Disasters

8

Disasters

Disasters as a result of human activity—both intentional actions, such as the illegal discharge of oil, and accidental ones, such as toxic spills or nuclear meltdown—can expose people, ecosystems, and animals to dangerous substances. Such vast quantities of hazardous materials are moved about by a variety of transportation modes that spills and other accidents are inevitable. Despite strong regulations governing the handling of hazardous material in North America, serious accidents that threaten human and environmental health and safety occasionally occur, prompting further preventive legislation.

In the United States, the number of incidents reported to the Hazardous Materials Incidents System (HMIS) rose from about 8,880 in 1990 to 13,853 in 1997. Most occurred on highways, with rail and aviation sectors reporting the next largest number of incidents. The incident rate is uncertain, however, since improved reporting or expanded economic activity may account for part of the increase (EPA 1999).

Oil spills during marine transport can cause severe harm to coastal and

Box 49: The Exxon Valdez Oil Spill

In March 1989, the Exxon Valdez oil tanker ran aground, spilling almost 50 million liters of crude oil into Prince William Sound. It was North America's worst oil spill and caused an ecological disaster: oil washed onto 2,092 km of Alaska's pristine and biologically rich coast, killing some 250,000 seabirds, 2,800 sea otters, 300 harbor seals, 150 bald eagles, and about 22 killer whales as well as millions of salmon eggs and plants and other organisms (EVOSTS 1999). Ten years later, oil is still leaching from beaches, and some populations of plants and animals have yet to completely recover. The disaster prompted new federal regulations to prevent oil spills, more severe penalties for those who cause them, and a call for safer vessel design (NOAA 2001). As a result, the volume of fuel spilled in the United States has decreased dramatically although the number of oil-spill incidents reported has increased (EPA 1999).

maritime ecosystems, as witnessed by the Exxon Valdez oil spill in 1982 (see Box 49). Maritime vessels also discharge solid wastes and sewage, which can also affect water quality, especially where there is a high volume of traffic (EPA 1999).

North America is also subject to a range of naturally occurring events with potentially disastrous impacts on the environment and human well-being. Earthquakes, volcanic eruptions, tornadoes, hurricanes, ice storms, droughts, dust storms, and other extreme weather events occur in different parts of the continent. North American governments have put in place many response mechanisms to prevent and alleviate the harm caused by such events. Now, it is becoming evident that some preventive actions, such as levees and wildfire suppression, have actually been part of a mix of factors—including global climate change, population growth, urbanization, and affluence—that have increased the frequency and severity of some types of natural hazards as well the economic losses they cause. Flooding and forest fires are two of the region's priority concerns.

Floods and Climate Change

Although climate change was identified as a pressing issue as early as 1972, the role of humans and their impact on natural hazards such as extreme weather events was unclear (Bruce, Burton, and Egener 1999). Today, however, there is a general consensus among a large and growing number of scientists that human activity plays a discernable role in the Earth's changing climate (IPCC 2001). Still, much uncertainty remains about how the shifts in climate will affect future weather-related natural hazards.

The disruption and intensification of the earth's water cycle is believed to be one of the most fundamental effects of climate change. Changes are already occurring in North America's hydrological conditions, as demonstrated by the increase in average annual precipitation over the past 30 years (see Figure 43) and in the marked increase since the 1970s of

Extreme Precipitation Trends in Canada and the United States, 1910-1995

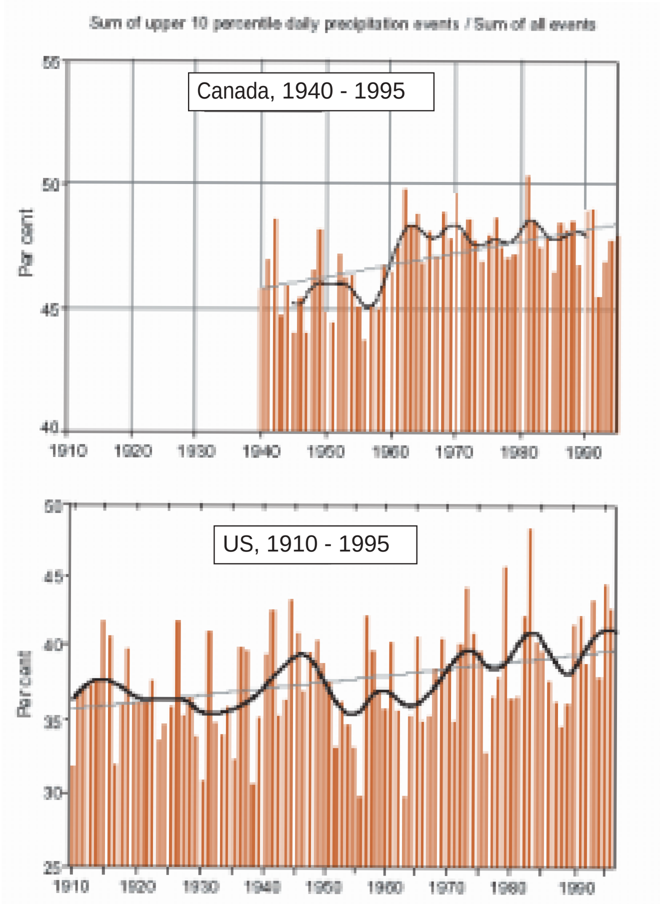

Figure 43
Extreme precipitation trends in Canda and the United States, 1910-1995.

Source: Francis and Hengeveld 1998

intense winter storms in the Northern Hemisphere (see Figure 44) (Bruce, Burton, and Egener 1999). In the United States, the average amount of moisture in the atmosphere rose by 5 percent per decade between 1973 and 1993 (Trenberth 1999). Most of the increase derived from heavier precipitation events resulting in floods and storms (O'Meara 1997,

Frequency of Intense Winter Storms in the Northern Hemisphere, 1900-2000

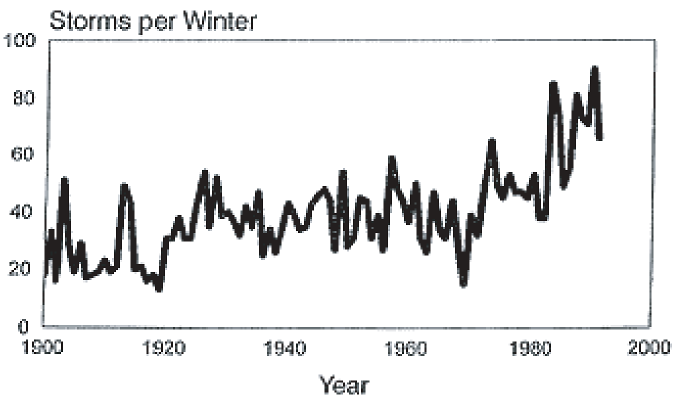

Figure 44
Frequency of intense winter storms in the northern hemisphere, 1900-2000.

Source: Bruce, Burton, and Egener 1999

Easterling, Meehl, and others 2000). During the second half of the 1900s, the relative amount of precipitation from North America's heaviest 10 percent of yearly precipitation events increased (Francis and Hengeveld 1998).

While the flooding that often follows heavy precipitation events is natural and essential to the health of watersheds, floods are also North America's most destructive and costly natural disasters. They affect large areas, cause extensive property loss and damage and are associated with large additional costs for recovery, adaptation, and prevention (Brun, Etkin, and others 1997, USGCRP 2000). During the 1960s and 1970s, over 90 percent of the natural disasters in the United States resulted from weather or climate extremes, and many North American floods were major disasters requiring massive federal aid and costly structural mitigation measures (Changnon and Easterling 2000). In response to these events, the US National Flood Insurance Act of 1968 established the National Flood Insurance Program (NFIP). The Flood Disaster Protection Act of 1973, which offers flood insurance to those communities that adopt and enforce floodplain management ordinances, strengthened it. Many of the separate and fragmented responsibilities of parallel state and local-level disaster programs were merged in 1979 under the Federal Emergency Management Agency (FEMA 1999). The United States also maps the nation's floodplains, an effort that has helped raise public awareness of flood hazards (FEMA n.d.).

Disaster Financial Assistance Arrangements were also inaugurated in Canada in 1970 to help provinces cope with the cost of disaster recovery and in 1975, the government introduced the Flood Damage Reduction Program (FDRP). Disaster mitigation and coordination were also among the goals addressed by Canada's Emergency Preparedness Act, passed in 1988, and its related agency, Emergency Preparedness Canada (EPC). Disaster plans that had been piecemeal also were made more comprehensive and the nature of emergencies to be accommodated was broadened (McConnell 1998; EC 2000). Settlement in flood-prone areas was discouraged in Canada through mapping and the designation of over 320 flood-risk areas (EC 1998).

These programs provided better flood mitigation, preparation, response and recovery measures.

Box 50: Some Major Floods of the Last 30 Years

The 1993 Mississippi flood, which submerged 75 towns and killed 48 people, cost between US $10 and $20 billion, surpassing all previous US floods in terms of economic losses as well as in the area, duration, and amount of flooding (USGCRP 2000). It was the result of record-breaking spring rains in the Midwest, a larger than usual snow cover, and high soil moisture content, but also from the river's confinement to its channel by levees and dikes, which helped to increase the flood crest. In 1996, Canada experienced its most destructive and costly flood in the Saguenay River valley in Quebec. An average of nearly 126 mm of rain fell in 48 hours over an area of 100,000 km^2, resulting in 10 deaths and about US $0.8 billion in damages (EC 1998, Francis, and Hengeveld 1998; EC 2001).

In 1997, the Red River, which flows north from the United States into Canada, experienced its worst flooding in 150 years. It followed a wet autumn, a winter of unusually heavy snowfall, and the arrival of an early spring blizzard that dropped 50–70 cm more of snow or freezing rain. Altogether, the flooding generated costs of almost US $5 billion. The Red River Floodway, which diverts the Red River's spring thaw when the exit to Lake Winnipeg remains frozen, protects the 550,000 residents of city of Winnipeg from being submerged (Francis and Hengeveld 1998; IJC 2000).

Flood policies in both countries focused primarily on building structures (levees, reservoirs, and floodways), which were tested during the damaging North American floods of the1980s and '90s (see Box 50).

The costs of natural disasters are difficult to determine with accuracy. They may or may not include indirect costs related to trade losses, human health effects, and the costs of adaptation, recovery, and financial disaster assistance. In the mid-1990s, it was estimated that on average, the United States lost about US $1 billion per week to natural disasters (NSTC 1996). Despite uncertainties in the data, globally there are solid indications that over the past few decades the costs of weather-related events have grown about three times faster than those linked to earthquakes, and a similar trend is evident in North America (Bruce, Burton, and Egener 1999). For example, evidence shows that flood dollar damages and flood-related deaths in North America have climbed at a steep rate since the early 1970s (Etkin, Vazquez, Conde, and Kelman 1998; USGCRP 2000).

In Canada, the costs of weather-related disasters grew from about US $325 million between 1983 and 1987 to more than US $1 billion between 1993 and 1997 (EC 2001). The largest US snowstorm in more than a century occurred in 1993 along the northeast coast, and in 1998, Canada experienced a major ice storm, the result of over 100 mm of freezing rainfall over six days, accompanied by unusual weather systems. It was the country's costliest weather catastrophe ever, causing 25 deaths, leaving nearly 3 million people without heat or electricity–in some cases for a matter of weeks–and costing about US $1.3 billion in

damage (Francis and Hengeveld 1998). In the mid-1990s, weather-related disasters on the North American subcontinent caused an average of 200 deaths and cost more than US $3.5 billion in property loss and damage per year (Parfit 1998).

The world insurance industry recognizes that extreme weather events like floods are becoming more common. Although rare before 1987, 23 weather-related disasters causing billion-dollar insurance losses have occurred in the United States since then (Francis and Hengeveld 1998). More people and settlements are exposed to floods because of population increase and concentration, while rising affluence and property values also ratchet up the costs of damage (Easterling, Meehl, and others 2000). A tendency to settle in flood-prone areas is also influenced by a perception that risk has been lowered by protective structures such as dams, dykes, and diversions and by the availability of disaster relief (Brun, Etkin, and others 1997; Bruce, Barton, and Egener 1999).

Floods can have significant environmental consequences such as washing away valuable topsoil and diminishing agricultural productivity (Francis and Hengeveld 1998). The Mississippi flood of '93 damaged much of the Midwest's fertile farmland and altered the natural ecosystems of the region's rivers and their floodplains. Since wetlands and temporary lakes act as storage areas for excess water, their loss heightens the vulnerability of the watershed to flood. Structures that prevent rivers from flooding often provoke extremely damaging floods when water eventually overflows. For example, human modifications over the last century to make the Mississippi floodplain habitable led to the loss of over 80 percent of the river basin's wetlands and changes in riparian and in-stream habitat, thus decreasing the watershed's resilience and increasing its vulnerability to flooding (McConnell 2000-01).

Both countries have modified their approach to disaster prevention and mitigation in recent years, moving from a focus on resisting natural hazards to policies aimed at building resilience. This is particularly the case in the United States, which is subject to more frequent and severe weather events than Canada. In the 1990s, it strengthened federal mitigation legislation and initiated a new strategy to encourage non-structural approaches to flood prevention, such as resettlement projects and wetland restoration (Newton 1997; Changnon and Easterling 2000). The 1996 US Strategy for Natural Disaster Reduction advocates major policy shifts toward the goal of sustainability by anticipating and assessing risks rather than just reacting to disasters; building resilience early in the planning stage; dealing with mitigation comprehensively instead of in a piecemeal manner; and implementing warning systems that encourage human resilience. Furthermore, new strategies acknowledge the need to ensure the continued viability of both human communities and managed and natural ecosystems (NSTC 1996; FEMA 2000). FEMA's Project Impact was initiated in 1997 with the aim of reducing the risk of property loss, deaths, and the amount of federal money spent on recovery throughout the United States (Barton and Nishenko 1997).

Historically, Canadian federal natural hazards action did not specifically target mitigation in a comprehensive manner (Newton 1997). The lack of coordination among disparate programs, reductions in financial support for existing programs, and the spate of recent weather-related disasters led to the recognition of a need for more comprehensive Canadian disaster relief policies and an integrated delivery structure (Etkin, Vazquez, Conde, and Kelman 1998; White 1997; Kerry, Kelk, and others 1998). In 2001, Canada established the Office of Critical Infrastructure and Emergency Preparedness (OCIPEP) to develop and implement a more comprehensive approach to disaster prevention and to provide national leadership in protecting its critical infrastructure in both its physical and cyber dimensions (OCIPEP 2001). Canada and the United States also cooperate in emergency planning for disasters (see Box 51).

According to climate change models, the magnitude, frequency, and cost of extreme hydrological events in some regions of North

Box 51: Bilateral Agreement

Canada and the United States cooperate to deal with disasters affecting either or both countries, especially those involving floods and forest fires. The 1986 Agreement between the Government of Canada and the Government of the United States of America on Co-operation in Comprehensive Civil Emergency Planning and Management establishes 10 principles of cooperation and provides a framework for future bilateral arrangements for civil emergency planning (McConnell 1998; Government of Canada 2000).

America are forecast to increase (USGCRP 2000). Among climate change's projected effects are changes in the patterns and frequency of the El Niño-Southern Oscillation (ENSO), a recurring warming and cooling pattern of surface waters in the tropical Pacific Ocean observed since the 1970s. It lasts from 12 to 18 months and occurs once every two to 10 years. El Niño's behavior has altered over the past 20 years, becoming more

frequent and persistent since the mid-1970s. El Niños are thought to be associated to some degree with the occurrence of increasingly severe and frequent weather events, especially since their recent intensification has no precedent in climate records over the past 120 years (Francis and Hengeveld 1998; Bruce, Burton, and Egener 1999). An uncommonly strong El Niño in 1997-98, for example, brought about storms, floods, droughts, and fires that killed thousands of people and displaced thousands more. It accounted for heavy floods in Florida, California, some Midwest states and parts of New England (Trenberth 1999).

The speculation that global climate change is likely to exacerbate weather extremes is based on the expectation that increased warming will modify heat distribution and energy flows in the climate system, affecting, in turn, atmospheric and oceanic circulation patterns and altering the hydrological cycle. A warmer atmosphere can hold more moisture, which spells more precipitation (Francis and Hengeveld 1998). In addition, this more intense rainfall will likely occur over smaller areas, probably leading to greater flooding, especially in smaller catchment areas. It may also be that with longer periods between heavy rainfall events, droughts could become more severe, exacerbated by higher air temperatures and increased evaporation (Bruce, Burton, and Egener 1999).

Regional differences in hydrological processes mean that the magnitude and direction of impacts are likely to vary greatly among regions (Frederick and Schwartz 2000). Where rainstorms intensify and flooding increases, the risks to humans and the environment will be greater. Impacts include the potential for damage to low-lying settlements and dock and port facilities as well as for problems with water distribution and sewage systems that can have human health implications (EC 1999a).

Given the continental nature of climatic systems, the two countries will need to increase their cooperative efforts to address both climate change and disaster preparedness. As shown in the freshwater section, the International Joint Commission (IJC) assists both governments in managing their shared waters. A report on the 1997 Red River flooding cautioned that given impending increased flooding due to climate change, a comprehensive, integrated, binational strategy should be developed and implemented (IJC 2000).

Forest Fires

Forest fires are a natural part of North America's landscape and play an important role in maintaining and regenerating some types of forest ecosystems. The pattern or regime of fire frequency, severity, and area burned varies from place to place. In North America's boreal forests (see Box 40 in the forests section), a natural cycle of destruction and renewal occurs as robust new trees mature, quickly replacing stands burned by lightning-sparked wildfires (CCFM 2000). Fires occur in cycles ranging from 100 to 400 years, with major fires once every 50 to 100 years in Alaska's boreal forests and once every 200 years in eastern Canada (Gawthrop 1999). Such fires open spaces for new seedlings, help to increase diversity in the age and type of vegetation, clear debris, and enhance the availability of nutrients (Jardine 1994).

Since the 1970s, the annual area burned by forest fires has grown, particularly in the western United States, while the overall trend has been toward decreasing numbers of fires (see Figures 45 and 46). For example, prior to 1970 only 1 million ha per year burned in Canada; it is now close to 3 million ha per year. A number of factors have sparked the increase: fuel build-up from past effective fire protection programs; aging tree stands; changes in fire policy related to prescribed burning; and expanded public access to and use of the forests. Higher temperatures and lower rainfall associated with climate change have also been implicated. The relative importance of each of these factors remains controversial.

Total Area Burned, 1970-2000

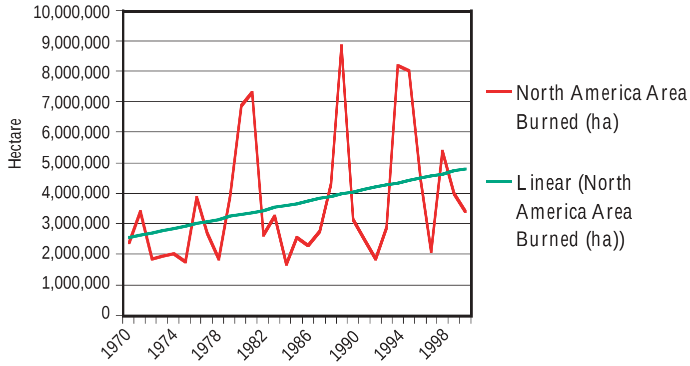

Figure 45
Total area burned, 1970-2000.

Source: CCFM 2000, CIFFC n.d., NIFC 2000

Number of Wildland Fires, 1970-2000

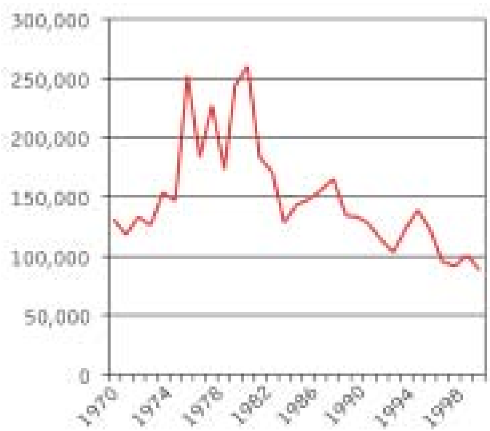

Figure 46
Number of wildland fires, 1970-2000.

Source: CCFM 2000, CIFFC n.d., NIFC 2000

Over the past century, natural fire regimes in North America were increasingly shaped by human presence and intervention, setting the stage for fire activity in the past 30 years. In the early part of the century, extensive logging left behind an unnatural fuel load from debris, undergrowth, and smaller trees that filled gaps. As a result, when fires started, they were larger and more destructive. To save valuable timber, the United States began an aggressive policy of fire suppression and 'Smokey Bear' campaigns in the 1930s to inform the public about the dangers of igniting fires. By the 1970s, fires were kept to about 2 million ha a year in the lower 48 states compared to the 1930s, when an average of 16 million ha burned every year (H. John Heinz III Center 1999; Booth 2000).

Increasingly effective fire suppression prevented natural low-intensity fires from burning the accumulated dead trees and those that had dried during periods of drought, continuing to create excessive fuel loads. Forest structure and make-up changed as species normally eliminated by fire became dominant, with fire-resistant trees being replaced by species that burn hotter and faster than those of the past. The result was ever larger and more disastrous fires.

In the 1970s, the importance of periodic natural wildland fires began to be recognized in both Canada and the United States. Late in the decade, US policies that required suppressing all fires before they reached four ha in size by 10 am the

Box 52: The 1988 Yellowstone Fires

Yellowstone National Park in the Rocky Mountains of northwestern Wyoming is the oldest and most famous US National Park. Until the 1970s, wildfires were viewed as destructive and were suppressed. But without the natural fires, debris in the forests built up to fuel bigger fires. In recognition that wildfire is part of a natural process of change, a fire policy was launched in 1972 that allowed most fires to take their natural course. In 1988, the policy aroused controversy when parts of Yellowstone struck by lightning were allowed to burn. The fires spread quickly because of severe summer drought and high winds, and 485,623 ha burned in the Yellowstone area in eight huge fire complexes. Eventually a decision was made to suppress the fires. At the cost of US $120 million, it was the costliest fire-fighting event in US history (Robbins 1998; PBS 2000). Fire management plans were rewritten, and today policies continue to support a more natural fire regime, yet also seek to remove excess fuel loads in the forests.

The post-fire ecology of the Park has led to renewal. Usable forms of potassium and phosphorus were released from burned lodgepole pines and other vegetation, boosting production in soils, streams, and rivers. More sunlight falling on the earth also created conditions conducive to the growth of some species. By the end of the 1990s, some lodgepole pines that seeded since 1988 were already about 1.8 m tall. More than a century will be needed for Yellowstone to return to pre-fire conditions, however (Robbins 1998).

next day ended (Gorte 1996). Parks Canada and the US Forest Service and National Park Service decided not to interfere with fires in wilderness areas and parts of national parks systems unless people or neighboring lands were threatened (COTF 2000; Turner 2001). In addition, prescribed burning and 'let burn' policies to reduce built-up fuels and protect settlements and businesses were introduced. These policies call for either purposefully lighting fires or allowing lightning fires to burn. Annually, over 2 million ha are treated by prescribed fire in the United States and 7,881 ha were deliberately burned in Canada in 2000 (CIFFC n.d., Mutch 1997). This policy has not been uncontroversial, however, as illustrated by the 1988 fires in Yellowstone National Park (see Box 52). The two countries have begun to work together, along with Mexico, to learn more about wildfire at the continental level, and have engaged in several joint initiatives and field experiments though the Fire Management Study Group (FMSG) of the 1958 North American Forestry Commission (NAFC 2000).

Road building in North America's forests has opened access to both people and wildfire. US government's studies suggest that fires are almost twice as likely to occur in roaded areas of forest than in those without roads. Another view is that keeping out roads allows fuel to accumulate, prevents access of forest protection services, and increases chances for large-scale fire damage. In 2001, a 'roadless rule' was announced in the United States that banned road building and other development on 23.7 million ha of national forests, or 2 percent of the US land base (USDA 2001).

The challenge of managing wildfire in North America has been exacerbated in recent decades by population increases in the urban-wildland interface, where settlement and other developments intermingle with flammable forests and grasslands (Hirsch 2000). The population growth rate in the US West now ranges from 2.5 to 13 percent, compared to the national annual average of about 1 percent. It is estimated that in the 1990s, wildfires damaged six times more homes than during the previous decade (Morrison, Karl and others 2000). In 1999, fire damage from all types of fire cost over US $10 billion, a 16 percent increase from the previous year (IFA 2000).

The 1988 and 1994 fire seasons were particularly severe in the United States and led to the 1995 revision in the federal wildland fire

Western Forests at Wildfire Risk, 1998

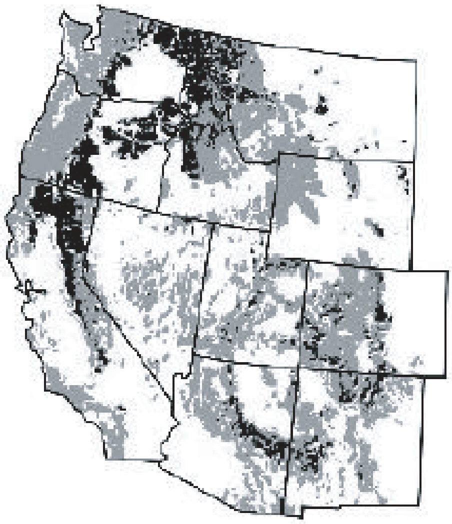

Figure 47
Western forests at wildfire risk, 1998.

Source: WGA 2000

policy. It underscores the important role of fire and the use of prescribed burns and thinning techniques to reduce hazardous fuel accumulations as well as the importance of further research to understand better the ecological significance of wildfire (CEQ 2000; Chepesiuk 2001). In 2001, the Western Governors' Association agreed to a 10-year plan to prevent wildfires, which included the thinning of fuel-rich areas, a strategy that has generated some controversy (Greenwire 2001). Figure 47 shows the regions most at risk for wildfire in the Western states.

Changes in climate that bring drier conditions and more severe storms also appear to play a role in changing fire patterns in North America. In 1989, for example, record fires burned in western Canada and the areas east of James Bay. They were caused by more frequent and extreme fire-weather conditions, including high tornado activity in the Prairies and an unprecedented heat wave in the Arctic

Box 53: The 2000 Fire Season

Although not excessively high compared to the national long-term average, fire activity in 2000 was especially high and severe in some regions, such as the northern Rockies and Texas. It was one of the worst fire seasons on record in the Western states, where more than 30,000 fires burned over 2.8 million ha of forests and grasslands (WGA 2002). About 8 percent of US fires occurred in dry forests on National Forest land where previous fire exclusion policies are thought to have created a build-up of brush and small trees that led to more severe wildfires (Morrison, Karl, and others 2000). Severe, long-lasting, La Niña-related drought, accompanied by thousands of lightning strikes from a series of storms, also contributed to the severity of the 2000 fire season (USDA Forest Service 2001).

Many fires burned in areas of urban-wildland interface, causing property losses and damage and disrupting community services (USDA Forest Service 2001). Over 400 homes were destroyed in the Los Alamos area of New Mexico, for example (Ross, Lott, and Brown 2000). In many instances, fire-fighting resources were stretched to the limit (CEQ 2000). In September, a report by the secretaries of Agriculture and the Interior was released in response to the wildfires of 2000. It provided an overall framework for fire management and forest health programs that includes increased investments in reducing fire risks and requirements to work with local communities to reduce fire hazards close to settlements (USDA Forest Service 2001).

(Jardine 1994; Flannigan, Stocks, and Wotton 2000). The severity of Canada's 1995 fire season, which burned 6.6 million ha of forestland, was also due in part to extremely dry conditions (EC 1999b). Drought and frequent winds in the year 2000 also contributed to a severe fire season in the western United States when more than 2.8 million ha of public and private lands went up in flames (USDA Forest Service 2001) (see Box 53).

Apart from the threat they pose to human settlements and lives and the valuable timber they may burn, wildfires can also emit large amounts carbon that contribute to greenhouse warming and send large amounts of particulate matter into the atmosphere. They can create smoke hazards as well, and some highways, airports and recreation areas periodically have to close because of reduced visibility. In addition, smoke constitutes a health hazard because of the variety of toxic chemicals and heavy metals it contains. Contaminants in the smoke can include carbon monoxide, hydrocarbons, benzo[*a*]pyrene, nitrogen oxides, and volatile oxygenated organic compounds, among others. Chronic exposure can lead to a number of respiratory ailments (Chepesiuk 2001).

Fires also have a direct impact on wildlife, killing hundreds of large mammals as well as more-vulnerable amphibians, nest-bound birds, rodents, and other small animals. They alter wildlife habitat, especially in the short term. On the other hand, many species depend on habitat that is maintained by periodic fires and suppressing fires can actually reduce the habitat available for some species (Turbak 2001). For example, the alteration of fire regimes through extensive fire suppression has contributed to the threatened status of a number of native habitats in the southern

United States (USGS 1999). The effects of wildfires also include runoff and erosion when vegetation dies and sediment and ash fall into watercourses (Chepesiuk 2001).

In the future, North America's annual fire severity rating may well grow as a result of climate change, which is predicted to augment the number of lightning strikes and the intensity and frequency of windstorms (Jardine 1994). Increasingly, research is being conducted into the potential links between climate and forest change. The Canadian Forest Service's Fire Research Network, for example, has initiated five science and technology programs (NRCan 1998).

Questions still remain about the proper roles of wildfire suppression, prescribed burning, salvage timber logging, fuel management, roadless areas, and other tools. Also part of the debate are the relative responsibilities of federal, state, and provincial governments to protect ecosystems and citizens, and those of home and landowners in the urban-wildland interface to take precautionary measures through proper home design, building materials, and property maintenance (Gorte 1996; Morrison, Karl, and others 2000).

More and more, human interference with the functioning of natural processes requires sharper scientific understanding about how the natural world functions and how humans need to adjust to live in harmony with nature. Both communities living in areas susceptible to natural hazards and the ecosystems in which they live need to maintain their resiliency in the face of naturally occurring, but potentially disastrous events that have been exacerbated by human activity.

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