection Agency by Federal Agencies *(continued)*

Agency	Totals by Subject Matter	Totals
Department of Transportation		90
Road Construction	76	
Airport Improvements	6	
Bridge Permits	2	
Mass Transportation	5	
Railroads	1	
Federal Energy Regulatory Commission		9
Natural Gas and Oil: Transportation, Pipeline, Storage	3	
Power Facilities: Hydroelectric	5	
Power Facilities: Natural Gas	1	
Department of Justice		6
Buildings for Federal Use	6	
Department of Veterans Affairs		3
Cemetery Development	3	
Total Federal EISs		465

Source: U.S. Environmental Protection Agency, Office of Federal Activities, unpublished data, Washington, DC, 1994.

1994 Environmental Impact Statements Filed with the Environmental Protection Agency by Federal Agencies

Agency	Totals by Subject Matter	Totals
Department of Agriculture		108
Natural Gas and Oil: Driling and Exploration	2	
Forestry and Range Management	67	
Wildlife Refuges, Fish Hatcheries	1	
Parks, Recreation Areas, Wilderness Areas, National Seashores	9	
Land Acquisition or Disposal, Management/ Jurisdiction Transfer	4	
Watershed Protection and Flood Control	4	
Pesticides, Hebicides Use	5	
Other Water Projects	1	
Mining	1	
Mining (Non-Energy)	4	
Comprehensive Resource Management	1	
Housing Subdivisions/New Communities	1	
Buildings for Federal Use	2	
Road Inprovements	1	
Miscellaneous Information	5	
Department of Commerce		11
Wetlands, Estuary, and Ocean Use (Sanctuary, Disposal, etc.)	3	
Fisheries	5	
Wildlife Refuges, Fish Hatcheries	3	
Department of the Air Force		21
Military Installations (Conventional, Chemical, Nuclear, etc.)	21	
Department of the Army		13
Military Installations (Conventional, Chemical, Nuclear, etc.)	11	
Defense Systems	2	
Buildings for Federal Use	1	
Department of Defense		4
Military Installations (Conventional, Chemical, Nuclear, etc.)	3	
Defense Systems	1	
Department of the Navy		18
Military Installations (Conventional, Chemical, Nuclear, etc.)	18	

1994 Environmental Impact Statements Filed with the Environmental Protection Agency by Federal Agencies *(continued)*

Agency	Totals by Subject Matter	Totals
Department of the Army, Corps of Engineers		53
Military Installations (Conventional, Chemical, Nuclear, etc.)	2	
Beach Erosion, Hurricane Protection, River/Lake Bank Stabilization	2	
Navigation	14	
Dredge and Fill	5	
Watershed Protection and Flood Control	10	
Other Water Projects	12	
Multi-Purpose Impoundments	2	
Road Improvements	2	
Mining	1	
Municipal and Industrial Water Supply Systems (Not Multi-Purpose Impoundments)	3	
Department of Energy		26
Power Facilities: Transmission	3	
Power Facilities: Fossil	9	
Power Facilities: Conservation and Other	6	
Natural Gas and Oil: Transportation, Pipeline, Storage	2	
Hazardous/Toxic Substance Disposal	1	
Radioactive Waste Disposal	2	
Nuclear Development (e.g., Fuel, Reactors)	1	
Other Water Supply Projects	2	
Environmental Protection Agency		8
Sewage Treatment and Sewage Facilities	2	
Wetlands, Estuary, and Ocean Use (Sanctuary, Disposal, etc.)	1	
Nuclear Development (e.g., Fuel, Reactors)	1	
Power Facilities: Transmission	2	
Natural Gas and Oil: Drilling and Exploration	1	
Mining	1	
General Service Administration		8
Buildings for Federal Use	5	
Road Improvements	3	

1994 Environmental Impact Statements Filed with the Environmental Protection Agency by Federal Agencies *(continued)*

Agency	Totals by Subject Matter	Totals
Department of Housing and Urban Development		3
Buildings, Federally Licensed or Assisted (Including Production Facilities)	3	
Department of Health and Human Services		0
Department of the Interior		98
Buildings, Federally Licensed or Assisted (Including Production Facilities)	2	
Natural Gas and Oil: Drilling and Exploration	5	
Land Acquisition or Disposal, Management Jurisdiction Transfer	16	
Parks, Recreation Areas, Wilderness Areas, National Seashores	21	
Forestry and Range Management	19	
Mining (Non–Energy)	15	
Comprehensive Resource Management	2	
Other Water Projects	10	
Wildlife Refuges, Fish Hatcheries	7	
Miscellaneous Information	1	
Nuclear Regulatory Commission		4
Power Facilities: Nuclear	2	
Power Facilities: Conservation and Other	1	
Mining	1	
Tennessee Valley Authority		1
Comprehensive Resource Management	1	
Department of Transportation		125
Road Construction	102	
Airport Improvements	12	
Bridge Permits	7	
Mass Transportation	3	
Railroads	1	
Federal Energy Regulatory Commission		15
Power Facilities: Hydroelectric	14	
Power Facilities: Natural Gas	1	

1994 Environmental Impact Statements Filed with the Environmental Protection Agency by Federal Agencies *(continued)*

Agency	Totals by Subject Matter	Totals
Department of Justice		9
Buildings for Federal Use	9	
Department of Veterans Affairs		2
Cemetery Development	1	
Building for Federal Use	1	
Interstate Commerce Commission		3
Railroads	3	
Federal Emergency Management Agency		1
Building for Federal Use	1	
National Aeronautics and Space Administration		1
Space Programs	1	
Total Federal EISs		532

Source: U.S. Environmental Protection Agency, Office of Federal Activities, unpublished data, Washington, DC, 1995.

NEPA Cases by Agency for 1993

Agencies	Number of cases filed	Number resulting in injunctions	Number of injunctions from pre–1993 cases
Environmental Protection Agency	0	0	0
International Boundary and Water Commission	0	0	0
Health and Human Services	0	0	0
Federal Deposit Insurance Company	1	1	0
United States Postal Service	0	0	0
Department of Energy	1	0	1
Department of the Air Force	1	0	0
TVA	0	0	0
Interstate Commerce Commission	7	0	0
Nuclear Regulatory Commission	2	0	0
Department of the Interior	21	1	1
Department of Agriculture	23	3	0
Department of Commerce	5	1	0
Department of the Army	13	0	0
Department of the Navy	0	0	1
Department of Transportation	15	2	1
TOTAL	89	8	4

Causes of Action Filed Under NEPA in 1993

Causes of Action	1993	Pre-1993 where injunction issued in 1993-1994
Inadequate Environmental Impact Statement	23	0
No Environmental Impact Statement	38	3
Inadequate Environmental Assessment	19	1
No Environmental Assessment	16	0
No Supplemental Environmental Impact Statement	4	0
Other	13	0
TOTAL	113	4

Plaintiffs for NEPA Lawsuits in 1993

Causes of Action	1993	Pre-1993 where injunction issued in 1993-1994
Environmental Groups	40	1
Individuals for Citizen Group	38	1
State Governments	7	2
Local Governments	10	0
Business Groups	11	1
Property Owners or Residents	12	1
Indian Tribes	3	0
Other	0	0
TOTAL	121	6

NEPA Cases by Agency for 1994

Agencies	Number of cases filed	Number resulting in injunctions
Environmental Protection Agency	4	0
International Boundary and Water Commission	1	0
Health and Human Services	1	0
Federal Deposit Insurance Company	0	0
United States Postal Service	1	0
Department of Energy	3	2
Department of the Air Force	1	0
TVA	1	0
Interstate Commerce Commission	3	0
Nuclear Regulatory Commission	1	0
Department of the Interior	13	1
Department of Agriculture	33	5
Department of Commerce	6	1
Department of the Army	23	2
Department of the Navy	2	1
Department of Transportation	13	1
TOTAL	106	13

Causes of Action Filed Under NEPA in 1994

Causes of Action	1994
Inadequate Environmental Impact Statement	40
No Environmental Impact Statement	31
Inadequate Environmental Assessment	28
No Environmental Assessment	13
No Supplemental Environmental Impact Statement	7
Other	10
TOTAL	129

Plaintiffs for NEPA Lawsuits in 1994

Causes of Action	1994
Environmental Groups	56
Individuals for Citizen Group	26
State Governments	2
Local Governments	10
Business Groups	15
Property Owners or Residents	13
Indian Tribes	1
Other	0
TOTAL	123

Agencies Reporting No NEPA Litigation for 1993 and 1994

Department of Education
Department of Labor
Department of Veterans Affairs
American Battle Monuments Commission
Agency for International Development
Central Intelligence Agency
Committee for Purchase from People who are Blind or Severly Disabled
Export-Import Bank of the United States
Farm Credit Administration
Federal Election Commission
Federal Emergency Management Agency
Federal Energy Regulatory Commission
Federal Maritime Commission
Federal Labor Relations Authority
Federal Mine Safety and Health Review Commission
Federal Trade Commission
National Aeronautics and Space Administration (NASA)
Naional Labor Relations Board
National Science Foundation
Overseas Private Investment Corporation
Peace Corps
Pennsylvania Avenue Development Corporation
Small Business Administration
The Appalachian Regional Commission
United States Consumer Product Safety Commission
United States Department of Education
United States Information Agency
United States International Trade Commission
United States Merit System Protection Board

"The needs and aspirations of future generations make it our duty to build a sound and operable foundation of national objectives for the management of our resources for our children and their children. The future of succeeding generations in this country is in our hands. It will be shaped by the choices we make. We will not, and they cannot escape the consequences of our choices."

The Honorable Henry M. Jackson

On Passage of the National Environmental Protection Act, 1969

"[W]e can now move forward to preserve and enhance our air, aquatic, and terrestrial environments . . . to carry out the policies and goals set forth in the bill to provide each citizen of this great country a healthful environment."

The Honorable John D. Dingell

On Passage of the National Environmental Protection Act, 1969

"Maintaining and enhancing our environment, passing on a clean world to future generations, is a sacred obligation of citizenship. We all have an interest in clean air, pure tap water, safe food and protected national treasures. Our environment is, quite literally, our common ground."

President Bill Clinton