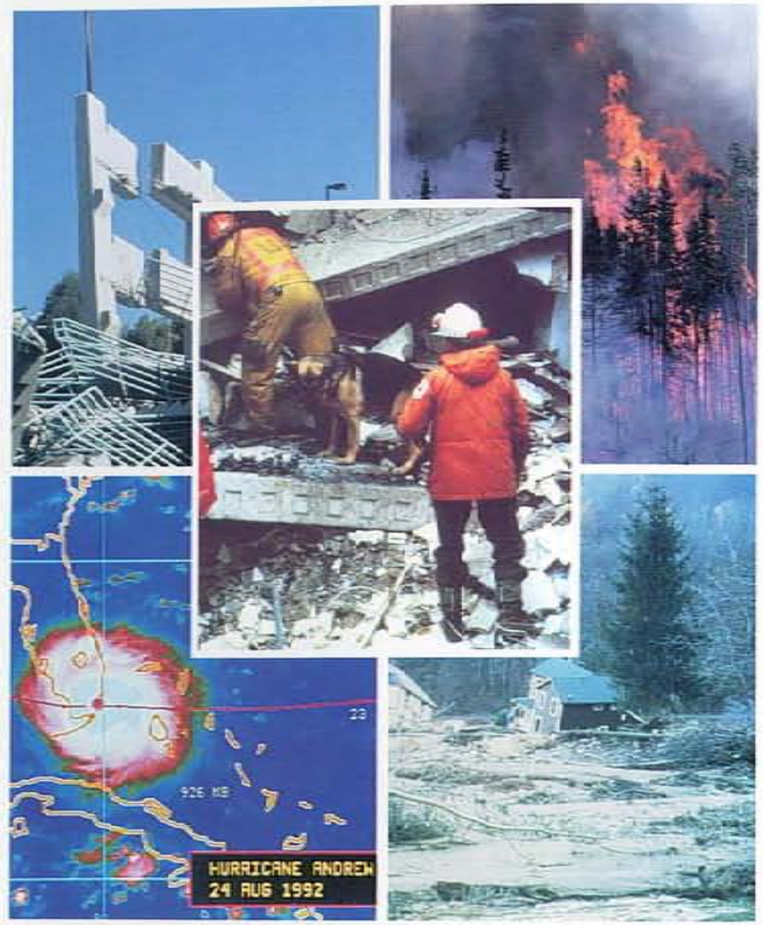
NATURAL DISASTER REDUCTION
A PLAN FOR THE NATION



National Science and Technology Council
Committee on the Environment and Natural Resources
Subcommittee on Natural Disaster Reduction

December 1996

The purpose of this report is to highlight ongoing Federal research efforts in this science and technology (S&T) field and to identify new and promising areas where there might be gaps in Federal support. The report is intended for internal planning purposes within the Federal agencies and as a mechanism to convey to the S&T community the types of research and research priorities being sponsored and considered by the Federal agencies. The Administration is committed to a broad range of high-priority investments (including science and technology), as well as to deficit reduction, and to a smaller, more efficient Federal Government. These commitments have created a very challenging budget environment—requiring difficult decisions and a well-thought-out strategy to ensure the best return for the Nation's taxpayers. As part of this strategy, this document does not represent the final determinant in an overall Administration budget decisionmaking process. The research programs presented in this report will have to compete for resources against many other high-priority Federal programs. If these programs compete successfully, they will be reflected in future Administration budgets.

About the National Science and Technology Council

President Clinton established the National Science and Technology Council (NSTC) by Executive Order on November 23, 1993. This Cabinet-level council is the principal means for the President to coordinate science, space, and technology policies across the Federal Government. The NSTC acts as a "virtual" agency for science and technology to coordinate the diverse parts of the Federal research and development enterprise. The NSTC is chaired by the President. Membership consists of the Vice President, the Assistant to the President for Science and Technology, Cabinet Secretaries and Agency Heads with significant science and technology responsibilities, and other top White House officials.

An important objective of the NSTC is the establishment of clear national goals for Federal science and technology investments in areas ranging from information technologies and health research to improving transportation systems and strengthening fundamental research. The Council prepares research and development strategies that are coordinated across Federal agencies to form an investment package that is aimed at accomplishing multiple national goals.

To obtain additional information regarding the NSTC, please contact the NSTC Secretariat at 202-456-6100.

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Policy, Organization, and Priorities Act of 1976. OSTP's responsibilities include advising the President on policy formulation and budget development on all questions in which science and technology are important elements; articulating the President's science and technology policies and programs; and fostering strong partnerships among Federal, State, and local governments, and the scientific communities in industry and academia.

To obtain additional information regarding OSTP, please contact the OSTP Administrative Office at 202-395-7347.

THE WHITE HOUSE

WASHINGTON

December 10, 1996

Dear Colleague:

Natural disasters cause fatalities and inflict human suffering. In addition, they destroy property, diminish economic productivity, negatively impact the environment, and cause lingering disruptions of entire communities. Between August 1992 and December 1995, the United States experienced structural losses amounting, on average, to approximately one billion dollars a week due to natural disasters. Such expenditures, which divert assets from much needed investment in our country's future, can and should be reduced.

Reducing losses from natural disasters is one of the Administration's top priorities for science and technology. Natural disasters jeopardize sustainable development. Inaction today regarding natural hazards compromises safety, economic growth, and environmental quality for generations to come. However, forward-looking decision making today regarding land use, the direction and nature of economic development, and needed investment in societal infrastructure and capital facilities can improve the prospects and opportunities afforded to future generations.

I am pleased to introduce the NSTC's *Natural Disaster Reduction: A Plan for the Nation*, which provides an interagency approach for the strategic coordination and advancement of programs, strategies, and research to reduce the social, environmental, and economic costs of natural hazards. This document focuses on creating a sustainable society resilient to natural hazards through the establishment of anticipatory practices with regard to risk assessment, mitigation, and warning systems. *Natural Disaster Reduction: A Plan for the Nation* lays the groundwork for a comprehensive set of Federal R&D policies to address this critical issue.

Sincerely,

John H. Gibbons
Assistant to the President
for
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NATURAL DISASTER REDUCTION

A Plan for the Nation

EXECUTIVE SUMMARY

During the period August 1992–December 1995, the United States experienced structural losses amounting, on average, to about $1 billion a week on natural disasters.[1] Such expenditures can, and should, be reduced. The United States must create a sustainable society, resilient to natural hazards.

Natural hazards of terrestrial origin (earthquakes, volcanic eruptions, landslides, tsunamis, hurricanes and other severe storms, tornadoes and high winds, floods, wildfires, and drought) and solar-terrestrial hazards (solar flares and geomagnetic storms) are inevitable.

By contrast, natural disasters—the lingering disruption of entire communities, persisting long after the causative event itself and exceeding the communities' ability to recover unaided—are determined as much or more by societal behavior and practice as by nature per se. The impacts of natural hazards can, at a minimum, be mitigated or, in some instances, prevented entirely.

Natural disasters kill and inflict human suffering. In addition, they destroy property, economic productivity, and natural resources, and they harm the environment. Assets are diverted from much-needed investments in our future—

Natural disasters can, at a minimum, be mitigated or, in some instances, prevented entirely

research, education, and the eradication of crime, disease, and poverty. Recent population growth, urbanization, worldwide

[1]Between August 1992 and December 1995, major losses resulted from: Hurricane Andrew, $25 B; Hurricane Iniki, $12 B; March 1994 blizzard, $6 B; 1993 Midwest floods, $30 B; Northridge earthquake, $30 B; 1993-1994 winter storms, 1994 spring floods, and summer wildfires, $25 B; 1995 spring floods, $7 B; 1995 hurricanes, more than $6 B. In addition to these major losses, numerous other storms and flooding events resulted in losses exceeding $1 B each. These estimates cover structural losses only; economists estimate that direct business losses are comparable in magnitude.

social change, and technological advances are exposing new vulnerabilities to natural hazards; the costs of natural disasters are escalating at an alarming rate.

Natural disasters jeopardize sustainable development. Inaction today regarding natural hazards compromises safety, economic growth, and environmental quality for generations to come. Furthermore, the burden of natural disasters falls disproportionately on the poor and disenfranchised. However, forward-looking decisionmaking today regarding land use, the direction and nature of economic development, and needed investment in societal infrastructure and capital facilities can improve the prospects and opportunities afforded to future generations.

The impact of natural hazards mirrors many of the challenges of global change: in microcosm and on an accelerated time scale. Because natural hazards occur frequently, they could allow testing and rapid evaluation of policy options in a wide range of geographical and cultural contexts. However, in most instances today, such analyses are not conducted. Accordingly, although effective natural disaster reduction could also improve U.S. adaptation with respect to global change, this opportunity is largely being missed. In a similar way, natural disaster reduction research and activities directly address Federal research priorities in ecosystem management.

Natural disaster reduction poses two international challenges for the United States. First, because the United States has a global reach, it has a global vulnerability. For example, the Mount Pinatubo volcanic eruption, which occurred half a world away, forced the closure of Clark Air Force Base and thus changed U.S. strategic posture in the western Pacific for the foreseeable future. Second, natural disasters worldwide are an increasingly potent trigger of geopolitical instability. For reasons stemming from both self-interest and humanitarianism, the United States should exercise leadership in reducing natural disasters worldwide. After two centuries of research and development on natural hazards, the United States leads the world in developing and implementing technologies for both monitoring natural hazards and reducing natural disasters. For example, we have weather surveillance technologies and wind and seismic engineering that are unsurpassed. This investment creates an extraordinary foreign policy opportunity for the United States with respect to both foreign assistance and trade promotion.

Business-as-usual approaches to natural disaster reduction have focused on saving lives and disaster recovery. The limited attention paid to mitigation encouraged societal **resistance** to natural hazards—

We can help create a sustainable society, resilient to natural disasters

e.g., building levees that would withstand the lesser flooding events but fail during major floods; putting out smaller forest fires but allowing the buildup of forest fuels over time and thus setting the stage for the massive forest fires of recent years. As a result, we now have the same number of natural disasters, but those that do occur are often of greater magnitude. The Nation's Strategy for Natural Disaster Reduction focuses on the transition

from policies aimed at resistance to natural hazards to policies that build resilience to natural hazards.

To meet the challenges ahead, our Nation must make three major policy shifts: (1) anticipate and assess risk, not simply react to disasters; (2) focus on mitigation that builds resilience at the earliest planning stages, not as an afterthought, and deal with mitigation comprehensively rather than piecemeal; and (3) implement warning and dissemination systems that allow society to bring its resilience into play. By expanding our goal beyond saving lives to ensuring the continued, uninterrupted functionality and viability of communities, regions, and their associated managed and natural ecosystems, we can help create a sustainable society, resilient to natural disasters.

Research is needed to drive this transition, especially with respect to (1) the physical and biological structure and character of the hazards themselves; (2) improved *risk assessments* to guide natural disaster reduction; (3) holistic, systems-level understanding of the socioeconomic factors driving societal vulnerability and the full range of engineering and other strategies available to improve *mitigation* and adaptation; and (4) improved use of new information technologies to disseminate *warnings* and provide integrated, ready access to information on natural disaster reduction. This research will improve the links between the physical, biological, and social and economic sciences and environmental policy and will aid in the development of science policy tools.

Future directions for natural disaster reduction, in addition to individual agency plans relating to specific responsibilities, build on the National Mitigation Strategy, developed in concert with over two dozen Federal agencies under the leadership of the Federal Emergency Management Agency (FEMA), and on a multibillion-dollar modernization and associated restructuring of the National Weather Service (Department of Commerce/National Oceanographic and Atmospheric Administration) in coordination with parallel efforts at the Department of Defense and Department of Transportation (not under National Science and Technology Council auspices). Key elements include:

- Development of a National Risk Assessment to report periodically on the Nation's exposure to natural hazards and trends or changes in that exposure and to guide priorities in natural disaster reduction efforts.
- Development of an Integrated Natural Disaster Mitigation Information Network to provide the tools needed by Federal agencies, State and local governments, the private sector, and the general public as they identify necessary steps and take the actions dictated by the National Mitigation Strategy. The network will also facilitate much-needed augmentation of education and training.
- Augmentation of comprehensive, hazard-specific programs, including the National Earthquake Hazards Reduction Program, the National Space Weather Program, and the U.S. Weather Research Program.

STRATEGIC PLAN

Goal / Opportunity

Create a Sustainable Society, Resilient to Natural Hazards

Sustainable development—which meets the needs of the present without compromising the ability of future generations to meet their own needs—is generally understood to require (1) economic growth, (2) protection of the environment, and (3) sustainable use of ecological systems. There is, however, a fourth criterion of equal importance: Sustainable development must be resilient with respect to the natural variability of the Earth and the solar system.

Sustainable development must be resilient with respect to the natural variability of the Earth and the solar system

This variability can be extreme. Violent events—earthquakes, volcanic eruptions, landslides, subsidence, tsunamis, hurricanes and other severe storms, tornadoes and high winds, floods, wildfires, drought, geomagnetic storms, meteoritic and cometary impacts—brutally interrupt the affairs of society and ecosystems alike. These events have not merely punctuated Earth's history so much as they have defined it. Although some natural events such as wildland fires and floods are important for maintaining the viability and health of the landscape, certain ones can have adverse effects on society. Our success in coping with these events in the future will determine our destiny.

Natural hazards—that is, the extreme geophysical phenomena themselves—are inevitable. In principle and (in most cases) in practice, they can be predicted, although sometimes only a few hours or days in advance. The threat that they pose can be assessed, albeit with some uncertainty, decades or centuries in advance.

All too often, however, natural hazards lead to natural disasters—lingering disruptions of entire communities, persisting long after the causative event itself and exceeding the communities' abilities to recover unaided. Such natural disasters are determined as much or more by societal behavior and practice as they are by nature alone. They reveal that our economic development is unacceptably brittle and fragile, altogether too vulnerable to the normal workings of nature. The effects of natural disasters can, and should, be reduced.

Cost-effective, affordable opportunities for natural disaster reduction abound. Disaster reduction begins with risk assessment and care to stay out of harm's way. Proper land use and management, especially in coastal and riverine environments, near fault zones, and in other geologically active sites, can result from good *risk assessments*. They can also lead to mitigation of disastrous consequences. Further opportunities for disaster reduction are afforded by good *mitigation practices*—adequate building codes and proper enforcement of these codes; careful attention to ensure the resilience of societal lifelines such as transportation systems, gas, water, and electrical power delivery, and communications; and appropriate agriculture and silviculture. Proper societal frameworks and policies, with respect to public awareness, cultural values, and financial and insurance institutional structure and behavior, are also essential components of any mitigation strategy.

Once the risk becomes reality—from the event onset, throughout its duration, and in the immediate aftermath—the highest priorities for saving lives and reducing injury are an adequate *warning system* and well-rehearsed, effective emergency response procedures. Some hazards, notably drought, flooding, and wildfires, offer opportunities for active intervention. Much can also be done during short- and long-term disaster recovery to mitigate the impacts.

These three elements—*risk assessment* as the necessary starting point, to identify the resiliency needed; an overarching *mitigation* strategy to build societal resilience to hazards; and *warning and information dissemination* to bring that resiliency into play immediately before and during the hazardous event itself—are the cornerstones of natural disaster reduction.

U.S. Stakes Are High and Climbing

Today, the rising toll of insured losses, government expenditures and other indicators provide mounting evidence that the United States lacks resilience in the face of natural hazards. Risk assessments, mitigation strategies, and warning capabilities of the past and present are inadequate to meet future requirements. Although fatalities have decreased in recent years, despite population growth, there are worrisome signs that this decrease reflects recent good fortune more than foresight. Meanwhile, the rise in property and economic losses has been meteoric. In a 1-year period, Hurricanes Andrew and Iniki, the March 1993 "storm of the century," and the Midwest floods cost the country over $50 billion. A few months later, the Northridge earthquake added another $30 billion to the price tag. NOAA's National Climate Data Center estimates that 15 major weather-related disasters alone resulted in direct and indirect losses of $70 billion between August 1992 and January 1996.

Future prospects are sobering. Continued U.S. population growth, increased urbanization and concentration in hazard-prone coastal areas, increased capital and physical plant, accelerated deterioration of the urban infrastructure, and emerging but unknown new vulnerabilities posed by technological advance virtually guarantee that economic losses from natural hazards will continue to rise throughout the early part of the coming century. Losses of $100 billion from individual events, and perhaps unprecedented loss of life, loom in our future.

Natural Disaster Reduction is a Sustainable Development Issue

Sheer size and geography expose the United States to a broad range of hazards, so that natural disaster reduction and sus-

tainable development are necessarily woven together. Physical plants and facilities must be designed to survive the natural hazards that they can expect to experience throughout their lifetimes. New technologies must be examined with an eye to the new vulnerabilities that they may create with respect to natural hazards. For example, current dependence on computers and high-speed telecommunications means that, even if electrical power is protected during a storm or earthquake, the loss of business activity could be substantial if computers are destroyed and communications disrupted.

Natural disaster reduction is also a matter of environmental justice. The burden of natural disasters falls disproportionately on the disenfranchised—the poor, ethnic minorities, the aged, and those with disabilities. Worldwide, loss of life from floods, earthquakes and storms is far higher among the less developed nations than it is in developed nations. Within each nation, the poor are most greatly affected, even in developed nations. Two thirds of the casualties after the Kobe earthquake in Japan were the elderly. In the United States, the greatest danger from tornadoes lies in mobile home parks. In the 1995 heat wave, most of the fatalities were among the elderly. Furthermore, natural disaster reduction is intergenerational. The disasters we suffer today are, to a large extent, inevitable consequences of decisions made by our forefathers. By contrast, forward-looking decisionmaking today regarding land use, the direction and nature of economic development, and needed investment in societal infrastructure and capital facilities improves the prospects and opportunities afforded to future generations. Unfortunately, these forward-looking practices are rarely proportionately distributed across economic, ethnic, and societal groups. In addition, housing for the poor and disenfranchised is often located in marginal areas (such as along flood plains or on hillsides) and is rarely retrofitted with modern mitigation technologies.

Natural disaster reduction and sustainable development are necessarily woven together

Natural hazards impact and shape the environment and biodiversity. The Midwest drought of 1988 and the floods of 1993 both had impacts not only on local riverine ecosystems but also downstream on Gulf of Mexico coastal ecologies, through changes in salinity, as well as transport of toxins and other pollutants washed out by the floods. The floods also accelerated the spread of the Zebra mussel in the Mississippi watershed. In many respects, the Mississippi River flooding of 1993 was exacerbated by failure to take into account the role of riverine ecologies in mitigating flooding and by years of engineering practices that neutralized much natural protection.

Hurricane Andrew had a strong effect not only on the city of Homestead, Fla., but also on the entire ecosystem of the Everglades and nearby coastal waters. Timber losses during the winter ice storms of 1993-94 cost casualty insurers more than their total payout in the aftermath of Hurricane Andrew. The 1994 forest fires cost several lives, destroyed millions of acres of habitat, and threatened many communities. Current strategies for protecting renewable natural resources and biodiversity in the United States must therefore take into account the impact of natural hazards.

In keeping with its commitment to natural disaster reduction, the United States should build optimal decisionmaking into weather- and climate-sensitive sectors of the economy such as agriculture, construction, energy production and use, transportation, and water-resources management. In most cases, decisionmaking will need to be based on pinpoint, timely forecasts rather than on simple observation of prevailing conditions.

Fundamental New Approaches Are Required

Sustainable development requires a reworking of the U.S. posture toward natural disaster reduction. In general:

- Attention must shift from the current emphasis on reaction to natural disasters to greater anticipation of natural hazards, on the basis of long-range risk assessment and accurate, timely, deterministic prediction.
- Hazard-by-hazard, site-by-site approaches must give way to comprehensive, coordinated, communitywide planning and action.
- After-the-fact retrofits must give way to societal planning and ways of doing business that build in resilience to natural hazards from the beginning and from the ground up.

More specifically:

- Broadcast warnings must be replaced by fail-safe two-way communications to ensure that warnings reach those in harm's way.
- Special attention must be given to the needs of the disenfranchised, because the burden of natural disasters often falls primarily on the poor.
- Reliance on Federal bailouts must give way to increased individual responsibility for insuring against unacceptable risk.
- Federal, State, and local governments, as well as the private sector and the general public, must act in partnership.
- The United States must show leadership internationally and focus on a multi-hazard approach.

Policy Questions and Issues

The broad outline of a U.S. strategy for reducing losses from natural disasters is clear—improved risk assessment, better mitigation practice, and enhanced warning. Within that envelope, however, important policy questions remain.

What are the expected impacts of natural hazards on the United States in future years under prevailing policies?

Who should bear these costs? What is the Federal share? How should these costs be built into the Federal budget? Can the U.S. insurance industry remain economically viable following a future major earthquake or hurricane? If not, what form of reinsertion is needed?

To what extent can these costs be reduced by changes in policy (e.g., land use and

management, building codes, engineering design and practice, and financial and insurance institutional frameworks)? Just where are the favorable cost-benefit boundaries in specific mitigation actions and policies?

Precisely how are urbanization, rapid societal change, and technological advance increasing or decreasing our vulnerability to natural hazards? What technological opportunities are there for natural disaster reduction?

How will climate change affect the frequency, intensity, and (or) geographic track of natural hazards such as hurricanes and other storms, flooding, drought, and wildfires?

By improving U.S. resilience with respect to the environmental extremes represented by natural hazards, could the United States address the bulk of its vulnerabilities to global change?

What is the threat of natural hazards to the production of food and fiber? To biomass and biodiversity? To societal infrastructure? What are the options for reducing these impacts?

Given the threat of natural hazards worldwide, what are the U.S. opportunities and responsibilities with regard to foreign policy and foreign aid? By helping other nations cope with natural hazards, how can the United States (1) foster its international trade, especially technology export, and (2) reduce global tensions?

Currently, the answers to these questions remain vague. The effect of this uncertainty is to inhibit effective policy formulation. To guide the United States in this task of natural hazards reduction, continued research and development is needed.

Scientific Goal

To develop the predictive understanding, technological capabilities, and societal frameworks necessary for a sustainable society resilient to natural hazards.

This cross-cutting scientific goal addresses areas in which research and development are necessary for improvements in the three objective areas of assessment, mitigation, and warning and dissemination.

Subgoal: *To improve understanding of the physical and biological nature of natural hazards*

- Determining climate, weather, and hazard linkages, with special attention to the linkages between weather events and floods and between weather events and storm surges and waves.
- Understanding how crustal stress accumulates and is released suddenly to generate earthquakes; how release of dissolved gases from magma controls the timing, explosivity, and magnitude of most volcanic eruptions; which factors are responsible for the timing and location of landslides and liquefaction; and how tsunamis are generated by submarine fault movements, volcanic explosions, and landslides.

- Examining the fundamental relationships between ecosystem dynamics and natural hazards such as drought, wildfires, and pestilence, including learning what ecosystem changes precede and contribute to natural hazards and how these changes, in turn, affect the structure and function of ecosystems and hence the probability of subsequent events.
- Researching the underlying processes by which observable structures on the Sun generate disturbances in the interplanetary medium, the interaction of those disturbances with the Earth's environment, and the effects of the resulting disruptions on communications, navigation, transportation, security, and power and distribution systems.

Subgoal: *To better understand the impact of natural hazards on human health, ecological systems, and socioeconomic framework (and the possibilities of improving the resilience of these systems to natural variability, especially extreme events)*

- Studying human behavior, health, and communication in the context of natural hazards, including developing highly diagnostic tools for social assessments; identifying and developing a variety of incentives for safe behavior; acquiring knowledge of how individuals and groups react to emergencies; clearly understanding information on health impacts, including increased knowledge about the epidemiology of natural disasters, and methods for estimating casualties; and developing effective techniques for designing and delivering disaster reduction programs, including identification of effective strategies for preventing disaster-related injuries.
- Building the resilience of managed environmental systems in the face of natural hazards to reduce damages to plants and livestock; agricultural and forest management techniques to minimize vulnerability to disease, pests, and fire; soil management; and improved biological controls.
- Determining institutional opportunities and constraints and the role of government, financial institutions, industry, and public and private partnerships.
- Developing accurate economic analyses of disasters; tools for evaluating the costs and benefits of disaster reduction measures and estimating the costs of rehabilitation; and making effective decisions in the face of natural hazards.

Subgoal: *To expand the base of new environmental technologies (i.e., engineering and technological capabilities for natural disaster reduction)*

- Understanding how structures and lifelines and their systems respond to natural hazards and how existing structures and lifelines might be modified for more resilience in the face of natural hazards; improving engineering design with respect to natural hazards; developing advanced tools for hazard-averting engineering; improving the engineering of architectural and mechanical subsystems in struc-

tures; and developing engineering systems for monitoring, testing, communications, search and rescue, and event suppression.

Subgoal: *To improve data management*

- Providing timely dissemination and convenient online access to real-time hazards observations and warnings as well as complete metadata and retrospective information on all aspects of natural disaster reduction; making expert systems available to help with application of the information.

Subgoal: *To substantially improve assessments of risk (with respect to geographical and temporal specificity of risks likely from individual hazards and to cumulative risk associated with multiple hazards, end-to-end impacts, and cost-benefit analyses of disaster reduction measures)*

- Improving the Nation's capacity to perform systems-level risk assessments to provide (1) reliable and valid estimates of the expected losses from natural hazard events (structures, buildings, building contents, life loss and injury), (2) an assessment of the consequences of those losses (social, economic, political, environmental, and legal), and (3) a means for assessing the costs, benefits, effectiveness, and priorities of alternative risk mitigation policies and strategies.

- Developing regional hazard, vulnerability, exposure, and socioeconomic databases for performing quantitative risk assessments and for monitoring and validating risk simulations.

- Developing enhanced dynamic simulation models to assess high-consequence risks resulting from catastrophic changes that are extremely difficult to predict in nature.

Current State of Understanding

Scientific Basis for Ecosystem Management

Characterization of basic physical and biological hazards varies a great deal from hazard to hazard and between geographic locations. Generally, however, we lack the understanding needed for making timely predictions that are specific enough to allow those potentially impacted to take measures to mitigate or entirely prevent a disaster. For example, there is currently no fully accepted explanation of the entire causal series of processes responsible for the 1993 Midwest floods. Although important progress has been achieved in predicting the effects of earthquakes and in delineating zones of potential damage, many potentially active fault zones remain unidentified. Furthermore, prediction of earthquakes themselves remains elusive. Volcano monitoring has reached an advanced stage and the importance of certain precursors is now

recognized; however, further work is needed in the fundamental physics of magma flow, flows of exsolved volatiles and heated ground water, and related edifice deformation and failure. We have a far better understanding of how interplanetary disturbances affect the Earth than we have of the processes responsible for the creation of these disturbances on the Sun itself and their propagation through the interplanetary medium—knowledge that is necessary for timely predictions.

Research Priorities

Climate, weather, and hydrologic systems: Better monitoring and prediction of the causal linkages between climate and weather and hazards such as floods, drought, and wildfire. Special focus on hydrologic impacts, such as improved ability to predict floods and better manage our water resources. Improved predictive capability with regard to storm surge. Research priorities for this element are embodied in the Federal publication *Predicting Our Weather: A Strategic Plan for the U.S. Weather Research Program.*

Solid earth processes: Improved understanding with regard to the crustal stress accumulation and release responsible for earthquakes; release of dissolved gases from magma and interactions with ground water to control the timing, explosivity, and magnitude of major volcanic eruptions; the influences of rock strength, slope, water saturation, and preexisting slip planes on landslides and soil liquefaction; the recurrence rates and identification of high-risk fault zones; and tsunami generation by submarine fault movements, volcanic explosions, and landslides.

Ecosystem processes: Improved understanding of how multiple hazards interact to threaten forests and agriculture; ecosystem response to physical and biological events; the causal mechanisms and abatement processes that determine the origin, development, and termination of ecological hazards; and the effects of catastrophic events that induce disasters indirectly (both natural and anthropogenic, such as damage to oil and chemical facilities).

Ecological systems: Improved resistance of important plant and domestic livestock species to diseases, insect pests, and environmental stresses induced by drought; improved methods for managing forest and agricultural vegetation to reduce the intensity, frequency, and (or) magnitude of the impacts of natural hazards; improved soil management to enhance drought and flood resistance before and during droughts or floods; and development of natural biological controls of insect and disease outbreaks.

Space environment processes: Better monitoring, understanding, and prediction of the causal linkages between conditions on the Sun and in the interplanetary medium and hazards to terrestrial systems such as geomagnetic disturbances and solar particle events.

Socioeconomic Dimensions of Environmental Change

A clear understanding of the socioeconomic forces needed to reduce natural disasters versus those that exacerbate the problem is only now coming into focus.

The roles of massive urbanization, technological advance, globalization of society, and cultural diversity in changing societal vulnerability to natural hazards in particular are not well understood. Especially worrisome is the prospect that such trends will lead to more massive, complex disasters in the world of the future and the growing contribution of such events to geopolitical instability.

Research Priorities

Human interactions: Our understanding of individual response and vulnerability to natural hazards must be improved, and opportunities for safer behavior must be increased. Improved analytical tools are needed for the study of institutional opportunities, as are constraints for natural disaster reduction. Improved cost-benefit analysis is essential for natural disaster reduction.

Integrated assessments: Methods of integrated assessments must be developed that include scientific and technological information as integral components of the decisionmaking process. These integrated assessments provide a measure of the "value in use" of the information, as well as the direct linkages between scientific and technological information and social and economic policy instruments.

Development of Science Policy Tools

Our understanding of the options and opportunities for reducing the impact of natural hazards and adapting to their occurrence is rudimentary at best. The major policy tool of the past has been insurance; as the scale and cost of natural disasters have grown, the casualty insurers have been threatened. Prior to 1988, casualty insurers had never suffered a loss from any single event exceeding $1 billion; since then, they have suffered such losses on 17 occasions. Over half of all the losses incurred throughout their entire history have been suffered since 1990.

Research Priorities

Health: Capabilities for assessing health impacts immediately following a disaster must be improved, including methods of data collection that will characterize affected populations and the need for emergency medical services. Without this information, it is difficult to plan in a cost-beneficial way to handle future medical emergencies stemming from natural disasters.

Disaster epidemiology: The following issues must be addressed: description of the public health impacts of different types of natural disasters; descriptions of the natural history of acute health effects; analysis of risk factors for adverse health effects in order to develop effective strategies for preventing death and injury; clinical investigations of the impact of diagnostic and treatment approaches; improved understanding of the long-term health effects and psychosocial impacts of disasters; the effectiveness of various kinds of assistance and the long-term effects of aid on the restoration of pre-disaster conditions; and improved public health surveillance and accurate reporting of disease outbreaks following a disaster so that appropriate disease control measures and proper follow-up actions can be taken.

Casualty estimation modeling: Estimations of disaster-related casualties must be improved to guide the public- and private-sector organizations responsible for public safety. Predictions from more realistic models could be used to improve natural hazard mapping, risk assessment and management strategies, and early warning systems. In addition to improving estimates of casualties from future disasters, this research can also be used to develop more realistic scenarios for training simulations and exercises, improve design guidelines for building safety, help planners predict the impact of hazards on vulnerable subpopulations and allocate medical resources, and lead to more effective medical training for response personnel.

Economic assessments: Validation of the methods and models available for accurately assessing economic impacts both before and following disasters on all scales (local, regional, and international) must be improved. Methods for assessing ecological system damage are also needed, as are methods for measuring the risk to cultural assets and the valuation of these assets. Research is also needed in the development of improved and innovative cost-benefit models and methods for assessing past, present, and proposed mitigation, prediction, response, and recovery policies and the development of improved methods for accurately assessing the costs of rehabilitating both natural and built environments following natural disasters.

Environmental Technologies

A number of promising technologies exist for monitoring, risk assessment, and mitigation; however, their use in demonstration projects, let alone in general practice, has been extremely limited.

Research Priorities

Engineering: Research is needed to develop new or promising technologies and speed their utilization. Increased attention should be focused on engineering of massively integrated human systems and identification of unanticipated new exposures and risks to natural hazards emerging as a result of technological advance.

Observations and Information and Data Management

Information on natural disaster reduction—real-time information regarding the development of hazards as well as general information on risk, natural hazards, opportunities, and "how-to" information for mitigation—remains today fragmented and difficult to access. No single source exists for the broad range of information needed for natural disaster reduction, nor are there aids to help integrate information from diverse sources.

Research Priorities

Information dissemination: Development, through demonstration projects, of an information resources network on the information highway. Geographic information systems (GIS) technology will permit interactive visualization and analysis of any natural hazard or combination of hazards, population densities, streets, lifelines, communities at risk, and other information that can be shown on maps. Different types of information can be overlain, and degrees of risk can be aggregated. GIS will also provide references to germane case studies (both suc-

cesses and failures), resource directories, and other nonspatial metadata. One important goal of such a network would be to aid community development of mitigation plans. Rapidly improving artificial intelligence expert system software and new graphics capabilities would aid in this effort. Modules would include general hazard information and "how-to" information.

Program Objectives And Plans

Achieving a sustainable society, resilient to natural hazards, implies not only protection of life and property but also continued, uninterrupted community and regional functionality, including both natural and managed ecosystems. The United States has taken important initiatives toward these objectives in both a domestic and an international context.

Domestically, FEMA led two dozen Federal agencies in the development of a National Mitigation Strategy (see box). The National Mitigation Strategy has two components: by the year 2020, (1) *to substantially increase public awareness* of natural hazard risk so that the public demands safer communities in which to live and work; and, (2) *to significantly reduce the risk* of loss of life, injuries, economic costs, and destruction of natural and cultural resources that result from natural hazards.

The National Mitigation Strategy

The Federal Emergency Management Agency (FEMA) has developed a National Mitigation Strategy involving its Federal agency partners, the Congress, State and local governments, academia, the private sector, and individual citizens. The strategy is intended to be a living, flexible conceptual approach to mitigation. It proposes initiatives in (1) hazard identification and risk assessment, (2) applied research and technology transfer, (3) public awareness, training, and education, (4) incentives and resources, and (5) leadership and coordination to further the goal of reducing risk to life and property from natural hazard events. Finally, the strategy includes provisions for evaluation not just of the achievement of strategic objectives but of mitigation itself.

The United States already has in place a multi-agency Federal Response Plan that coordinates the actions of 26 Federal agencies in the event of natural disasters. An interagency framework will also be used in developing the National Mitigation Strategy to facilitate integrating disaster reduction measures into policy formulation and regulation rather than adding them onto established ways of doing business as an afterthought.

Developing and implementing the National Mitigation Strategy requires both the solidification of existing partnership arrangements with constituencies and the forging of new partnerships beyond the traditional emergency management community. Working with architects, lenders, insurers, economic development agencies, builders, and others will assure that all possible incentives and activities that encourage individuals, business, and local and State governments to implement mitigation strategies have been identified and explored. FEMA has conducted a series of mitigation forums throughout the country to solicit advice and counsel on how best to gain public acceptance and support for mitigation. These forums also have provided an opportunity to promote mitigation at the State and local levels, where effective mitigation must be implemented.

Another domestic initiative of considerable size and scope—and one that holds broad implications for natural disaster reduction—is the multibillion-dollar modernization and associated restructuring of the National Weather Service (Department of Commerce/NOAA) and complementary technology modernization activities within the Departments of Defense and Transportation. The modernization addresses a broad range of hydrometeorological hazards (from drought to floods to tornadoes) that are responsible for 85 percent of the Presidentially declared disasters in the United States.

National Weather Service Modernization

The National Weather Service is nearing completion of a modernization that includes deployment of proven observational, information processing, and communications technologies and the establishment of an associated cost-effective operational structure. New Doppler Weather radar, high-resolution satellite instruments, automated surface observations, and interactive information processing systems are ushering in radical improvements at the local forecast level. These developments are supported by greatly enhanced numerical weather prediction, enabled by improved understanding of atmospheric processes and by a new generation of computers. The modernization and associated restructuring will ensure that major advances in our ability to observe and understand the atmosphere are applied to the practical problems of providing weather and hydrologic services to the Nation.

In addition, steps are being taken to build on U.S. capabilities to provide all-hazards warnings. Programs will coordinate development of warnings to ensure that critical environmental information vital to response actions reaches local decision-makers and the public in a timely, consistent, and effective manner; Federal, State, and local efforts will be fully coordinated; and new technologies will be quickly incorporated into operations as they become available. A program to modernize, upgrade, and expand the NOAA Weather Radio (NWR) and the NOAA Weather Wire Service into all-hazards warning networks will incorporate geophysical and post-event information (e.g., location of shelters and other emergency services) as well as information on technological hazards provided by State and local officials.

Internationally, the United States is participating in the United Nations International Decade for Natural Disaster Reduction (see box below), intended to ensure that, by the year 2000, all countries, as part of their plans to achieve sustainable development, will have in place:

- Comprehensive national assessments of risks posed by natural hazards (these assessments to be taken into account in development plans).
- Mitigation plans at national and local levels involving long-term prevention and preparedness measures and community awareness.

The International Decade for Natural Hazard Reduction

In 1984, Frank Press, President of the National Academy of Sciences, proposed an International Decade for Natural Hazard Reduction. In 1989, the U.N. General Assembly declared the years 1990 through 2000 as the International Decade for Natural Disaster Reduction (IDNDR), a period of concerted international action to reduce loss of life and property caused by natural disasters, especially in developing countries. The goals of such action, as stated by the United Nations, are that each nation will:

—Improve its capacity to mitigate the effects of natural disasters.

—Apply existing scientific and technological knowledge.

—Foster advances in science and engineering.

—Disseminate new and existing technical information.

—Develop measures for the assessment, prediction, prevention, and mitigation of natural disasters through technical assistance and technology transfer, demonstration projects, education and training, and evaluation of program effectiveness.

The U.S. Congress passed resolutions calling for U.S. participation in the Decade. Within the Executive Branch of the Federal Government, the President's Science Advisor requested that the Committee on Earth and Environmental Sciences, of the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET), the predecessor of the National Science and Technology Council, recommend appropriate U.S. action. This strategy and implementation plan, which builds on existing Federal programs and activities and on the strategy formulated under FCCSET, is aimed mainly at reducing the domestic impact of natural hazards but will also contribute to the IDNDR.

- Ready access to global, regional, national, and local warning systems and broad dissemination of warnings.

The National Mitigation Strategy, the National Weather Service Modernization, and the IDNDR incorporate numerous milestones and performance measures. However, these activities are operational and are not included as focused research programs under the Committee on Environment and Natural Resources. The research activities under the Subcommittee on Natural Disaster Reduction (SNDR) are necessarily built on and contribute significantly to these programs.

In particular, several important objectives can be achieved only through coordinated, sustained action by the research and development community across a spectrum of disciplines. Achieving these objectives will require close collaboration among Federal agencies, State and local governments, the private sector, and the general public. These objectives are the focus of the SNDR plan. They include:

- A comprehensive national risk assessment.
- An information network to support the National Mitigation Strategy.
- Comprehensive programs addressing specific hazards.

A Comprehensive National Risk Assessment

During the next 5 years, the United States must refine capabilities for risk assessment, with respect to:

- More precise characterization of the physical/biological risk of specific natural hazards, including microzonation and the cumulative risk associated with multiple hazards.
- Improved knowledge of the interactions between natural hazards and natural/manmade environments and technological systems.
- Impact assessment (i.e., characterization of risk in terms of the lives, property, economic activity, and ecological and environmental aspects affected).
- Extension of analysis capabilities beyond the structural integrity of individual buildings to comprehensive assessments of the functional viability of communities (especially large urban areas) and regions.
- Improved ability to analyze the cost-benefit tradeoffs of various policy options.
- Improved introduction of best-available risk assessment into operational practice.
- Expanded capabilities to aid other nations in their efforts to carry out national assessments of risks from their natural hazards.

During the same period, the United States must begin to exercise these new analytical capabilities in an integrated fashion. One product of such efforts should be a national risk assessment. The exact form of such an assessment has yet to be determined, but it should contain the following elements:

- A summary of recent disasters and extreme events.
- A comparison of the past loss of life and economic loss during the previous reporting period with the predictions of previous risk assessments.
- Assessment of risk in future years, over time frames ranging from the next year to the next quarter century.
- Identification of special risks by theme (e.g., hazard type, or engineering vulnerability, or ecological and environmental concerns) and (or) by urban area or geographical region.
- Highlights of advances in risk assessment methodology and (or) national capabilities for risk assessment.

An Information Network to Support the National Mitigation Strategy

A basic principle underlying the National Mitigation Strategy is that mitigation occurs at the local level. Accordingly, the proposed 5- and 10-year goals for achieving the National Mitigation Strategy focus on the development and implementation of specific plans at State and local levels and implementation of incentives for undertaking mitigation. Statewide vulnerability assessments in all States and territories, as well as the establishment of public awareness programs to develop grass roots support for mitigation, adoption and enforcement of local multi-hazard building code provisions, and implementation of wind, seismic, and flood standards for all Federal construction, are necessary elements to support

the National Mitigation Strategy. The development and adoption of design guidelines and standards for lifelines will also be essential to this support.

To facilitate the accomplishment of these objectives, to speed the transfer of research and technology advances into operational practice, and to ensure that best-available practice is fully communicated, Federal agencies will develop an information network building on the National Information Infrastructure.

Comprehensive Programs Addressing Specific Hazards

Building societal resilience with respect to specific hazards continues to be an effective approach toward natural disaster reduction, especially when these programs address end-to-end aspects of the challenge, beginning with risk assessment, including a mitigation emphasis, paying special attention to socio-economic impacts and aspects of the problem, and addressing the warning/dissemination needs. Such broad programs generally require multi-agency coordination over a substantial period of years.

Several programs of this type are either underway or in the planning and preparation stages. They include:

The National Earthquake Hazards Reduction Program

In 1977, Congress passed the Earthquake Hazards Reduction Act, which established the National Earthquake Hazards Reduction Program (NEHRP) as a long-term, nationwide earthquake risk reduction program. In November 1990, the President approved Public Law 101-614, "The National Earthquake Hazards Reduction Program Reauthorization Act," which refined the descriptions of agency responsibilities, program goals, and objectives. The purpose of NEHRP has been to reduce the risks to life and property from earthquakes in the United States through the establishment and maintenance of an effective national earthquake risk reduction program. This goal is accomplished through activities and research aimed at improving understanding, characterization, and prediction of earthquake hazards and vulnerabilities; improving building codes and land use practices; reducing risks of earthquakes through post-earthquake investigations and education; developing and improving design and construction techniques; improving mitigation capacity; and accelerating application of research results. NEHRP supports research on:

- Science of earthquakes.
- Earthquake performance of buildings, lifelines, and other structures.
- Earthquake-resistant structural design standards and practices.
- Societal impacts.
- Emergency response and recovery.
- Regional and land use planning.
- Education programs for the public.

Although original legislation named only FEMA, USGS, the National Institute of Standards and Technology (NIST), and the National Science Foundation (NSF) as participating agencies, a NEHRP review committee in OSTP resulted in an expansion of the program to include a broader representation by Federal agencies.

Review of the National Earthquake Hazards Reduction Program (NEHRP)

In response to the continuing earthquake threat and to concerns expressed by Congress, Dr. John H. Gibbons, Presidential Science Advisor and Director of the Office of Science and Technology Policy (OSTP), announced in March 1994 that a review would be made under the auspices of the OSTP to address methods for improving the performance and effectiveness of the national earthquake program from two perspectives. The first is earthquake research and development (R&D) performed under the sponsorship of the NEHRP, and the second is the implementation of knowledge gained from this R&D in reducing earthquake losses. The review was conducted under the direction of the President's National Science and Technology Council (NSTC) and was coordinated with the SNDR. The review activities were conducted by the National Earthquake Strategy Working Group (NESWG), with membership drawn from over a dozen Federal agencies in addition to the four NEHRP agencies, and was sponsored and chaired by OSTP.

The goal of the resulting National Earthquake Loss Reduction Strategy is to mobilize and integrate the actions of numerous programs in both the public and private sectors into an aggressive, focused ***National Earthquake Loss Reduction Program***. The Program will include enhancement of elements of the National Earthquake Hazard Reduction Program. All sectors of society and all levels of government have a fundamental responsibility for and a self-interest in addressing the threat of earthquakes. Local and state governments, as well as private firms, must make independent choices to safeguard people and property. The Program will provide stimuli and information to all sectors of society to help them to make these choices.

The National Space Weather Program

In response to the increasing vulnerability of the Nation's technological systems, a National Space Weather Program (NSWP) is being developed to improve space weather forecasts and services. "*Space weather*" refers to conditions on the Sun and in the solar wind, magnetosphere, and ionosphere/thermosphere that can significantly influence the performance and reliability of space-borne and ground-based systems and endanger human life. Examples include effects, some potentially catastrophic, on satellites, navigation and communication systems, electric power distribution, and people in spacecraft or high-altitude aircraft.

The goal of the National Space Weather Program is to fully achieve an active, synergistic, interagency, "single-minded" system to provide timely, accurate, and reliable space environment observations, specifications, and forecasts in the next 10 years.

The U. S. Weather Research Program

The U.S. Weather Research Program is an interagency program designed to advance observing capabilities and fundamental understanding of weather to:

- Eliminate observational blind spots with respect to offshore conditions, humidity, and space and time resolution (in particular).
- Improve the prediction of high-impact weather.
- Enhance communication of life-protecting information and warnings.
- Accelerate the application of research and development.

The results of this program will have broad-reaching impact. Optimal decision-making in agriculture, construction, energy, transportation, and water-resources management must be based on reliable predictions of extreme weather phenomena. Community infrastructure is quite vulnerable to weather hazards. The more these hazards are understood and made predictable, the better the risk assessments and mitigation strategies for dealing with them will be.

The USWRP supports the scientific basis for integrated ecosystem management by providing better predictions of natural change; development of science policy tools by providing predictive input to risk assessments and mitigation strategies and by developing warning dissemination systems; and environmental technology through research and development on new observing technologies.

An implementation plan sent to Congress in January 1994 (requested in NOAA's Authorization Act for FY 1993) describes the science and applications priorities, critical activities and projected budgets for the next 10 years, an outline of agency roles and responsibilities, and linkages to other national programs. There are no new funds yet associated with this program.

Wildland Fire Management and Protection

The U.S. Forest Service in the Department of Agriculture and the Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and Bureau of Indian Affairs in the Department of the Interior provide fire protection for life, property, and natural resources on an interagency and intergovernmental basis in cooperation with State, local, and Tribal governments. The five agencies maintain protection organizations consisting of lookouts, aerial detection and fire prevention patrols, engines, crews, helicopters, dispatchers, fire suppression overhead, and firefighting equipment. Technical assistance is provided in fire behavior, smoke management, fuels management, prescribed fire, fire research, infrared systems, equipment development, fire training, and prevention. The Forest Service also provides cooperative fire protection assistance to the States, Territories and Commonwealths, and other Federal agencies through cooperative agreements. In addition, the Department of Defense manages 25 million acres and is currently working to develop standard wildfire policies and procedures consistent with those of other Federal agencies. The five agencies

- Operate a three-tier interagency dispatch and resource coordination system to provide the equipment, personnel, aircraft mobilization, and information needs for rapid deployment and logistical support to wildfires and other disasters. The system includes 12 geographic area coordination centers and the National Interagency Coordination Center in Boise, Idaho.
- Develop national training standards and qualifications programs in the Incident Command System to assure an interagency approach with Federal, State, and local partners using the same standards and qualifications for wildfire suppression and disaster response.
- Develop and maintain national interagency incident management teams to respond to wildfires or other natural disasters and provide skills in operations, planning, finance, logistics, and command functions as needed.
- Develop and implement prescribed fire programs as a tool to accomplish mission objectives such as reduction of hazardous levels of brush, grasses, and other fuels.

National Interagency Wildland Fire Mitigation Activities

One of the primary risk areas in fire management is in the wildland/urban interface. An important task is to provide mitigation through zoning and fuels management. Much of this responsibility must occur at the county and city level. The need for increased partnerships in this area is addressed in "Federal Wildland Fire Management Policy and Program Review" (December 1995). This report deals with wildfire hazard mitigation and ecosystem health through broader use of fire as a management tool.

Agency Roles and Activities

The SNDR is made up of 19 member agencies and departments, cooperating to increase the overall effectiveness and productivity of U.S. Federal agency programs for reducing deaths, injuries, and economic and social disruptions from natural hazards. The scope of Federal programs represented on the SNDR encompasses all types of natural hazards and agency activities ranging from basic research to emergency services response. The agencies of the SNDR believe that, through expanded and enhanced coordination, communication, information systems, education, research, and public policy options, we can have a direct, positive impact on the resiliency of U.S. society with respect to natural hazards. Specific agency activities and services toward this end are provided in the Appendix.

Constraints and Challenges

To achieve a resilient society in the face of natural hazards means overcoming significant societal inertia. The entire U.S. posture toward natural disasters must be reworked in the face of government, business and individual decisions that each day create new vulnerabilities. The continued upward spiral of the costs of natural disasters in the United States will be broken only by a strategy that addresses the full range of obstacles to natural disaster reduction. With the growth in population and the globalization of the economy and trade, the value of property and capital assets at risk in the United States and around the world is constantly increasing. As a consequence, more assets than ever are in harm's way in a given event. The continued location of these assets at hazardous sites and in inadequate shelter further raises the possible losses. Decisions regarding the siting of valuable, fragile, long-range capital investment are typically made with little or no regard for natural hazards. Furthermore, this problem is compounded when these assets are sheltered in structures that are inadequately engineered to survive a hazardous event. Decisions are rendered more difficult still by the complexity, interdependence, and

inertia of modern society, which serves to reduce flexibility and responsiveness.

Today's cities, by virtue of their large scale alone, have become increasingly complex systems. Interlocking, technology- dependent systems of communication, transportation, banking, and defense, among others, are therefore increasingly vulnerable to natural hazards. Often, many individual structures in a large urban area may survive a hazardous event, but the area is rendered dysfunctional by the disruption of one or more of the five basic lifelines: gas/liquid fuel supplies, electrical power, communication, transportation, and water/sewage. Currently, cities and regions of the United States are themselves becoming increasingly interlocked and interdependent. Thus the Northridge earthquake disrupted delivery of electrical power as far north as Seattle. Flooding in downtown Chicago resulting from the breakage of old water transport infrastructure affected financial markets nationwide. A major concern regarding a repeat of the New Madrid earthquake is the potential disruption of heating oil supply to the Northeast in the winter. The threat of solar flares to electrical power supplies is compounded by the current interlocking of power grids, in some cases across national boundaries. Technological advances that have changed the structure of today's society have also given rise to new, mixed hazards. A tornado striking above-ground facilities for nuclear waste or floods releasing toxic substances from chemical plants into watersheds are examples of complex disasters that challenge the mitigation capabilities of local entities.

Mitigation efforts generally fall to State and local governments, businesses, and individuals; as a result, societal attitudes and perceptions can present a formidable obstacle to disaster reduction. Few communities have conducted comprehensive risk assessments or considered the full range of available disaster reduction measures despite their feasibility and cost effectiveness. Misperceptions of risk, a failure to learn from past disasters, inadequate dispersion of knowledge and resources, and community planning divorced from prevention are but a few of the challenges at the State, local, and regional levels. Lack of awareness of the potential threat and indifference to the consequences, underestimation of the risk to the community, business, or individual, and overreliance on technology, luck, or personal ability to cope with a "hypothetical" disaster can precipitate an apathetic or inactive response to the threat of natural disasters on the part of State and local officials as well as individuals. As a result, scarce local funds are not committed to hazard reduction.

Fundamentally new approaches to natural disaster reduction are called for to address these challenges. Attention must shift from reaction to anticipation on the basis of long-range risk assessment and comprehensive, coordinated communitywide planning and action. After-the-fact retrofits must give way to societal planning and ways of doing business that build resilience to natural hazards from the beginning and from the ground up. To achieve these ends, Federal, State, and local governments, as well as the private sector and the general public, must make the commitment to create a more resilient and sustainable society through assessment, mitigation, and preparedness.

External Input

Partnerships among Federal, State, and local governments and the private sector are essential to successful natural disaster reduction. Assessment efforts need such partnerships, both to develop accurate estimates of vulnerability and impact and to ensure that those who will be affected by natural disasters will contribute to the needed response. Mitigation is necessarily the sum of many individual actions. Because most of the assets at risk are non-Federal, most of the needed actions reside in these other sectors. Because warnings and dissemination necessarily involve both the giving and the receiving of information, partnership is therefore fundamental.

The agencies of the SNDR, through expanded and enhanced coordination, communication, information systems, education, research, and public policy options, are working to impact the policy environments of local jurisdictions across the Nation and throughout the world. Federal-State-academia-industry linkages will deepen our understanding of the social, technical, administrative, political, legal, and economic forces that shape the policy environments in each jurisdiction. With this deeper understanding, decisionmakers will be able to balance these forces, which change with time, place, and circumstances, and to seize windows of opportunity to adopt policies and professional practices that will benefit their community. The kinds of changes that are envisioned include:

- New and improved preventive mechanisms and techniques.
- New and cost-effective remedial measures.
- Interdisciplinary approaches to mitigation, which integrate all available knowledge and benefit from the continuous flow of new knowledge from ongoing research and the interaction of researchers and practitioners.
- Efficient transfer of knowledge and technology among and between Federal, State, academic, industrial, and public partners across the United States with counterparts worldwide.

Projects involving the private sector are an integral part of the activities of many SNDR agencies. Hazard information centers, educational forums, advisory participation of the user community, Federal assistance programs, preparedness simulation exercises, and publication and dissemination of resource materials are essential to involve the private sector and local decisionmakers in disaster reduction. Reducing losses caused by natural hazards requires that hazard information, risk assessments, and warnings be transferred to the user community, including various State and local agencies, private industry, and the public, and that the user community be actively involved in the creation and implementation of strategies for mitigation. The National Mitigation Strategy will not only solidify existing partnership arrangements with constituencies but, more importantly, will also forge new partnerships beyond the traditional allies in the emergency management community. Working partnerships with architects, lenders, insurers, economic

development agencies, builders, and others will ensure that all possible incentives and activities that encourage individuals, businesses, and State and local governments to implement mitigation strategies have been addressed and explored. The All-Hazards Radio Network, proposed as an enhancement of the Weather Radio Network, will provide rapid dissemination of hazard warnings to local communities, especially critical facilities such as schools and hospitals. The private sector and State and local governments will play a key role in the implementation of the network. Truly, programs aimed at reducing the impact of natural hazards must occur on a local or regional level and, therefore, require the considerable involvement of State and local governments and the private sector.

International Dimension

Natural disaster reduction is not a domestic matter alone but rather an international challenge for the United States. The Mount Pinatubo eruption occurred half a world away, yet it caused immediate U.S. losses of over $1 billion and triggered a change in U.S. strategic military presence in the western Pacific that will have implications for decades. For many nations of the world, a single natural disaster can significantly reduce that year's gross national product; in a number of regions, these events recur so frequently that they strain the social fabric, not just the economic growth. The resulting unrest contributes significantly to global geopolitical instability. As a world leader, the United States cannot afford to focus its efforts on disaster reduction on a domestic scale only; it must continue to take a global approach.

Currently, the Office of Foreign Disaster Assistance (OFDA) has the responsibility for U.S. Government response to international disasters. Within OFDA, the Division of Prevention, Mitigation, Preparedness, and Planning (PMPP) has the responsibility for natural disaster reduction internationally, and has achieved significant success in reducing lives lost and economic losses due to natural disasters globally. For example, the impact of the Mount Pinatubo eruption was significantly reduced because of the monitoring provided by OFDA/PMPP through the U.S. Geological Survey (USGS).

The United States Agency for International Development (USAID), through OFDA/PMPP's contributions, has significantly improved the leadership capability of the USGS in geophysical hazards, particularly volcanic, and in enhancing scientific and technical exchanges relating to geophysical issues. OFDA has a continuing link with the Joint U.S./Japan Panel on Wind and Seismic Effects through the National Institute of Standards and Technology and has supported the Board on Natural Disasters of the National Academy of Sciences.

OFDA/PMPP works with numerous regional institutions, such as the Organization of American States, the Pan American Health Organization, the Asian Institute of Technology's Disaster Preparedness Center, and the World Environmental Center on training and educational programs. These programs have resulted in major improvements in the ability of countries in the Latin American and Caribbean region and in the Asian and South Pacific regions to manage disaster response and decrease the social and economic impact of natural disasters within their countries, directly supporting the goals of the IDNDR.

The challenge of reducing losses from natural disasters brings with it significant opportunity. By dint of its unique vulnerability to the full range of natural hazards, the United States enjoys unmatched world leadership in the development and use of a number of technologies for monitoring natural hazards and for disaster reduction. Continuing cooperation will enable the United States to learn from the experience and expertise of other nations. Similarly, all nations profit from data exchange on natural hazards.

International cooperation in natural disaster reduction technologies and associated educational training programs could provide important benefits to the United States and to our foreign policy goals. For example, cooperation can:

- Create American jobs by increasing U.S. exports of products and services related to infrastructure, communications, and disaster response technologies.
- Advance the state of science and technology by providing the United States with access to data, procedures, and facilities of other nations.
- Promote global stability and sustainable international economic development by reducing the impact of disasters on economies that are particularly vulnerable, such as developing economies.
- Accelerate the development of a global climate observing system and improve prospects for international conventions on global climate change.

A United Nations framework for achieving these goals already exists—the International Decade for Natural Disaster Reduction (IDNDR) displayed at the midterm World Conference on Natural Disaster Reduction in Yokohama in May 1994. The Clinton Administration showed strengthened U.S. participation and commitment to the IDNDR by having Vice President Al Gore make a videotaped statement to the Conference Plenary and through high-level representation at the meeting. The U.S. delegation was led by Walter F. Mondale, Ambassador to Japan, supported by Vice Chairs Frank Press and James Lee Witt, Director of FEMA.

Natural disaster reduction poses two international challenges for the United States. First, because the United States has a global reach, it has a global vulnerability as well. The international financial and monetary system has evolved to a point where the effects of catastrophic events are no longer confined to the nation in which they occur. Second, natural disasters, even occurring outside U.S. political and geographical boundaries, can significantly impact U.S. global strategic interests and world geopolitical stability in ways that far exceed mere dollar figures. Developing nations in particular are least able to recover from disasters, and, as the least prepared and protected,

suffer the most devastating impacts. More than 95 percent of all deaths caused by disasters occur in developing countries, and the losses, as a percentage of gross national product, are almost 20 times greater than those suffered by industrialized countries. When disasters occur frequently, a nation's economic development is constrained, social stability is undermined, and the stage is set for civil and political unrest. However, example after example has demonstrated that, although natural hazards will always exist, natural disasters need not be. Through effective action, it is possible to reduce the impact of natural hazards on everyday human experience. Indeed, expenditures for disaster prevention are repaid several times over in savings of unbudgeted disaster relief and recovery expenses.

In response to the global need to reduce loss of life and property and to reduce social and economic disruption caused by natural disasters, especially in developing countries, the United Nations General Assembly declared 1990 through 2000 A.D. as the International Decade for Natural Disaster Reduction (IDNDR). Each member nation was urged to develop a national program for the IDNDR that, together with others, would constitute the core of the IDNDR effort. The work of the SNDR in providing a forum for cooperation among U.S. Federal agencies participating in natural hazard assessments, mitigation, and warning and dissemination is congruent with the U.N. request. The SNDR has also been an active participant in the global effort for the IDNDR, through its active participation in the development of alert systems, mitigation capabilities, and the capacity to assess vulnerability as well as participation in international forums, including the 1994 World Conference on Natural Disaster Reduction at Yokohama, Japan.

For both self-interest and humanitarian reasons, the United States should exercise leadership in reducing natural disasters worldwide. After two centuries of research and development on natural hazards, the United States leads the world in technologies for monitoring natural hazards and for reducing natural disasters. This investment creates an extraordinary foreign policy opportunity for the United States, with respect to both foreign assistance and trade promotion. In addition, the United States would gain important data as well as access to engineering and scientific expertise through cooperation with other nations.

APPENDIX

Agency Roles and Activities

Agency for International Development

Mission:

The Agency for International Development (USAID) is charged with coordinating the U.S. Government response to declared disasters worldwide. Within USAID, the Bureau of Humanitarian Response's Office of Foreign Disaster Assistance (OFDA) is concerned with minimizing loss of life and damage to property from both natural and manmade disasters. During relief operations, OFDA provides emergency assistance in the areas of shelter, water and sanitation, health, food, logistics, and technical assistance. OFDA also promotes disaster prevention, mitigation, and preparedness through public education, emergency management training, drought and famine mitigation, shelter structural mitigation, and disaster early warning systems.

Activities:

- Provides technical assistance to design and implement interventions for famine mitigation.
- Trains disaster professionals in Latin America, Asia, and Africa.
- Performs worldwide volcano and earthquake monitoring and risk assessment in cooperation with the U.S. Geological Survey.
- Fosters cooperation between communities, the private sector, and local government to reduce the threat of industrial accidents in cooperation with the World Environment Center.
- Reduces vulnerability to regional hazards and promotes sustainable development through risk mapping, public awareness programs, and incorporation of risk level in insurance pricing.

U.S. Department of Health and Human Services

Mission:

The Public Health Service (PHS), Office of Emergency Preparedness, coordinates the disaster preparedness, response, and recovery activities of the Department. The Centers for Disease Control and Prevention (CDC), and other appropriate agencies, have responsibilities for responding when natural disasters occur in the United States and, upon request, provide technical assistance to other countries. Recently, the PHS has assisted after earthquakes in Japan, Egypt, and the Philippines; hurricanes in the Caribbean and the United States; typhoons in the Western Pacific; tornadoes in the United States; a catastrophic cyclone and storm surge in Bangladesh; volcanic eruptions in the Philippines, Chile, and Nicaragua; a severe drought in southern Africa; and serious flooding in China and the United States.

Activities:

- Develops disaster preparedness plans for assisting community officials in dealing with a disaster.
- Develops improved strategies to prevent or mitigate injury and death, such as warning, evacuation, and sheltering systems.
- Provides programs and activities to ensure that the health and medical needs of stricken areas are quickly assessed and people receive appropriate medical and public health assistance.
- Identifies risk factors for morbidity and mortality during disasters through epidemiologic research and environmental health studies to develop strategies for preventing deaths and injuries in the future.
- Evaluates emergency preparedness programs and the effectiveness of response to disasters.
- Disseminates information, manages emergency information systems, and promotes disaster information technology.

Department of Energy

Mission:

The Department of Energy (DOE) performs basic and applied research and development and implements policies, standards, and practices to reduce the effects of natural hazards on buildings, facilities with hazardous materials, and energy transmission systems. It also assesses the site-specific nature of natural hazards, develops criteria for design and evaluation of new and existing facilities, upgrades existing facilities, and encourages technology transfer through training, conferences, and technical newsletters. DOE strives to achieve substantial mitigation of natural hazards through development and application of performance-based, multi-hazard design and evaluation standards to support mission objectives in energy and nuclear programs.

Activities:

- Developed the Seismic Safety Guide providing plant engineers with tools to develop and manage practical and cost-effective seismic safety programs.
- Developed computerized earthquake ground-motion models for Eastern United States tectonics; improved deterministic and probabilistic methods to obtain site-specific seismic loads for facility design.
- Improved standards and guides for design and evaluation of structures, systems, and components using performance goals to provide a graded approach for building design and risk assessment.
- Uses experience data from earthquakes to provide cost-effective methods to evaluate and qualify equipment for earthquake loads in existing plants.
- Evaluates the structural response of existing masonry buildings by using the results of destructive and nondestructive testing of unreinforced materials and structural systems.
- Conducts emergency preparedness activities at DOE sites and supports the Federal Disaster Response Planning.

Federal Emergency Management Agency

Mission:

The Federal Emergency Management Agency (FEMA) provides leadership and support to reduce the loss of life and property and to protect our institutions from all types of hazards through a comprehensive, risk-based, all- hazards emergency management program of mitigation, preparedness, response, and recovery.

Activities:

- Provides continuing financial and technical assistance to State and local governments for natural hazard reduction activities.
- Provides post-event grants to State and local governments, after Presidentially declared disasters, for identification of hazards and risks and implementation of hazard mitigation measures.
- Prepares and disseminates information on hazard-resistant building codes and practices.
- Prepares and executes training, education, and public awareness programs in natural hazard reduction.
- Plans and coordinates activities of the National Earthquake Hazards Reduction Program and the National Hurricane Program.
- Coordinates and leads a unified national program for floodplain management.
- Administers the National Flood Insurance Program, including hazard identification, risk assessment, implementation of loss reduction measures, and provision of flood insurance.
- Develops and coordinates the execution of Federal response and recovery plans for disasters.

Federal Energy Regulatory Commission

Mission:

The Federal Energy Regulatory Commission (FERC), under the Federal Power Act, is mandated to regulate all non-Federal public and private hydroelectric projects in the United States. The Commission has established a dam safety program to require repairs and/or modifications of projects, or changes in their operation, as may be necessary to ensure project safety and adequacy of project works and for the protection of life, health, property, and the environment.

Activities:

- Develops engineering guidelines for dam safety analyses.
- Establishes methodology and criteria for determining probable maximum precipitation and probable maximum floods.
- Conducts seismic analyses and evaluations and develops criteria for analyzing and protecting dams against failure due to seismic events.
- Establishes and maintains an emergency action plan program to provide early warning notification and provides training for conducting tests.
- Provides criteria to promote public safety at jurisdictional projects.

Department of Housing and Urban Development

Mission:

The Department of Housing and Urban Development (HUD) administers Federal housing programs that increase the quality and affordability of housing. This effort fulfills its legislative mandate to provide decent, safe, and sanitary housing in a suitable living environment for every American family by enhancing the strength and stability of the Nation's housing markets. HUD also funds earthquake studies related to disaster response, damage assessment, and mitigation. HUD is also engaged in conducting seismic risk assessments of HUD-assisted properties and in developing seismic safety standards for such properties as well as for manufactured housing. Additionally, the Department provides major rebuilding and emergency housing assistance to earthquake-stricken communities such as Northridge, Calif.

Activities:

- Develops Minimum Property Standards (MPS) for design and construction of single-family, multifamily, and public housing projects and Manufactured Housing Construction and Safety Standards (MHCSS) to enable manufactured housing to resist natural hazards.
- Performs risk and vulnerability assessments of existing residential construction under HUD programs and retrofits and strengthens buildings to resist natural hazards.
- Trains professional engineers for post-disaster investigation and maintains and equips quick-response post-disaster investigation teams.
- Provides natural disaster reduction information to all HUD field offices and disseminates information to civil engineers at local, State, and Federal levels.
- Provides structural engineering review and analysis of designs of new and existing residential buildings to assure resistance to natural hazards.
- Conducts building technology research and tests residential building components and systems to assure adequate and cost-effective resistance to natural hazards; fosters interagency agreements with other Federal agencies for research and testing.
- Maintains representation on building code and standards committees to upgrade natural hazard provisions to current state of knowledge; recommends revisions to building codes and standards.

National Aeronautics and Space Administration

Mission:

The National Aeronautics and Space Administration uses the unique vantage point of space to obtain information about the Earth—its land, atmosphere, and oceans—and the processes that occur among these domains. Environmental and hazards research focuses on the development, implementation, and application of new and improved remote sensing and high-resolution space geodetic systems and the modeling and data analysis techniques needed for such research.

Activities:

- Conducts fundamental research on the processes of hazard occurrence and recurrence.
- Performs space-based hazard mapping, risk assessment, and monitoring; detects minute changes in topography; measures volcanic inflation and deflation and thermal properties; tracks and models volcanic plumes; monitors crustal deformation and strain buildup to assess earthquake hazards; tracks severe storms; monitors wildfires and landslides.
- Develops information and communication systems for information dissemination and disaster mitigation.

National Institute of Standards and Technology U.S. Department of Commerce

Mission:

The National Institute of Standards and Technology's Building and Fire Research Laboratory is dedicated to improving the life-cycle quality of constructed facilities. Its performance prediction and measurement technologies enhance the competitiveness of U.S. industry and public safety. The laboratory studies structural, mechanical, and environmental engineering, fire science and fire safety engineering, building materials, and computer-integrated construction practices.

Activities:

- Performs problem-focused research and development to improve practices, standards, and codes for new and existing buildings and lifelines to reduce loss from earthquakes, extreme winds, and fire.
- Identifies mechanisms of failure and establishes criteria to ensure structural safety.
- Develops technical criteria and methods to strengthen and repair buildings and lifelines.
- Develops methods to predict the behavior of fire and smoke and to enable high performance of fire detection and suppression systems.

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Mission:

The mission of the National Oceanographic and Atmospheric Administration (NOAA) is to promote global environmental stewardship and to describe and predict changes in the Earth's environment. NOAA provides forecasts and warnings of various natural hazards related to the atmosphere and the oceans: tornadoes, hurricanes, floods, tsunamis, and geomagnetic storms. Research and development is conducted by NOAA in support of its operational responsibilities to protect life and property from these hazards. NOAA develops observing and monitoring systems, advances understanding of underlying environmental processes and predictive methodologies, and disseminates these predictions to State and local governments and the general public.

Activities:

- Is completing the National Weather Service modernization and associated restructuring, a major effort to upgrade weather observing and data-processing systems.
- Leads the multi-agency U.S. Weather Research Program, which seeks to improve the 0- to 48-hour weather forecast.
- Participates in the National Space Weather Program, a multi-agency effort to improve the Nation's civilian and military space weather services.

National Science Foundation

Mission:

The National Science Foundation (NSF) is an independent agency of the Federal Government established to promote and advance scientific and engineering progress. The NSF sponsors and funds scientific and engineering research and education projects and supports cooperative research between the United States and other countries. Although the NSF does not itself conduct research, it funds research on natural hazards that focuses on new and fundamental knowledge needed to better understand, manage, and mitigate natural disasters.

Activities:

Supports basic research to:

- Improve understanding of underlying physical phenomena, such as disruptions in the space environment; formation of severe weather systems; precipitation, runoff, and flood relationships; seismicity and seismic wave propagation; stability and soil collapse processes; soil failure mechanisms; and ground movement phenomena.
- Enhance hazard prediction and forecasting methodologies as the basis for new and improved warning, evacuation, and response systems.
- Improve knowledge of the behavior of structures, buildings, facilities, lifelines, technological systems, and mechanical features under extreme conditions by conducting scale, physical simulation experimentation and mathematical simulation to provide a framework for new and improved design, monitoring, control, and construction systems.
- Advance understanding of recovery and reconstruction processes as a foundation for new and better methods of and decision-support systems for expedited and improved recovery.

U.S. Department of Defense

Mission:

As part of its mission to preserve national security, the Department of Defense (DoD) develops programs to deal with emergency preparedness, assessment, mitigation, intervention, response, and recovery from natural disasters. The DoD conducts research and development to minimize the reduction in operational readiness caused by the occurrence of natural disasters and to minimize the resources needed to restore these capabilities. The DoD response to natural disasters includes military assistance to insure the security of populations and property, rapid damage assessment to facilitate rehabilitation programs, and emergency reconstruction of critical infrastructure. To support these loss-minimization activities, DoD conducts research and development in military and civil works programs that relate to every major kind of natural disaster, as well as militarily oriented research that has dual applicability to natural disasters.

Activities:

- Anticipates and quantifies disaster scenarios.
- Develops efficient, resilient design or retrofit of conventional DoD facilities, including buildings and utilities.
- Develops innovative techniques for construction of airfields and pavements and advanced engineering systems to maintain or restore critical airbase capability under adverse conditions.
- Improves survivability of critical facilities.
- Develops logistics capabilities, systems, and structures for effective ocean and waterfront operations under adverse conditions.
- Provides logistics support for rapid deployment of people and supplies and engineering design for rapid development or repair of essential infrastructure (such as power supply, communication, transportation routes, shelters, water supply, etc.).
- Evaluates earthquake effects on reservoir dams and appurtenant structures and develops effective remediation where necessary. The Corps of Engineers has direct responsibility for over 600 dams, 200 of which are located in seismically hazardous areas. Failure of these structures would have great potential for large loss of life and property.

U.S. Environmental Protection Agency

Mission:

The U.S. Environmental Protection Agency (EPA) improves and preserves the quality of the environment, both national and global. EPA works to protect human health and the productivity of the natural resources on which all human activity depends. EPA ensures that Federal environmental laws are implemented and enforced effectively.

Activities:

- Implements environmental research into standards for bioremediation, debris burning, water quality, and soil toxicity after chemical and oil spills.
- Develops computer models and programs for management of chemical releases, including plume and dispersion models.
- Performs systematic risk assessments of chemical industries, particularly in areas at risk for earthquakes, hurricanes, tornadoes, and floods.
- Maintains a cadre of highly trained specialists in chemical response and environmental disasters.
- Promotes international coordination and cooperation between industrial and industrializing countries to improve chemical safety practices and regulation and provides training, technical assistance, and response for chemical emergencies.

U.S. Department of Agriculture
U.S. Forest Service

U.S. Department of the Interior
Bureau of Land Management
Bureau of Indian Affairs
Fish and Wildlife Service
National Park Service

Mission:

These Federal agencies, in cooperation with other Federal, State, county, and municipal cooperators, provide fire protection for life, property, and natural resources. They maintain lookouts, aerial detection, and fire prevention patrols, engines, crews, helicopters, dispatchers, fire suppression overhead, and firefighting equipment. Technical assistance in fire behavior, smoke management, fuels management, prescribed fire, fire research, infrared systems, equipment development, fire training and prevention is also available. The Forest Service has the lead, with assistance and support from the other agencies, for Emergency Support Function 4—Firefighting—in the National Response Plan and for providing cooperative fire protection to the 50 States, and 6 Territories and Commonwealths.

Activities:

- Maintains the National Interagency Coordination Center in Boise, Idaho, for rapid deployment and logistical support of personnel, aircraft, and equipment for responding to wildfires and other disasters.
- Maintains 12 strategic geographic area coordination centers to provide the equipment, personnel, and aircraft mobilization needs for rapid deployment and logistical support in responding to wildfires and other disasters.
- Develops national training standards and qualifications programs in the Incident Command System to assure an interagency approach in which Federal, State, and local partners use the same standards and qualifications for wildfire suppression and disaster response.
- Develops and maintains national incident management teams to respond to wildfires or other natural disasters and provides skills in operations, planning, finance, logistics, and command functions as needed.
- Develops prescribed fire programs as a tool to accomplish mission objectives such as reduction of hazardous fuels and enhancement and maintenance of natural resources. This fire-use program is implemented under strict guidelines and management-approved burning plans.

Natural Resources Conservation Service
U.S. Department of Agriculture

Mission:

The Natural Resources Conservation Service (NRCS) Emergency Watershed Protection Program of the U.S. Department of Agriculture helps individuals, organizations, and State and local governments to conserve and wisely use natural resources. NRCS may provide technical and financial assistance whenever fire, flood, or other natural disasters cause sudden damage in a watershed. To safeguard lives and property, as authorized by the Secretary of Agriculture, NRCS can assist local sponsors with emergency measures to retard runoff and reduce erosion and sedimentation. Frequently used emergency measures include vegetative cover, gully control, stream bank protection devices, debris and sediment removal, and repair of dams, dikes, and other water control structures.

Activities:

- Responds immediately in cooperation with other Federal and local agencies to provide the technical support to assess damages and identify needed actions. If life or property is threatened, provides remedial action in 1 or 2 days. Assistance can continue until all hazards are controlled.
- Uses contract easements for reconstituting wetlands on flood-damaged agricultural lands.
- Uses contract easements in specific sites that are ecologically sensitive and should be conserved as habitats for endangered species.

U.S. Geological Survey
Department of the Interior

Mission:

The U.S. Geological Survey conducts research, transfers technology to end users, and fosters the adoption and implementation of public policies and professional practices to reduce losses from earthquakes, volcanic eruptions, landslides, ground subsidence, geomagnetic storms, floods, droughts, wildfires and biological hazards in the United States and abroad.

Activities:

- Conducts basic research on geologic and geophysical hazards (earthquakes, volcanoes, landslides, ground subsidence, and geomagnetic storms), hydrologic hazards (floods and droughts), and biological hazards (including land cover characteristics for fire-fuel assessments and disease in natural populations).
- Performs hazard and risk assessments on national, international, regional, urban, and local scales.
- Develops monitoring networks and geographic information systems.
- Transfers the technology needed to enhance professional skills and to expand the technical capacity for mitigation, preparedness, emergency response, and recovery.
- Organizes and conducts post-disaster investigations.

Tennessee Valley Authority

Mission:

Tennessee Valley Authority (TVA) activities include emergency preparedness, mitigation, response, and recovery programs; development of agency plans, exercises, and training; support of State and local preparedness and evacuation planning efforts; and interagency planning and coordination. TVA also is involved in the evaluation, design, and construction of specific projects to mitigate flood threats. TVA updates hazard models; develops design standards and guides; evaluates risks due to natural hazards; and modifies and strengthens existing dam structures and designs and constructs new facilities to withstand threats from natural hazards. In conjunction with regional power distributors, TVA works to reduce losses from earthquakes, severe weather, and fire. The agency manages a seismic safety program to implement seismic design standards and Federal mandates and conducts research to assess seismic hazards at its facilities. TVA supports Federal disaster response and recovery efforts with technical engineering and specialized support, as required, and supports major wildland firefighting with trained firefighters.

Activities:

- Conducts research aimed at improving forecasting and warning services.
- Modernized its Reservoir Forecast Center by creating state-of-the-art forecast processing to include creating an emergency backup center.
- Developed a state-of-the-art Emergency Operations Center to effectively manage all emergency situations.
- Participates in training programs aimed at improving hazard awareness, preparedness, and warning capabilities.
- Designs and provides training exercises for agency personnel involving various emergency scenarios, including dam safety, flood, natural disasters, security violations, fire, police, etc.
- Establishes open communications with other local, State, and Federal agencies involved with emergency management.
- Assesses earthquake ground motion at selected hydro facilities.
- Implements Federal seismic safety standards for new building construction.
- Studies seismic mitigation for existing switch houses, switchboards, and relay boards.
- Replaces critical live-tank circuit breakers with dead-tank circuit breakers; designs transmission line structures that will be subject to liquefaction; provides proper bracing for transformer radiators; extends the length of jumpers from rigid buses to bushing of equipment; and improves the telecommunications capability of the seismic monitoring network.
- Modernizes the valleywide communications system to better integrate and coordinate wide-area emergency response.
- Provides trained, qualified teams to assist other Federal agencies in damage assessment, technical assistance, and firefighting.

U.S. Department of Transportation

Mission:

The U.S. Department of Transportation (DOT) conducts research to advance disaster-resistant design, construction, and retrofit of the transportation infrastructure through nationally applicable specifications and guides to recommended practice; assesses DOT facilities to prevent interruption of vital DOT functions; and provides immediate response to major disasters.

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ABSTRACT

The United States currently loses, on average, about $1billion per week to natural disasters. Such losses can and should be reduced. The United States must create a sustainable society, resilient to natural hazards. Natural hazards of terrestrial origin (earthquakes, volcanic eruptions, landslides, tsunamis, hurricanes and other severe storms, tornadoes and high winds, floods, wildfires and drought) and solar-terrestrial hazards (solar flares and geomagnetic storms) are inevitable. By contrast, natural disasters—the lingering disruption to entire communities, persisting long after the causative event itself—are determined as much or more by societal behavior and practice as by nature itself. The impacts of natural hazards can, at a minimum, be mitigated or, in some instances, prevented entirely.

To meet the challenges ahead, our Nation must make three major policy shifts: (1) anticipate and assess risk, not simply react to disasters; (2) focus on mitigation that builds resilience at the earliest planning stages, not as an afterthought, and deal with mitigation comprehensively rather than piecemeal; and (3) implement warning and information dissemination systems that allow society to bring its resilience into play. The first steps toward achieving this goal rely upon our Nation's ability to focus its efforts on the following elements: (1) a national risk assessment; (2) an integrated natural disaster mitigation information network; and (3) augmentation of comprehensive, hazard-specific programs, including the National Earthquake Hazards Reduction Program, the National Space Weather Program, and the U.S. Weather Research Program. By expanding our goal beyond saving lives to ensuring the continued, uninterrupted functionality and viability of communities, regions, and their associated managed and natural ecosystems, we can create a sustainable society, resilient to natural disasters.

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