

GAO

Report to the Committee on Homeland  
Security and Governmental Affairs,  
U.S. Senate

March 2007

# CLIMATE CHANGE

## Financial Risks to Federal and Private Insurers in Coming Decades Are Potentially Significant





Highlights of [GAO-07-285](#), a report to the Committee on Homeland Security and Governmental Affairs, U.S. Senate

# CLIMATE CHANGE

## Financial Risks to Federal and Private Insurers in Coming Decades Are Potentially Significant

### Why GAO Did This Study

Weather-related events have cost the nation billions of dollars in damages over the past decade. Many of these losses are borne by private insurers and by two federal insurance programs—the National Flood Insurance Program (NFIP), which insures properties against flooding, and the Federal Crop Insurance Corporation (FCIC), which insures crops against drought or other weather disasters.

GAO was asked to (1) describe how climate change may affect future weather-related losses, (2) determine past insured weather-related losses, and (3) determine what major private insurers and federal insurers are doing to prepare for potential increases in such losses. In response, among other things, GAO reviewed key scientific assessments; analyzed insured loss data; and contacted private insurers, NFIP, and FCIC.

### What GAO Recommends

GAO is recommending that the Secretaries of Agriculture and Homeland Security analyze the potential long-term fiscal implications of climate change for the FCIC and the NFIP, respectively, and report their findings to the Congress. In commenting on a draft of this report, the two agencies agreed with the recommendation. The Departments of Agriculture and Commerce made comments and suggestions on the presentation of several findings. The Department of Energy elected not to comment.

[www.gao.gov/cgi-bin/getrpt?GAO-07-285](http://www.gao.gov/cgi-bin/getrpt?GAO-07-285).

To view the full product, including the scope and methodology, click on the link above. For more information, contact John Stephenson at (202) 512-3841 or [stephensonj@gao.gov](mailto:stephensonj@gao.gov).

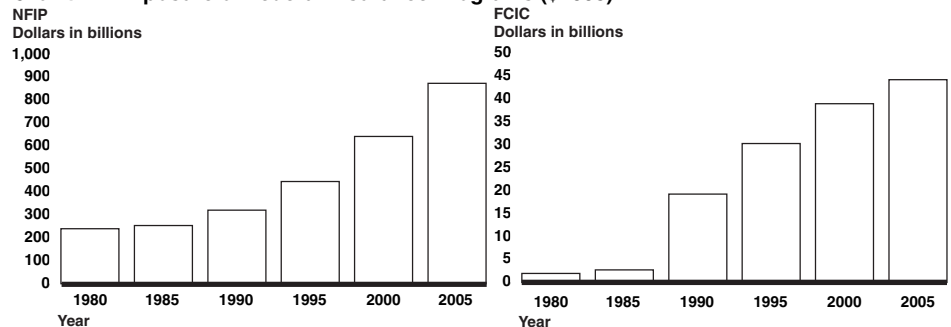
### What GAO Found

Key scientific assessments report that the effects of climate change on weather-related events and, subsequently, insured and uninsured losses, could be significant. The global average surface temperature has increased by 0.74 degrees Celsius over the past 100 years and climate models predict additional, perhaps accelerating, increases in temperature. The key assessments GAO reviewed generally found that rising temperatures are expected to increase the frequency and severity of damaging weather-related events, such as flooding or drought, although the timing and magnitude are as yet undetermined. Additional research on the effect of increasing temperatures on weather events is expected in the near future, including a highly anticipated assessment of the state of climate science this year.

Taken together, private and federal insurers paid more than \$320 billion in claims on weather-related losses from 1980 to 2005. Claims varied significantly from year to year—largely due to the effects of catastrophic weather events such as hurricanes and droughts—but have generally increased during this period. The growth in population in hazard-prone areas and resulting real estate development have generally increased liabilities for insurers, and have helped to explain the increase in losses. Due to these and other factors, federal insurers' exposure has grown substantially. Since 1980, NFIP's exposure quadrupled, nearing \$1 trillion in 2005, and program expansion increased FCIC's exposure 26-fold to \$44 billion.

Major private and federal insurers are both exposed to the effects of climate change over coming decades, but are responding differently. Many large private insurers are incorporating climate change into their annual risk management practices, and some are addressing it strategically by assessing its potential long-term industry-wide impacts. The two major federal insurance programs, however, have done little to develop comparable information. GAO acknowledges that the federal insurance programs are not profit-oriented, like private insurers. Nonetheless, a strategic analysis of the potential implications of climate change for the major federal insurance programs would help the Congress manage an emerging high-risk area with significant implications for the nation's growing fiscal imbalance.

**Growth in Exposure of Federal Insurance Programs (\$2005)**



Source: GAO.

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## Abbreviations

AAA	American Academy of Actuaries
AMO	Atlantic Multidecadal Oscillation
CCSP	Climate Change Science Program
FAIR	Fair Access to Insurance Requirements
FEMA	Federal Emergency Management Agency
FCIC	Federal Crop Insurance Corporation
HUD	Department of Housing and Urban Development
IPCC	Intergovernmental Panel on Climate Change
NAIC	National Association of Insurance Commissioners
NAS	National Academy of Sciences
NFIP	National Flood Insurance Program
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
PCS	Property Claim Services
RMA	risk Management Agency
SAP	synthesis and assessment product
SFIP	standard flood insurance policy
USDA	U.S. Department of Agriculture

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United States Government Accountability Office  
Washington, DC 20548

March 16, 2007

The Honorable Joseph I. Lieberman  
Chairman  
The Honorable Susan M. Collins  
Ranking Member  
Committee on Homeland Security and Governmental Affairs  
United States Senate

As the 2004 and 2005 hurricane seasons demonstrated, weather-related events can devastate affected communities and individuals, and are costly to the insurance industry, government disaster assistance programs, and other relief organizations. Apart from the record-setting losses experienced in 2005, weather-related events over the past decade have cost the country tens of billions of dollars each year.

The property and casualty segment of the insurance industry, spanning both the private and public sector, bears a large portion of weather-related losses.<sup>1</sup> The private sector includes primary insurers that insure individuals and businesses directly, and reinsurers that provide insurance to the primary insurers. The public sector includes federal programs—in particular, the National Flood Insurance Program (NFIP), which insures properties at risk of damage from flooding, and the Federal Crop Insurance Corporation (FCIC), which insures crops that are vulnerable to drought, floods, or other natural disasters. Many states also administer insurance pools that provide coverage for losses caused by weather-related events.

The uncertain and potentially large losses associated with weather-related events are among the biggest risks that property insurers face. Virtually anything that is insured—property, crops and livestock, business operations, or human life and health—is vulnerable to weather-related events. To remain financially solvent, the insurance industry must estimate and prepare for the potential impact of weather-related events. As such, any unanticipated changes in the frequency or severity of weather-related

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<sup>1</sup>Insurers use the term “loss” to refer to the dollar value of approved or settled claims arising from damages incurred by a policyholder. For the purposes of this report, weather-related loss refers to the dollar value of claims made on damage attributable to weather-related events. “Loss” does not account for premium or other income, deductibles, co-payments, or damages in excess of coverage.

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events can have financial consequences at the company level and industry-wide.

The earth's climate and weather patterns are dynamic, varying on seasonal, decadal, and longer time scales. The global average surface temperature has increased by 0.74 degrees Celsius over the past 100 years and climate models predict additional, perhaps accelerating, increases in temperature. While the temperature increases to date may appear small, climate models project that additional changes in temperature may alter social and economic activities in potentially profound ways. Much research and policy debate has centered on the extent to which human activities have contributed to the warming and how much is due to natural variability. For the purposes of this report, *climate change* refers to any change in the climate over time, whether due to natural variability or as a result of human activity.<sup>2</sup> Regardless of the cause, some contend that increasing temperatures—accompanied by changes in other aspects of the climate—may have adverse financial consequences for property insurers, which might slow the growth of the industry and shift more of the burden to governments and individuals.

Concerned about the implications of climate change for weather-related losses incurred by federal agencies and private insurers, you asked us to (1) describe what is known about how climate change might affect insured and uninsured losses, (2) determine insured losses incurred by major federal agencies and private insurers and reinsurers resulting from weather-related events, and (3) determine what major federal agencies and private insurers and reinsurers are doing to prepare for the potential risk of increased losses due to more frequent or more severe weather-related events associated with climate change.

To describe how climate change might affect insured and uninsured losses, we reviewed and summarized key scientific assessments by reputable international and national research organizations, including the Intergovernmental Panel on Climate Change *Third Assessment Report*, National Academy of Sciences reports, and the multifederal agency

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<sup>2</sup>More specifically, we used the Intergovernmental Panel on Climate Change definition, which refers to climate change as a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural factors (e.g., internal processes or external forcings such as solar variations or heavy volcanic activity), or to persistent human-induced changes in the composition of the atmosphere or land use patterns.

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Climate Change Science Program. To determine insured losses attributable to weather-related events, we analyzed data from 1980 through 2005 from the Department of Homeland Security's Federal Emergency Management Agency (FEMA) for the NFIP; from the Department of Agriculture's Risk Management Agency (RMA) for FCIC; and from the Property Claims Service, a leading source of insurance data. We analyzed changes in weather-related losses since 1980 and supplemented this analysis with a review of existing literature and the views of subject area experts on the key drivers of changes in losses.

To determine what key federal agencies and private insurers are doing to assess and manage the potential for increased losses, we conducted semistructured interviews with officials from the NFIP, RMA, and a sample of the largest private primary insurers and reinsurers in the United States, Europe, and Bermuda. The companies we interviewed represent about 45 percent of the total domestic insurance market but should not be generalized to represent all insurance companies. We also interviewed officials from catastrophe modeling firms, insurance industry associations, the National Association of Insurance Commissioners (NAIC),<sup>3</sup> and universities to provide additional context for respondents' statements. To supplement these interviews, we reviewed documentation of federal agencies' risk management practices, studies by subject area experts, industry reports, insurance company documents, and previous GAO reports. We performed our work between February 2006 and January 2007 in accordance with generally accepted government auditing standards. A more extensive discussion of our scope and methodology appears in appendix I.

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## Results in Brief

Assessments by the National Academy of Sciences (NAS) and the Intergovernmental Panel on Climate Change (IPCC), a leading source for international climate expertise, report that the effects of climate change on weather-related events and—by extension—weather-related losses could be substantial. IPCC reports that global mean temperatures increased by 0.74 degrees Celsius over the last 100 years and are projected to continue to rise over the next century. Although temperatures have varied throughout history due to natural processes, such as changes in the Earth's orbit and volcanic eruptions, the IPCC and NAS report that the

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<sup>3</sup>The National Association of Insurance Commissioners is an organization of insurance regulators from the 50 states, the District of Columbia, and the five U.S. territories.



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observed temperature increase during the twentieth century cannot be explained by natural variability alone but is largely attributable to human activities. Warmer surface temperatures are linked to global-scale oceanographic, meteorological, and biological changes. For example, as the earth warms, more water evaporates from oceans and other sources, eventually falling as rain or snow. Key assessments that rely on both observational data and computer models have reported that warmer temperatures are expected to increase the frequency and severity of damaging extreme weather-related events (such as flooding or drought), although the timing, magnitude, and duration of these changes are as yet undetermined. Further research on the effect of increasing temperature on weather events is ongoing. Of particular note, the IPCC is expected to release its fourth assessment of the state of climate science throughout 2007, and the Climate Change Science Program is currently assessing potential changes in the frequency or intensity of weather-related events specific to North America in a report scheduled for release in 2008.

Taken together, private and federal insurers paid more than \$320 billion in claims on weather-related losses from 1980 through 2005. In constant dollars, private insurers paid the largest part of the claims during this period, \$243.5 billion (about 76 percent); followed by federal crop insurance, \$43.6 billion (about 14 percent); and federal flood insurance, \$34.1 billion (about 11 percent). Claims varied significantly from year to year—largely due to the incidence and effects of catastrophic weather events such as hurricanes and droughts—but generally increased during this period. In particular, the years with the largest insured losses were generally associated with major hurricanes, which comprised well over one-third of all weather-related losses since 1980. The growth in population in hazard-prone areas, and resulting real estate development and increasing real estate values, have increased federal and private insurers' exposure, and have helped to explain the increase in losses. In particular, heavily-populated areas along the Northeast, Southeast, and Texas coasts have among the highest value of insured properties in the United States and face the highest likelihood of major hurricanes. Due to these and other factors, federal insurers' exposures have grown substantially. Since 1980, NFIP's exposure has quadrupled, nearing \$1 trillion, and program expansion has increased FCIC's exposure nearly 26-fold to \$44 billion. These escalating exposures to catastrophic weather events are leaving the federal government at increased financial risk. FCIC officials told us, for example, that if the widespread Midwest floods of 1993 were to occur today, losses would be five times greater.

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While both major private and federal insurers are exposed to increases in the frequency or severity of weather-related events associated with climate change, the two sectors are responding in different ways. Using computer-based catastrophe models, many major private insurers are incorporating some near-term elements of climate change into their risk management practices. One consequence is that, as these insurers seek to limit their own catastrophic risk exposure, they are transferring some of it to policyholders and to the public sector. In addition, some private insurers are approaching climate change at a strategic level by publishing reports outlining the potential industry-wide impacts and strategies to proactively address the issue. Federal insurance programs, on the other hand, have done little to develop the kind of information needed to understand the programs' long-term exposure to climate change for a variety of reasons. The federal insurance programs are not oriented toward earning profits like private insurers but rather toward increasing participation among eligible parties. Consequently, neither program has had reason to develop information on their long-term exposure to the fiscal risks associated with climate change.

We acknowledge the different mandate and operating environment in which the major federal insurance programs operate, but we believe that better information about the federal government's exposure to potential changes in weather-related risk would help the Congress identify and manage this emerging high-risk area—one which may not constitute an immediate crisis, but which does have significant implications for the nation's growing fiscal imbalance. Accordingly, GAO is recommending that the Secretary of Agriculture and the Secretary of Homeland Security direct the Under Secretary for Farm and Foreign Agricultural Services and the Under Secretary of Homeland Security for Emergency Preparedness to analyze the potential long-term fiscal implications of climate change for the FCIC and the NFIP, respectively, and report their findings to the Congress.

In commenting on a draft of this report, both the Departments of Agriculture (USDA) and Homeland Security (DHS) agreed with our recommendation, and USDA commented on the presentation of several findings in the draft. The Department of Commerce neither agreed nor disagreed with the report's findings, but instead commented on the presentation of several issues in the draft and offered technical comments which we incorporated into this report as appropriate. The Department of Energy elected not to provide comments on the draft.

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## Background

Insurance is a mechanism for spreading risk over time, across large geographical areas, and among industries and individuals. While insurers assume some financial risk when they write policies, they employ various strategies to manage risk so that they earn profits, limit potential financial exposures, and build capital needed to pay claims.<sup>4</sup> For example, they charge premiums for coverage and establish underwriting standards, such as refusing to insure customers who pose unacceptable levels of risk, or limiting coverage in particular geographic areas. Insurance companies may also purchase reinsurance to cover specific portions of their financial risk. Reinsurers use similar strategies to limit their risks, including charging premiums, establishing underwriting standards, and maintaining close, long-term business relationships with certain insurers.

Both insurers and reinsurers must also predict the frequency and severity of insured losses with some reliability to best manage financial risk.<sup>5</sup> In some cases, these losses may be fairly predictable. For example, the incidence of most automobile insurance claims is predictable, and losses generally do not occur to large numbers of policyholders at the same time. However, some infrequent weather-related events—hurricanes, for example—are so severe that they pose unique challenges for insurers and reinsurers. Commonly referred to as catastrophic or extreme events, the unpredictability and sheer size of these events—both in terms of geography and number of insured parties affected—have the potential to overwhelm insurers' and reinsurers' capacity to pay claims. Catastrophic events may affect many households, businesses, and public infrastructure across large areas, resulting in substantial losses that deplete insurers' and reinsurers' capital.

Given the higher levels of capital that reinsurers must hold to address catastrophic events, reinsurers generally charge higher premiums and restrict coverage for such events. Further, in the wake of catastrophic events, reinsurers and insurers may sharply increase premiums to rebuild capital reserves and may significantly restrict insurance and reinsurance coverage to limit exposure to similar events in the future.

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<sup>4</sup>Federal insurance programs are not designed to earn financial profits.

<sup>5</sup>To insure a risk, private insurers must be able to both estimate an event's occurrence and its associated damages and be able to set premiums sufficient to cover their risk and earn a profit. In some cases, insurers may be prevented from charging sufficient premiums due to state regulatory actions.

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Under certain circumstances, the private sector may determine that a risk is uninsurable. For example, while homeowner insurance policies typically cover damage and losses from fire and other perils, they usually do not cover flood damage because private insurance companies are largely unwilling to bear the financial risks associated with its potentially catastrophic impact. In other instances, the private sector may be willing to insure a risk, but at rates that are not affordable to many property owners. Without insurance, affected property owners must rely on their own resources or seek out disaster assistance from local, state, and federal sources.

In situations where the private sector will not insure a particular type of risk, the public sector may create markets to ensure the availability of insurance. For example, several states have established Fair Access to Insurance Requirements (FAIR) plans, which pool resources from insurers doing business in the state to make property insurance available to property owners who cannot obtain coverage in the private insurance market, or cannot do so at an affordable rate. In addition, six southern states have established windstorm insurance pools that pool resources from private insurers to make insurance available to property owners who cannot obtain it in the private insurance market.

Similarly, at the federal level, the Congress established the NFIP and the FCIC to provide coverage where voluntary markets do not exist.<sup>6</sup> The Congress established the NFIP in 1968, partly to provide an alternative to disaster assistance for flood damage. Participating communities are required to adopt and enforce floodplain management regulations, thereby reducing the risks of flooding and the costs of repairing flood damage. FEMA, within the Department of Homeland Security, is responsible for, among other things, oversight and management of the NFIP. Under the program, the federal government assumes the liability for covered losses and sets rates and coverage limitations.

The Congress established the FCIC in 1938 to temper the economic impact of the Great Depression and the weather effects of the dust bowl. In 1980, the Congress expanded the program to provide an alternative to disaster assistance for farmers that suffer financial losses when crops are damaged by droughts, floods, or other natural disasters. Farmers' participation is

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<sup>6</sup>See appendixes II and III for additional information on how these programs operate, how they assess risk, and how they are funded.

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voluntary, but the federal government encourages it by subsidizing their insurance premiums. USDA's RMA is responsible for administering the crop insurance program, including issuing new insurance products and expanding existing insurance products to new geographic regions. RMA administers the program in partnership with private insurance companies, which share a percentage of the risk of loss or the opportunity for gain associated with each insurance policy written.

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## Climate Change May Increase Losses by Altering the Frequency or Severity of Weather-Related Events

Global temperatures have increased in the last 100 years and are projected to continue to rise over the next century. Using observational data and computer modeling, climatologists and other scientists are assessing the likely effects of temperature rise associated with climate change on precipitation patterns and on the frequency and severity of weather-related events. The key scientific assessments we reviewed generally found that warmer temperatures are expected to alter the frequency or severity of damaging weather-related events, such as flooding or drought, although the timing, magnitude, and duration of these changes are as yet undetermined. Additional research on the effect of increasing temperature on weather events is expected in the near future. Nevertheless, research suggests that the potential effects of climate change on damaging weather-related events could be significant.

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## Warming Temperatures Are Expected to Alter the Frequency and Severity of Damaging Extreme Weather-Related Events

We reviewed the reports released by IPCC, NAS, and the federal Climate Change Science Program (CCSP) that are shown in figure 1.<sup>7</sup> These leading scientific bodies report that the Earth warmed during the twentieth century—0.74 degrees Celsius from 1906 to 2005 according to a recent IPCC report—and is projected to continue to warm for the foreseeable future.<sup>8</sup> IPCC, NAS, CCSP, and other scientific bodies report that this increase in temperature cannot be explained by natural variation alone. IPCC's 2001 assessment of the impact of increasing temperatures on extreme weather events found that it was likely the frequency and severity

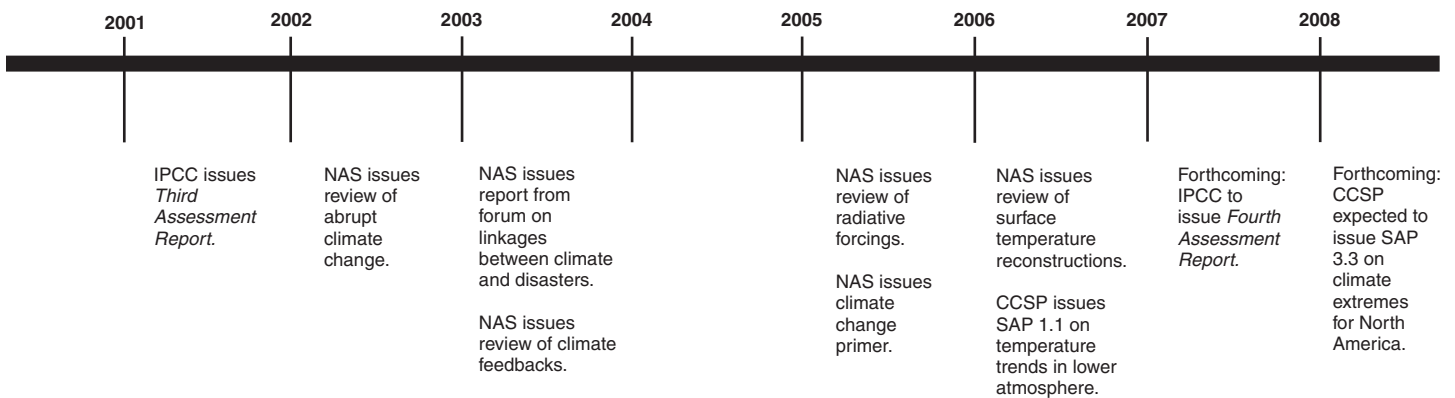
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<sup>7</sup>Appendix I contains additional information on the specific assessments we reviewed. CCSP is a multiagency effort to coordinate federal climate change science that is responsible for preparing a series of 21 climate science synthesis and assessment products (SAP) for the United States by 2008.

<sup>8</sup>This estimate comes from a recently released summary of a key component of IPCC's *Fourth Assessment Report* of the state of climate science, which reported an updated 100-year linear trend (1906-2005) of 0.74 degrees Celsius—larger than the corresponding 0.6 degrees Celsius reported in the 2001 *Third Assessment Report*.

of several types of events will increase as greenhouse gas emissions continue.<sup>9</sup>

**Figure 1: Time Line of Key Scientific Assessments**



Source: GAO.

### Average Global Temperatures Have Increased and Are Expected to Continue to Rise

The earth's climate system is driven by energy from the sun and is maintained by complex interactions between the atmosphere, the oceans, and the reflectivity of the earth's surface, among other factors. Upon reaching the earth, the sun's energy is either reflected back into space, or is absorbed by the earth and is subsequently reemitted. However, certain gases in the earth's atmosphere—such as carbon dioxide and methane—act like the glass in a greenhouse to trap some of the sun's energy and prevent it from returning to space. While these gases play an important part in maintaining life on earth, their accumulation in the atmosphere can significantly increase global temperatures.

The earth warmed by roughly 0.74 degrees Celsius over the past 100 years, and is projected to continue warming for the foreseeable future. While temperatures have varied throughout history, triggered by natural factors such as volcanic eruptions or changes in the earth's orbit, the key scientific assessments we reviewed have generally concluded that the observed increase in temperature in the past 100 years cannot be explained by natural variability alone. In recent years, major scientific

<sup>9</sup>For the purposes of this report, extreme weather-related events are those with a low frequency of occurrence, but that cause severe damage, such as hurricanes, drought, winter storms, tornadoes, wildfires, and floods, among others.

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bodies such as the IPCC, NAS, and the Royal Academy (the United Kingdom's national academy of science) have concluded that human activities, including the combustion of fossil fuels, industrial and agriculture processes, landfills, and some land use changes, are significantly increasing the concentrations of greenhouse gases and, in turn, global temperatures.

Although climate models produce varying estimates of the extent of future changes in temperature, NAS and other scientific organizations have concluded that available evidence points toward continued global temperature rise. Assuming continued growth in atmospheric concentration of greenhouse gases, the latest assessment of computer climate models projects that average global temperatures will warm by an additional 1.8 to 4.0 degrees Celsius during the next century.<sup>10</sup>

Some scientists have questioned the significance of the earth's present temperature rise relative to past fluctuations. To address this issue, the NAS recently assessed the scientific community's efforts to reconstruct temperatures of the past 2,000 years and place the earth's current warming in an historical context.<sup>11</sup> Based on its review, the NAS concluded with a high level of confidence that global mean surface temperature was warmer during the last few decades of the twentieth century than during any comparable period during the preceding 400 years. Moreover, NAS cited evidence that temperatures at many, but not all, individual locations were higher during the past 25 years than any period of comparable length over the past 1,100 years.

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<sup>10</sup>IPCC narrowed its range of projected warming in its recently released summary from the corresponding range of 1.4 to 5.8 degrees Celsius reported in the 2001 *Third Assessment Report*. Although these two sets of projections are broadly consistent, they are not directly comparable. IPCC notes in the summary that the new range is more advanced in that it provides best estimates and an assessed likelihood range. It also relies on a larger number of climate models of increasing complexity and realism, as well as new information regarding the nature of feedbacks from the carbon cycle and constraints on climate response from observations.

<sup>11</sup>National Research Council, *Surface Temperature Reconstructions for the Last 2,000 Years* (Washington, D.C.: 2006).

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## IPCC Expects Continued Warming to Alter Frequency and Severity of Damaging Extreme Weather-Related Events

Determining the precise nature and extent of the relationship between average global temperatures and weather-related events is an exceedingly challenging task. Several key assessments of the state of this science have addressed the large body of work on this topic. Using observational data and computer models, scientists are examining the effects of rising temperatures on precipitation patterns and the frequency and severity of extreme weather-related events. The complexity of weather systems, together with the limited statistical precision of projections of the extent of future temperature change, often produces different model results, and the results themselves represent a range of potential future conditions.

Nonetheless, a key assessment of climate model projections indicates that an increase is likely in the frequency or severity of damaging extreme weather-related events. In 2001, the IPCC, a leading scientific authority on climate science, released its *Third Assessment Report*, which assessed the state of knowledge of, among other things, the potential for global changes in extreme weather-related events. The IPCC described the relationship between temperatures, precipitation, and weather-related events. Increased global mean surface temperatures are linked to global-scale oceanographic, meteorological, and biological changes. For example, as the earth warms, more water evaporates from oceans or lakes, eventually falling as rain or snow. IPCC reported that permafrost is thawing, and the extent of sea ice, snow cover, and mountain glaciers are generally shrinking. The IPCC also noted that global sea level rose between 0.1 and 0.2 meters during the twentieth century through thermal expansion of seawater and widespread loss of land ice, and that this sea level rise could increase the magnitude of hurricane storm surge in some areas. Warming is expected to change rainfall patterns, partly because warmer air holds more moisture.

Based on model projections and expert judgment,<sup>12</sup> the IPCC reported that future increases in the earth's temperature are likely to increase the frequency and severity of many damaging extreme weather-related events (summarized in table 1). For instance, IPCC reported that increased drought is likely across many regions of the globe, including the U.S. Great

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<sup>12</sup>Likelihoods for projected changes are defined by the following conditions set by the IPCC: "very likely" indicates that a number of models have been analyzed for such a change, all those analyzed show it in most regions, and it is physically plausible; and "likely" indicates that theoretical studies and those models analyzed show such a change, but only a few models are configured in such a way as to reasonably represent such changes.



Plains. Also, IPCC concluded that the intensity of precipitation events is very likely to increase across almost all regions of the globe and that heavy precipitation events are expected to become more frequent. Compared with projected temperature increases, changes in the frequency and severity of extreme events can occur relatively rapidly, according to the IPCC.

**Table 1: Selected IPCC Estimates of Confidence in Projected Changes in Weather-Related Events**

Weather-related event	Confidence in projected future changes
Higher maximum temperatures and more hot days over nearly all land areas	Very likely
Higher minimum temperatures and fewer cold and frost days over nearly all land areas	Very likely
More intense precipitation events	Very likely
Increased summer drying and associated risks of drought	Likely <sup>a</sup>
Increase in hurricane peak wind intensities	Likely <sup>b</sup>
Increase in hurricane average and peak precipitation intensities	Likely

Source: IPCC, *Climate Change 2001: The Scientific Basis*, 2001.

<sup>a</sup>Projections for most midlatitude continental interiors. IPCC found a lack of consistent projections in other regions.

<sup>b</sup>IPCC reported that changes in the regional distribution of hurricanes are possible but have not been established.

Much research has been done since the IPCC's *Third Assessment Report*, but there has not been a similarly rigorous assessment of what is known with regard to temperature increase, precipitation, and weather-related events for the United States.<sup>13</sup> However, significant assessments will be completed in the near future. In particular, the IPCC is expected to release its *Fourth Assessment Report* throughout 2007.

<sup>13</sup>The most recent national assessment for the United States, entitled *Climate Change Impacts on the United States*, was forwarded by a federal advisory committee to the Congress and the President in 2000 as required by the Global Change Research Act of 1990. We reported in 2005 that the subsequent assessment was not submitted in November 2004 as required by the act. Instead, according to the Department of Commerce, CCSP has committed to issuing 21 shorter reports by 2008. See GAO, *Climate Change Assessment: Administration Did Not Meet Reporting Deadline*, [GAO-05-338R](#) (Washington, D.C.: Apr. 14, 2005).

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While we were completing our review, the IPCC released a summary of the first of three components of its *Fourth Assessment Report*, which builds upon past IPCC assessments and incorporates new findings from the physical science research since the *Third Assessment Report*. The summary reports higher confidence in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation, and some aspects of extreme events. In particular, the summary reports that it is very likely that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent. Moreover, based on a range of models, IPCC's summary states that it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases in tropical sea surface temperatures. IPCC reports less confidence in projections of a global decrease in the number of tropical cyclones, and that the apparent increase in the proportion of very intense storms since 1970 in some regions is much larger than simulated by current models for that period. The full first component report was not publicly released prior to the issuance of our report and is expected some time after May 2007.

The other two components of the *Fourth Assessment Report* will cover impacts, adaptation, and vulnerability, and mitigation. These reports are expected to assess, among other things, key vulnerabilities and risks from climate change, including changes in extreme events. Additionally, the IPCC has committed to producing a capping report that is intended to synthesize and integrate material contained in the forthcoming reports, as well as other IPCC products.

In addition to the IPCC's work, CCSP is assessing potential changes in the frequency or intensity of weather-related events specific to North America in a report scheduled for release in 2008. According to a National Oceanic and Atmospheric Administration (NOAA) official and agency documents, the report will focus on weather extremes that have a significant societal impact, such as extreme cold or heat spells, tropical and extra-tropical storms, and droughts. Importantly, officials have said the report will provide an assessment of the observed changes in weather and climate extremes, as well as future projections.

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## More Frequent or More Severe Extreme Weather-Related Events Could Significantly Increase Insured Losses

Extreme weather-related events impact communities and economic activity by damaging homes and vehicles (e.g., see fig. 2), interrupting electrical service and business operations, or destroying crops. IPCC reported that the insurance industry—especially the property and casualty segment—are sensitive to the effects of weather-related events. This was highlighted in the Department of Commerce’s comments on a draft of this report, which observed that altering either the frequency or severity of high impact extreme weather-related events could result in a significant increase in the risk posed to an insurer. For example, the agency said that what had been considered a 500-year event (i.e., its probability of occurring in a given year is 1 in 500) could shift under climate change to become a 100-year event (i.e., its probability of occurring in a given year is 1 in 100). Consequently, more frequent or more severe events have a greater potential for damage and, in turn, insured losses. As an official from Aon Re Australia, a large global reinsurer, reported, “The most obvious impact of climate change on the insurance sector will be the increase in insured property losses from extreme weather events.”<sup>14</sup>

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<sup>14</sup>Andrew Dlugolecki, *The Changing Risk Landscape: Implications for Insurance Risk Management* (1999) [http://www.aon.com.au/pdf/reinsurance/Aon\\_Climate\\_Change.pdf](http://www.aon.com.au/pdf/reinsurance/Aon_Climate_Change.pdf) (downloaded Jan. 8, 2007).

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**Figure 2: July 1993 Flood Damage at Chesterfield Airport in St. Louis, Missouri**



Source: FEMA.

Note: According to FEMA, the depth of the floodwaters underscores the extent of the damage caused by the 1993 Midwest flood. A total of 534 counties in nine states were declared for federal disaster aid.

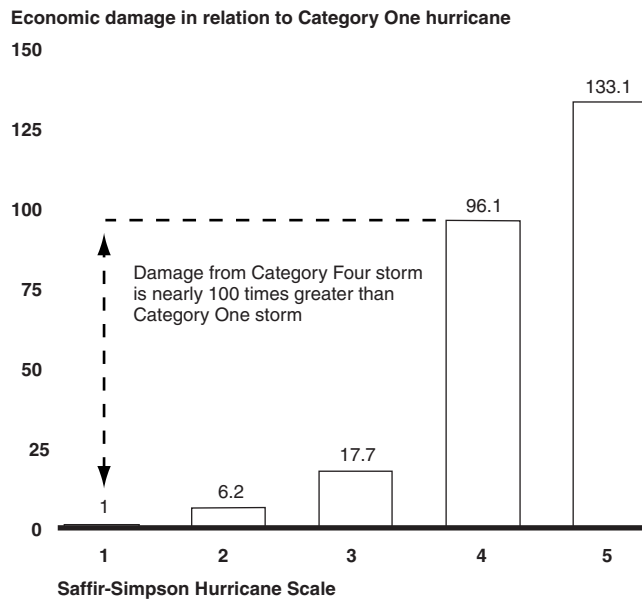
Notably, the economic damages associated with some extreme weather-related events could increase at a greater rate in comparison with changes in the events themselves. Seemingly small changes in the characteristics of certain weather-related events can lead to substantial increases in damage. For example, recent work on hurricanes by researchers at the University of Colorado, the National Weather Service, and other institutions examined losses associated with hurricanes that made landfall in the United States since 1900.<sup>15</sup> Holding constant the increased population and development in coastal counties during this period, the study compared the economic damage of stronger storms with weaker storms, based on

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<sup>15</sup>See Roger Pielke, Jr., et al., *Normalized Hurricane Damages in the United States: 1900-2005* (2007), accessed via [http://sciencepolicy.colorado.edu/publications/special/normalized\\_hurricane\\_damages.html](http://sciencepolicy.colorado.edu/publications/special/normalized_hurricane_damages.html) (downloaded Jan. 8, 2007).

the Saffir-Simpson Hurricane Scale.<sup>16</sup> The researchers found that stronger storms have caused many times more economic damages than weaker storms, as shown in figure 3. These findings are consistent with other independent analyses conducted by insurers and catastrophe modelers.

**Figure 3: Economic Damages by Hurricane Category for U.S. Hurricanes Making Landfall, 1900-2005**



Source: GAO adaption of Pielke et al. data.

Note: Value of each bar compares the median economic damage associated with hurricanes of that Saffir-Simpson category with the median economic damage of Category One storms. Of the 158 hurricanes reviewed, only three were Category Five.

Moreover, public reports from several of the world's largest reinsurance companies and brokers underscore the potential for substantially increased losses. These reports note that, in addition to greater losses in

<sup>16</sup>The Saffir-Simpson hurricane intensity category system was developed in the 1970s to calculate the destructive force of hurricanes. The scale ranges from Category One to Category Five, with Category Five being the most severe. For example, Category Three hurricanes have winds of 111 to 130 mph, whereas Category Five hurricanes have winds greater than 155 mph.

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absolute terms, the potential for greater variability in weather-related events could significantly enhance the volatility of losses.

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## Insured Weather-Related Losses Have Been Sizeable, and Federal Insurers' Exposure Has Grown Significantly

Taken together, insurers paid more than \$320 billion in claims for weather-related losses between 1980 and 2005.<sup>17</sup> Claims varied significantly from year to year—largely due to the effects of catastrophic weather events such as hurricanes and droughts—but generally increased during this period. The growth in population in hazard-prone areas, and consequent real estate development and increasing real estate values, have generally increased insurers' exposure to weather-related events and help to explain their increased losses. Due to these and other factors, the federal insurance programs' liabilities have grown significantly, leaving the federal government increasingly vulnerable to the financial impacts of extreme events.

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## Claims Paid on Weather-Related Losses Totaled More Than \$320 Billion between 1980 and 2005

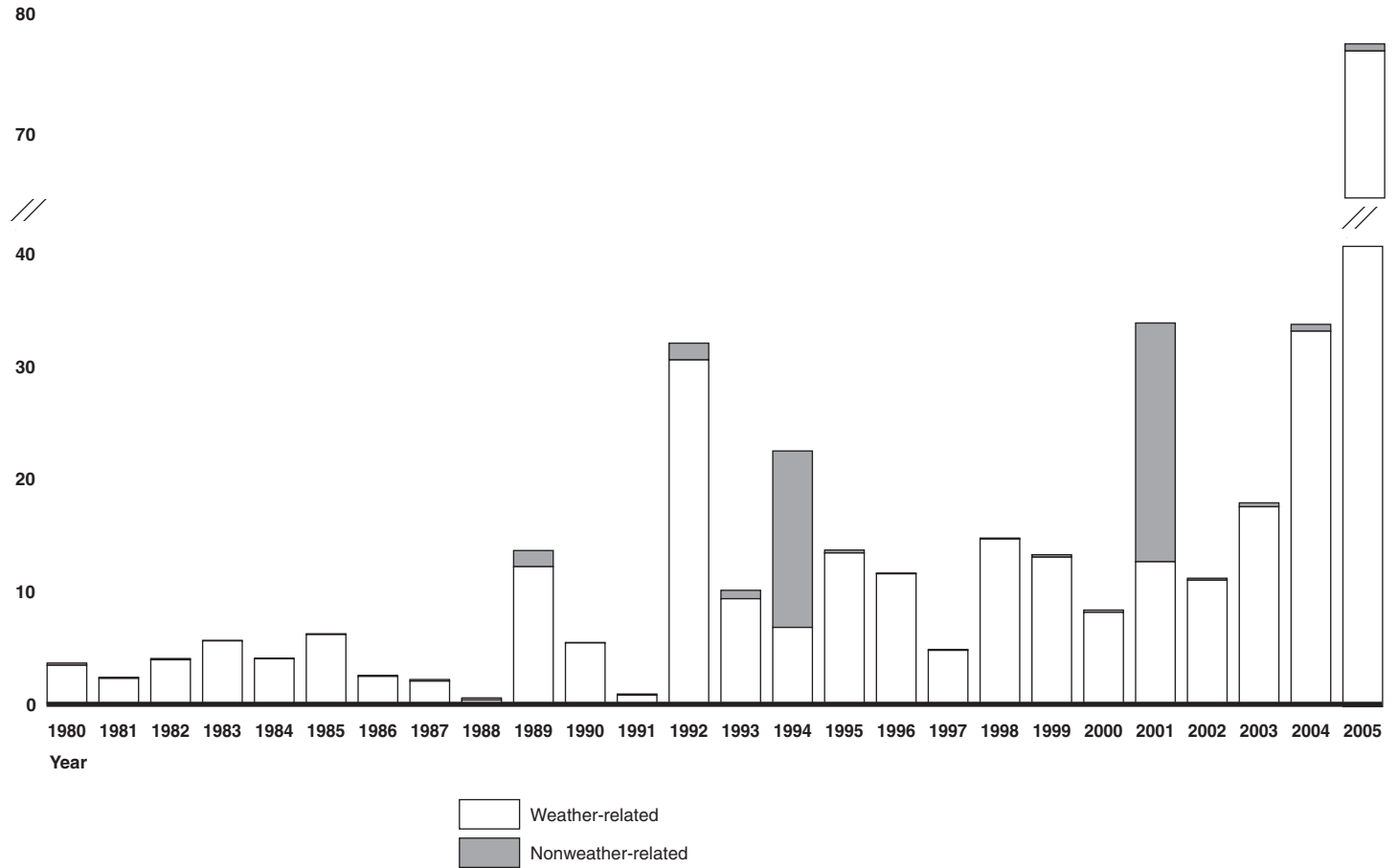
Based on an examination of loss data from several different sources, insurers incurred more than \$320 billion in weather-related losses from 1980 through 2005 (see fig. 4). Weather-related losses accounted for 88 percent of *all* property losses paid by insurers during this period. All other property losses, including those associated with earthquakes and terrorist events, accounted for the remainder. Weather-related losses varied significantly from year to year, ranging from just over \$2 billion in 1987 to more than \$75 billion in 2005.

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<sup>17</sup>Data throughout this section are presented in constant 2005 dollars to allow for a comparison of the dollar value of losses over time and are not otherwise adjusted. See appendix I for more information on data used in this report.

**Figure 4: Annual Weather- and Nonweather-Related Insured Losses**

Dollars in billions

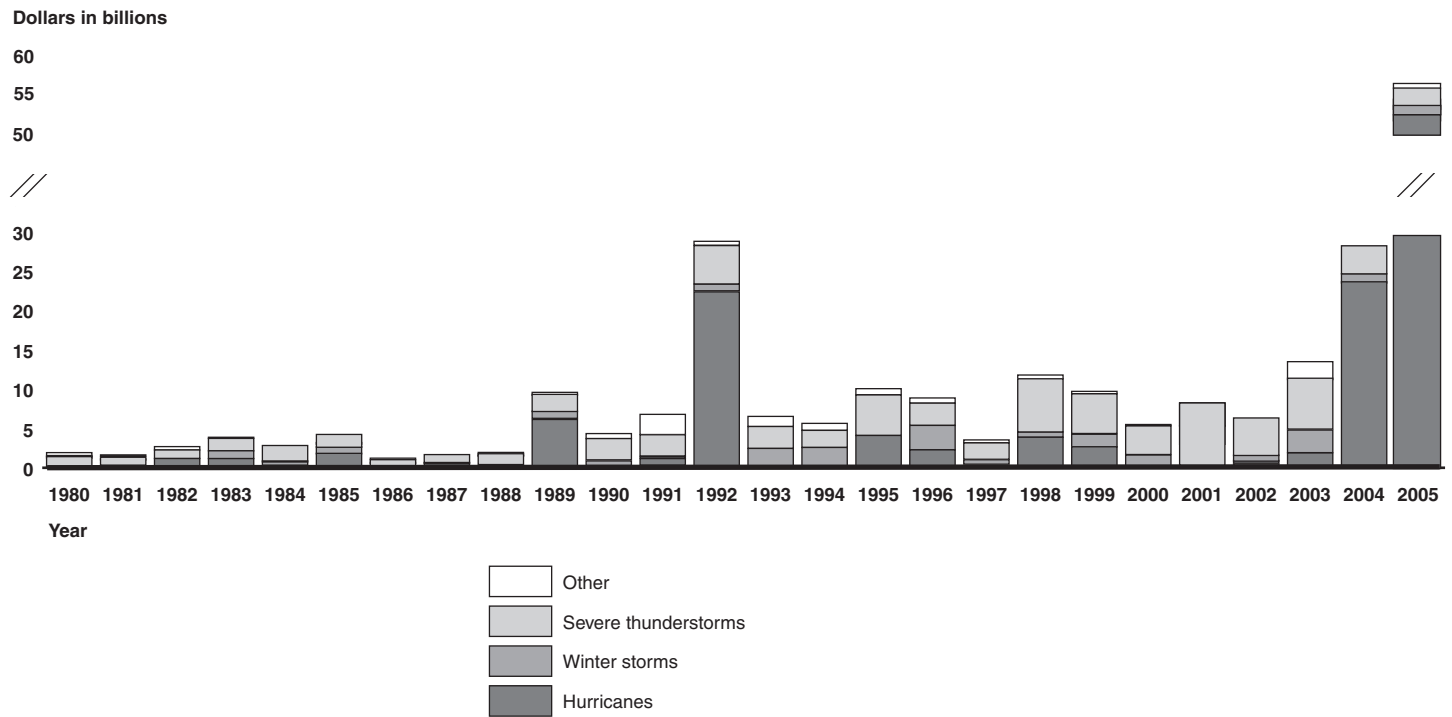


Sources: GAO analysis of PCS, NFIP, and FCIC data.

**Privately-Insured Losses**

Of the \$321.2 billion in weather-related loss payments we reviewed, private insurers paid \$243.5 billion—over three-quarters of the total.<sup>18</sup> Figure 5 depicts the breakdown of these payments among key weather-related events. Of the \$243.5 billion paid by private insurers, hurricanes accounted for \$124.6 billion, or slightly more than half. Wind, tornados, and hail associated with severe thunderstorms accounted for \$77 billion, or nearly one-third of the private total. Winter storms were associated with \$25.1 billion, or about 10 percent.

**Figure 5: Weather-Related Losses Paid by Private Insurers**



Source: GAO analysis of PCS data.

<sup>18</sup>Property Claim Services (PCS), an authority on insured property losses, maintains a database of estimated losses determined to be “catastrophes”—that is, loss events larger than \$25 million that affect a significant number of policyholders. PCS estimates include losses under personal and commercial property insurance policies and typically include payments made on behalf of state-administered risk pools. PCS data are described in greater detail in appendix I.



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## Federally-Insured Losses

The two major federal insurance programs—NFIP and FCIC—paid the remaining \$77.7 billion of the \$321.2 billion in weather-related loss payments we reviewed.<sup>19</sup> Although the performance of both NFIP and FCIC is sensitive to weather, the two programs insure fundamentally different risks and operate in very different ways.

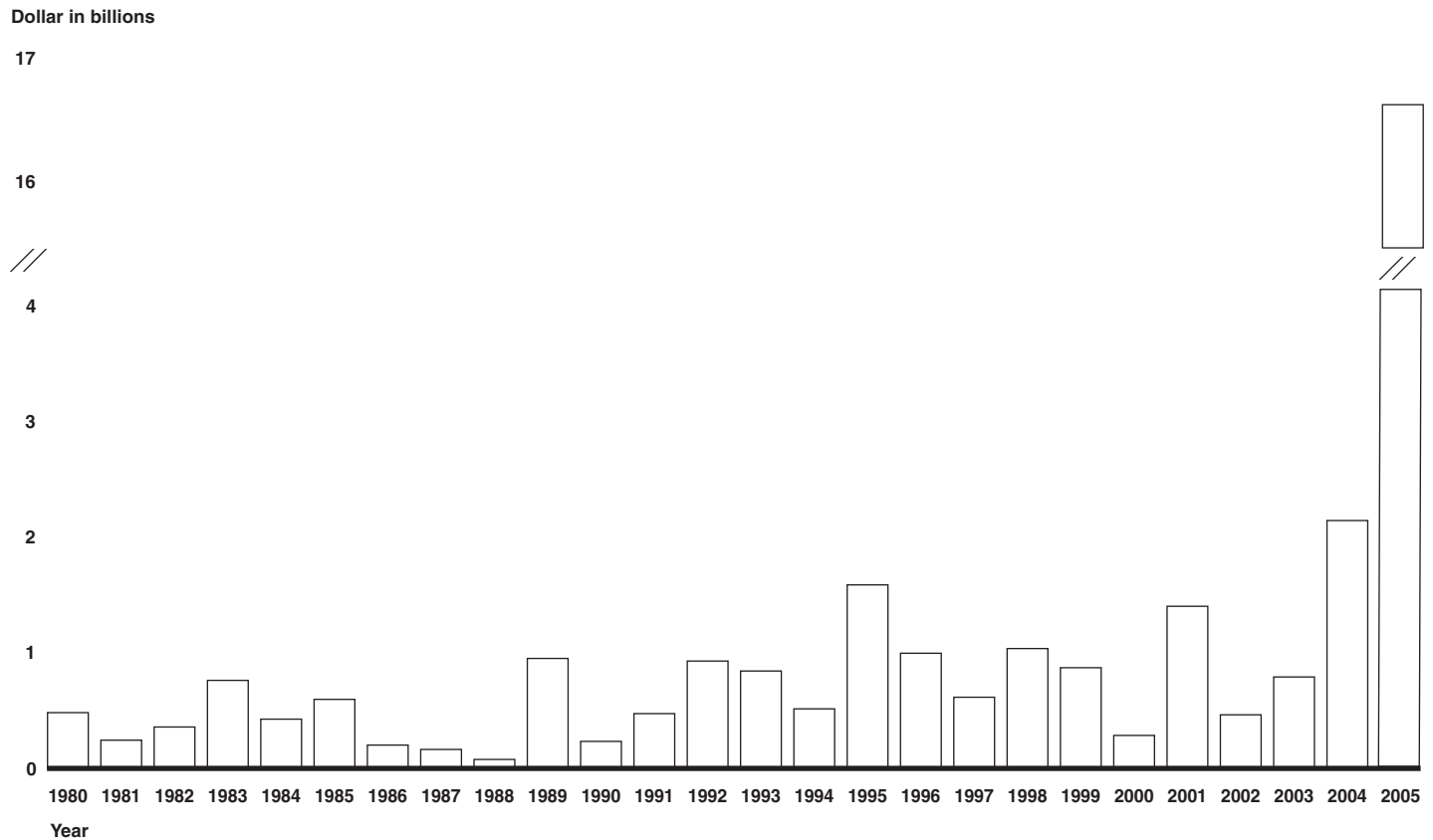
NFIP provides insurance for flood damage to homeowners and commercial property owners in more than 20,000 communities. Homeowners with mortgages from federally regulated lenders on property in communities identified as being in high flood risk areas are required to purchase flood insurance on their dwellings. Optional, lower cost flood insurance is also available under the NFIP for properties in areas of lower flood risk. NFIP offers coverage for both the property and its contents, which may be purchased separately.

NFIP claims totaled about \$34.1 billion, or about 11 percent of all weather-related insurance claims during this period. As shown in figure 6, NFIP covers only one cause of loss—flooding. Claims averaged about \$1.3 billion per year, but ranged from \$75.7 million in 1988 to \$16.7 billion in 2005.

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<sup>19</sup>Appendixes II and III provide additional information about the structure and operation of FCIC and NFIP. Importantly, totals only reflect what was paid during this time—some losses incurred in 2005 may be omitted from this data set.

**Figure 6: Weather-Related Losses Paid by NFIP**

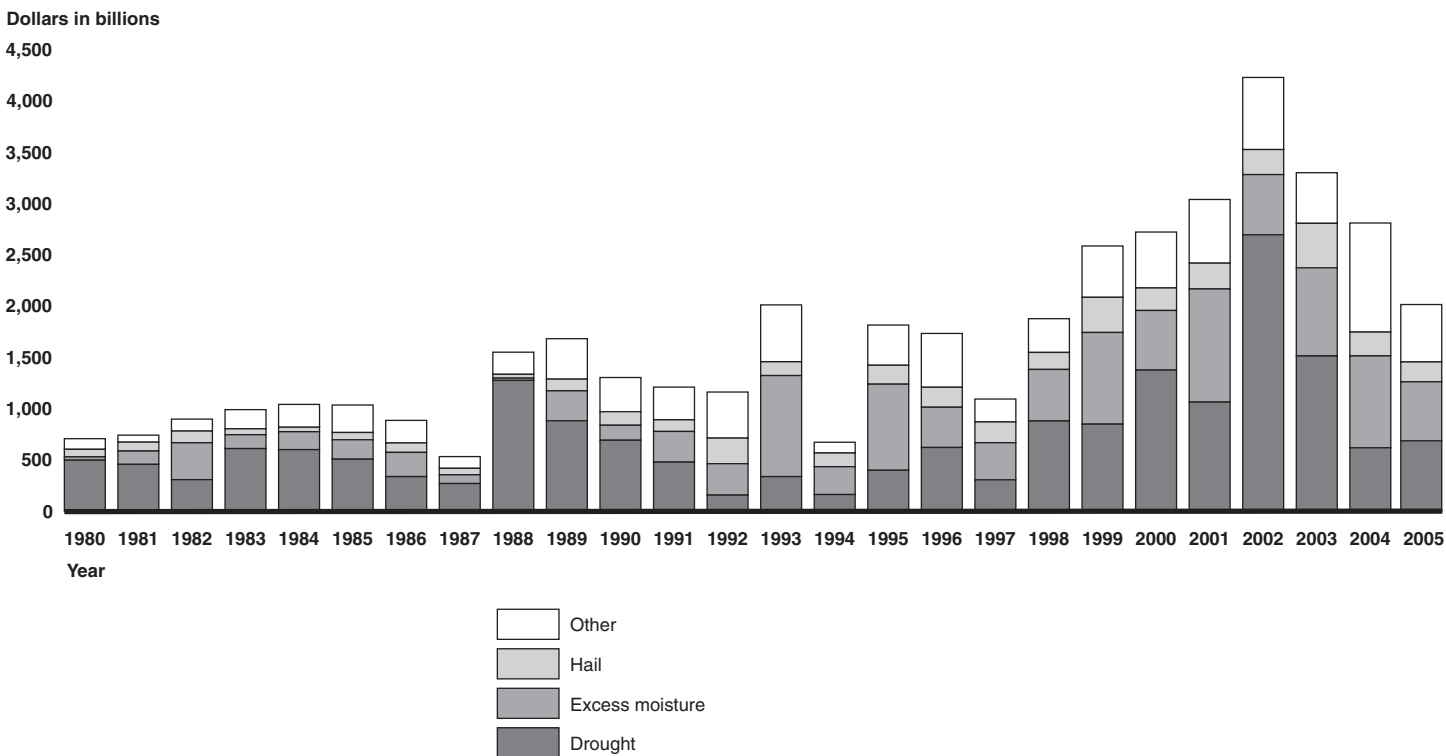


Source: GAO analysis of NFIP data.

FCIC insures commodities on a crop-by-crop and county-by-county basis based on farmer demand for coverage and the level of risk associated with the crop in a given region. Over 100 crops are covered by the program. Major crops, such as grains, are covered in almost every county where they are grown, and specialty crops, such as fruit, are covered only in some areas. Participating farmers can purchase different types of crop insurance, including yield and revenue insurance, and at different levels. For yield insurance, participating farmers select the percentage of yield of a covered crop to be insured and the percentage of the commodity price received as payment if the producer's losses exceed the selected threshold. Revenue insurance pays if actual revenue falls short of an assigned target level regardless of whether the shortfall was due to low yield or low commodity market prices.

Since 1980, FCIC claims totaled \$43.6 billion, or about 14 percent of all weather-related claims during this period. FCIC losses averaged about \$1.7 billion per year, ranging from \$531.8 million in 1987 to \$4.2 billion in 2002. Figure 7 shows the three causes of loss—drought, excess moisture, and hail—that accounted for more than three-quarters of crop insurance claims. In particular, drought accounted for \$18.6 billion in losses, or more than 40 percent of all insured crop losses. Excess moisture totaled \$11.2 billion, followed by hail with total claims of \$4.2 billion. The remaining \$9.6 billion in claims was spread among 27 different causes of loss, including frost and tornados.

**Figure 7: Weather-Related Losses Paid by FCIC**



Source: GAO analysis of FCIC data.

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## Insured Losses Understate Total Economic Damage

Importantly, the insured loss totals used in our analysis do not account for all economic damage associated with weather-related events.<sup>20</sup> Specifically, data are not available for several categories of economic losses, including uninsured, underinsured, and self-insured losses. As we reported in 2005, FEMA estimates that one-half to two-thirds of structures in floodplains do not have flood insurance because the uninsured owners either are unaware that homeowners insurance does not cover flood damage, or they do not perceive a serious flood risk.<sup>21</sup> Furthermore, industry analysts estimate that 58 percent of homeowners in the United States are underinsured—that is, they carry a policy below the replacement value of their property—by an average of 21 percent.<sup>22</sup> Finally, some individuals and businesses have the means to “self-insure” their assets by assuming the full risk of any damage.

Various public and private disaster relief organizations provide assistance to communities and individuals who suffer noninsured economic losses, although it was beyond the scope of this report to collect data on these losses. In particular, since 1989, \$78.6 billion in federal disaster assistance funds have been obligated through the Disaster Relief Fund administered by FEMA, the largest—but not only—conduit for federal disaster assistance money provided in the wake of presidentially declared disasters and emergencies.

Overall, according to data obtained from Munich Re, one of the world’s largest reinsurers, the type of insured losses we reviewed account for no more than about 40 percent of the total losses attributable to weather-related events.<sup>23</sup> NOAA’s National Hurricane Center (NHC) uses a similar proportion to produce the agency’s estimates of total economic damage

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<sup>20</sup>Weather-related damages are also responsible for many indirect and non-market impacts that are not entirely accounted for, if at all, in economic terms, such as environmental damage. See NAS, *The Impacts of Natural Disasters: A Framework for Loss Estimation* (Washington, D.C.: 1999), 55-64.

<sup>21</sup>GAO, *Catastrophe Risk: U.S. and European Approaches to Insure Natural Catastrophe and Terrorism Risks*, [GAO-05-199](#) (Washington, D.C.: Feb. 28, 2005), 61.

<sup>22</sup>Estimate was produced by Marshall & Swift/Boeckh, a leading supplier of local building cost information, residential and commercial property valuation services for the property and casualty insurance sector in the United States. GAO did not independently evaluate the reliability of this estimate.

<sup>23</sup>Munich Re, *Topics 2000: Natural Catastrophes—the Current Position*. Geoscience Research Group (Munich, Germany: 1999).

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attributable to hurricanes.<sup>24</sup> Although we did not independently evaluate the reliability of these estimates, subject area experts we spoke with confirmed that it was the best such estimate available and is widely used as an approximation of the relative distribution of losses.

The difficulties we and others faced in accounting for weather-related losses were the subject of the National Academies' *The Impacts of Natural Disasters: A Framework for Loss Estimation*.<sup>25</sup> Reporting how best to account for the costs of natural disasters, including weather-related events, NAS found that there was no system in place in either the public or the private sectors to consistently capture information about the economic impact. Specifically, the NAS report found no widely accepted framework, formula, or method for estimating these losses. Moreover, NAS found no comprehensive clearinghouse for the disaster loss information that is currently collected. To that end, NAS recommended that the Office of Management and Budget, in consultation with FEMA and other federal agencies, develop annual, comprehensive estimates of the payouts for disaster losses made by federal agencies. Reviewing the status of this recommendation was beyond the scope of this report. Nevertheless, our experience with trying to obtain comprehensive information on disaster costs and losses underscores the NAS findings.

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### Catastrophic Weather-Related Events Help Explain the Significant Year-to-Year Variance in Losses

The largest insured losses in the data we reviewed were associated with catastrophic weather events. These events have a low probability of occurrence, but their consequences are severe. Notably, both crop insurers and other property insurers face the catastrophic risks posed by extreme events, although the nature of the events for each is very different. In the case of crop insurance, drought accounted for more than 40 percent of all insured losses from 1980 to 2005, and the years with the largest losses were associated with drought. Taken together, though, hurricanes were the most damaging event experienced by insurers in the data we reviewed. Although the United States experienced an average of only two hurricanes per year from 1980 through 2005, weather-related claims attributable to hurricanes totaled more than 45 percent of *all* weather-related insured losses—more than \$146 billion. Moreover, these losses appear to be increasing.

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<sup>24</sup>NHC estimates total losses by extrapolating from insured losses by assuming they account for approximately 50 percent of total losses.

<sup>25</sup>NAS (1999), 1.

In the data we reviewed, the years with the largest insured losses were generally associated with major hurricanes, defined as Category Three, Four, or Five on the Saffir-Simpson Hurricane Scale. Table 2 shows that, while 29 Category One and Two storms account for nearly \$18 billion in losses, the 21 major storms account for over \$126 billion in losses. In fact, claims associated with major hurricanes comprised 40 percent of all weather-related insured losses since 1980.

**Table 2: Insured Losses Associated with Hurricanes**

Dollars in thousands

	<b>Categories One, Two</b>	<b>Categories Three, Four, Five</b>	<b>Total</b>
1980s	\$807,422 (11)	\$9,905,042 (6)	<b>\$10,712,464 (17)</b>
1990s	9,038,801 (11)	29,099,303 (8)	<b>38,138,104 (19)</b>
2000s	8,071,619 (7)	89,210,093 (7)	<b>97,281,712 (14)</b>
<b>Total</b>	<b>\$17,917,842 (29)</b>	<b>\$128,214,438 (21)</b>	<b>\$146,132,280 (50)</b>

Sources: GAO analysis of PCS and NFIP data; NOAA (hurricane intensity classification).

Note: Totals do not include crop losses associated with hurricanes. Number of hurricanes associated with losses is included in parentheses. Hurricane classification was based on peak intensity at landfall.

Importantly, hurricane severity is only one factor in determining the size of a particular loss—the location affected by the hurricane is also important. Generally, the more densely populated an area, the greater the extent of economic activity and accumulated value of the building stock. For instance, several studies have reviewed the economic impact of Hurricane Andrew, which tracked over Florida in 1992, in light of the dramatic real estate development that has occurred in the meantime. Researchers have normalized losses associated with the storm to account for societal changes by holding constant the value of building materials, real estate, and other factors so that the storm’s impact could be adjusted to reflect contemporary conditions.<sup>26</sup> Hurricane Andrew, which resulted in roughly \$25 billion in total economic losses in 1992, would have resulted in more than twice that amount—\$55 billion—were it to have occurred in 2005, given current asset values.

<sup>26</sup>A normalization provides an estimate of the damage that would occur if storms from the past affected the same location under the societal conditions of another year.

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Several recent studies have commented on the apparent increases in hurricane losses during this time period, and weather-related disaster losses generally, with markedly different interpretations. Some argue that loss trends are largely explained by changes in societal and economic factors, such as population density, cost of building materials, and the structure of insurance policies.<sup>27</sup> Others argue that increases in losses have been driven by changes in climate.<sup>28</sup>

To address this issue, Munich Re and the University of Colorado's Center for Science and Technology Policy Research jointly convened a workshop in Germany in May 2006 to assess factors leading to increasing weather-related loss trends.<sup>29</sup> The workshop brought together a diverse group of international experts in the fields of climatology and disaster research. Among other things, the workshop sought to determine whether the costs of weather-related events were increasing and what factors account for increasing costs in recent decades.

Workshop participants reached consensus on several points, including that analyses of long-term records of disaster losses indicate that societal change and economic development are the principal factors explaining observed increases in weather-related losses.<sup>30</sup> However, participants also agreed that changing patterns of extreme events are drivers for recent increases in losses and that additional increases in losses are likely given IPCC's projected increase in the frequency or severity of weather-related events.

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<sup>27</sup>See, for example, Roger A. Pielke, Jr., "Disasters, Death, and Destruction: Making Sense of Recent Calamities," *Oceanography*, vol. 19, no. 2 (2006); Stanley A. Changnon et al., "Human Factors Explain the Increased Losses from Weather and Climate Extremes," *Bulletin of the American Meteorological Society*, vol. 81, no. 3 (2000); and Roger A. Pielke, Jr., and Christopher W. Landsea, "Normalized Hurricane Damages in the United States: 1925-95," *Weather and Forecasting*, vol. 13 (1998).

<sup>28</sup>See, for example, Evan Mills, Richard J. Roth, Jr., and Eugene Lecomte, *Availability and Affordability of Insurance Under Climate Change: A Growing Challenge for the U.S.* (Boston, Mass.: December 2005); Paul Epstein and Evan Mills, eds., *Climate Change Futures: Health, Ecological, and Economic Dimensions* (Boston, Mass.: November 2005); and Cynthia Rosenzweig et al., "Increased Crop Damage in the U.S. from Excess Precipitation Under Climate Change," *Global Environmental Change*, vol. 12 (2002).

<sup>29</sup>Peter Höpfe and Roger Pielke, Jr., eds., *Report of the Workshop on Climate Change and Disaster Losses: Understanding and Attributing Trends and Projections*, Hohenkammer, Germany, May 25-26, 2006 (Munich, Germany: October 2006).

<sup>30</sup>Consensus statements agreed to at the workshop are listed in their entirety in appendix IV.

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## Value at Risk in Federal Insurers' Portfolios Increased Significantly between 1980 and 2005

The growth in population in hazard-prone areas, and consequent real estate development and increasing real estate values, are leaving the nation increasingly exposed to higher insured losses. The close relationship between the value of the resource exposed to weather-related losses and the amount of damage incurred may have ominous implications for a nation experiencing rapid growth in some of its most disaster-prone areas. We reported in 2002 that the insurance industry faces potentially significant financial exposure due to natural catastrophes.<sup>31</sup> Heavily populated areas along the Northeast, Southeast, and Texas coasts have among the highest value of insured properties in the United States and face the highest likelihood of major hurricanes. According to insurance industry estimates, a large hurricane in Miami could cause up to \$110 billion in insured losses with total losses as high as \$225 billion. Several states—including Florida, California, and Texas—have established programs to help ensure that coverage is available in areas particularly prone to these events.<sup>32</sup>

AIR Worldwide, a leading catastrophe modeling firm, recently reported that insured losses should be expected to double roughly every 10 years because of increases in construction costs, increases in the number of structures, and changes in their characteristics. AIR's research estimates that, because of exposure growth, probable maximum catastrophe loss grew in constant dollars from \$60 billion in 1995 to \$110 billion in 2005, and it will likely grow to over \$200 billion during the next 10 years.

Data obtained from both the NFIP and FCIC programs indicate the federal government has grown markedly more exposed to weather-related losses regardless of the cause. For example, NFIP data show that the number of policyholders and the value of the properties insured have both increased since 1980. Figure 8 shows the growth of NFIP's exposure in terms of both number of policies and the total coverage. The number of policies has more than doubled in this time period, from 1.9 million policies to more than 4.6 million. Moreover, although NFIP limits coverage to \$250,000 for a personal structure and \$100,000 for its contents, and \$500,000 of coverage

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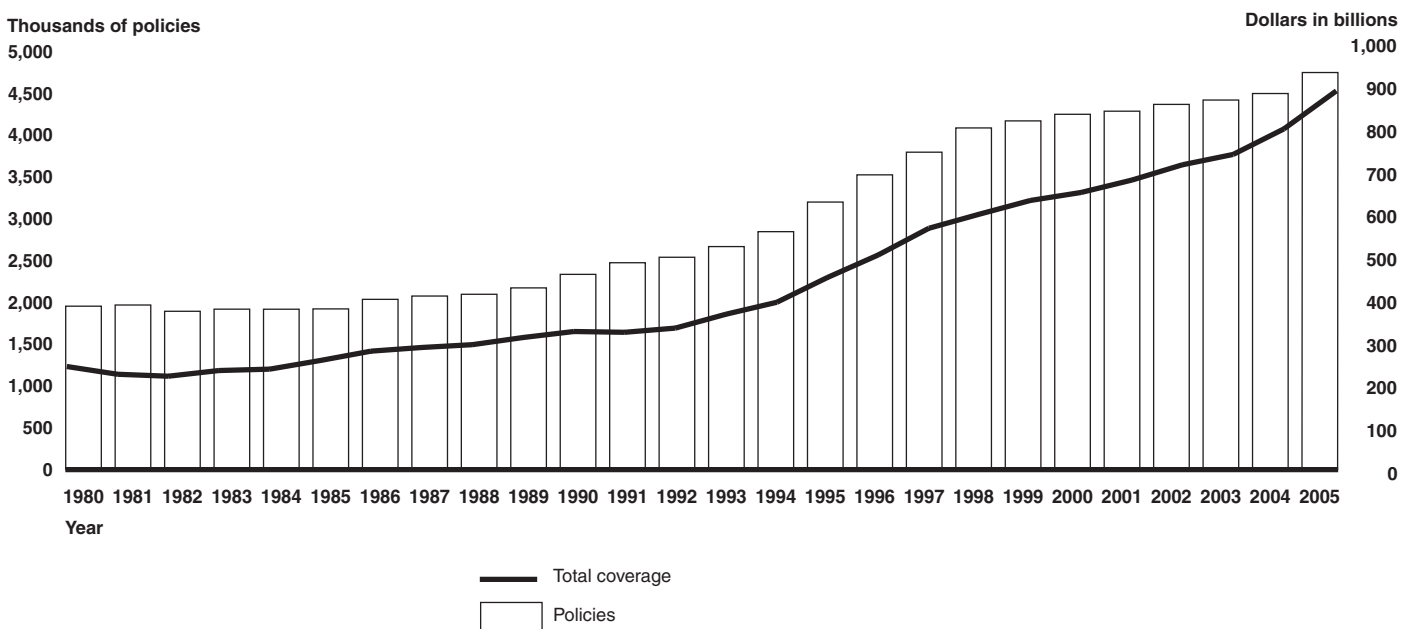
<sup>31</sup>GAO, *Catastrophe Insurance Risks: The Role of Risk-Linked Securities and Factors Affecting Their Use*, [GAO-02-941](#) (Washington, D.C.: Sept. 24, 2002), 3.

<sup>32</sup>Past GAO work provided information on the Florida Hurricane Catastrophe Fund, California Earthquake Authority, and the Texas Windstorm Insurance Association. See [GAO-02-941](#) and GAO, *Catastrophe Insurance Risks: Status of Efforts to Securitize Natural Catastrophe and Terrorism Risk*, [GAO-03-1033](#) (Washington, D.C.: Sept. 24, 2003).



for a business structure and \$500,000 on its contents, more policyholders' homes are approaching (or exceeding) these coverage limits. Accordingly, the total value covered by the program increased fourfold in constant dollars during this time from about \$207 billion to \$875 billion in 2005.

**Figure 8: NFIP Policies and Total Coverage**

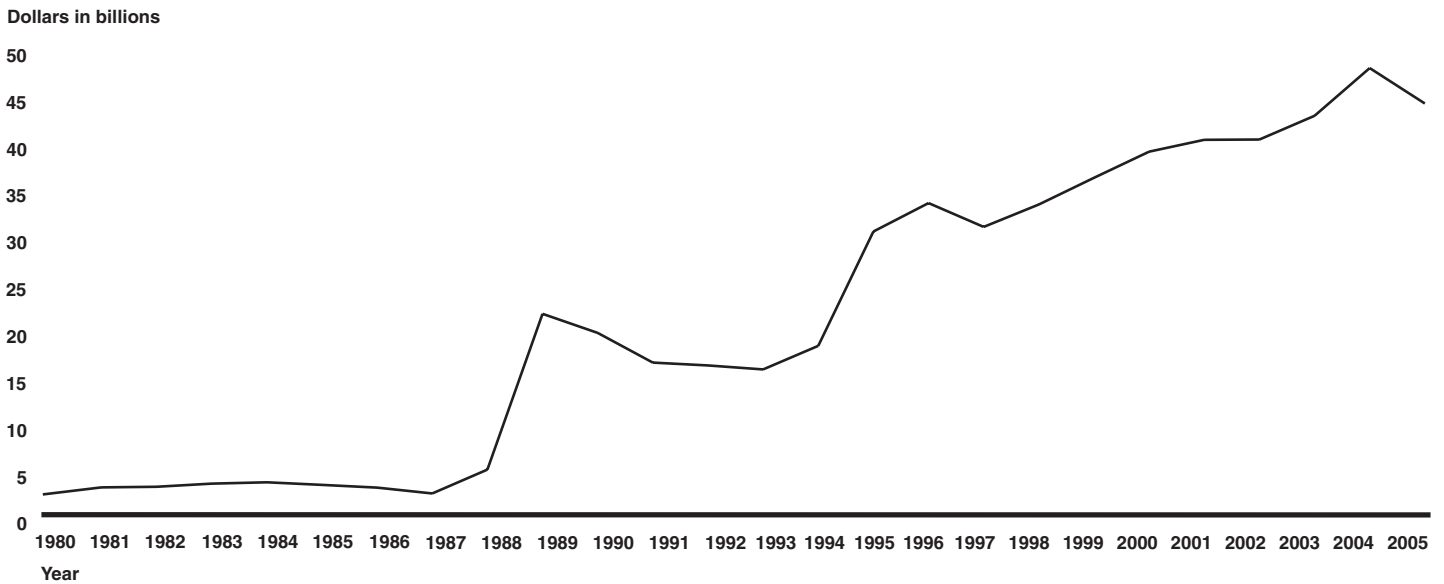


Source: GAO analysis of NFIP data.

Similarly, RMA data show that FCIC has effectively increased its exposure base 26-fold during this period (in constant dollars). In particular, the program has significantly expanded the scope of crops covered and increased participation. Figure 9 shows the growth in FCIC exposure since 1980.<sup>33</sup>

<sup>33</sup>To maintain comparability with other data, GAO did not adjust these data for changes in agricultural prices.

**Figure 9: FCIC Total Coverage**



Source: GAO analysis of FCIC data.

A senior RMA official told us that the main implication of FCIC's growth is that the magnitude of potential claims, in absolute terms, is much greater today than in the past. For example, if the Midwest floods of 1993 were to occur today, losses would be five times greater than the \$2 billion paid in 1993, according to RMA officials.

## Major Private and Public Insurers Differ in How They Manage Catastrophic Risks Associated with Climate Change

Although the relative contribution of event intensity versus societal factors in explaining the rising losses associated with weather-related events is still under investigation, both major private and federal insurers are exposed to increases in the frequency or severity of weather-related events associated with climate change. Nonetheless, major private and federal insurers are responding to this prospect differently. Many large private insurers are incorporating some elements of near-term climate change into their risk management practices. Furthermore, some of the world's largest insurers have also taken a long-term strategic approach toward changes in climate. On the other hand, for a variety of reasons, the federal insurance programs have done little to develop the kind of information needed to understand the programs' long-term exposure to climate change. We acknowledge the different mandate and operating environment in which the major federal insurance programs operate but believe that better information about the federal government's exposure to potential changes

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in weather-related risk would help the Congress identify and manage this emerging high-risk area; one which may not constitute an immediate crisis but which may pose an important longer term threat to the nation's welfare.

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### Major Private Insurers Prospectively Manage Potential Increases in Catastrophic Risk Associated with Climate Change

Extreme weather events pose a unique financial threat to private insurers' financial success because a single event can cause insolvency or a precipitous drop in earnings, liquidation of assets to meet cash needs, or a downgrade in the market ratings used to evaluate the soundness of companies in the industry. To prevent these disruptions, the American Academy of Actuaries (AAA)—the professional society that establishes, maintains, and enforces standards of qualification, practice, and conduct for actuaries in the United States—has outlined a five-step process for private insurers to follow to manage their catastrophic risk. These steps include the following:

- identifying catastrophic risk appetite by determining the maximum potential loss they are willing to accept;
- measuring catastrophic exposure by determining how vulnerable their total portfolio is to loss, both in absolute terms and relative to the company's risk management goals;
- pricing for catastrophic exposure by setting rates to collect sufficient premiums to cover their expected catastrophic loss and other expenses;
- controlling catastrophic exposure by reducing their policies in areas where they have too much exposure, or transferring risk using reinsurance or other mechanisms; and
- evaluating their ability to pay claims by determining the sufficiency of their financial resources to cover claims in the event of a catastrophe.

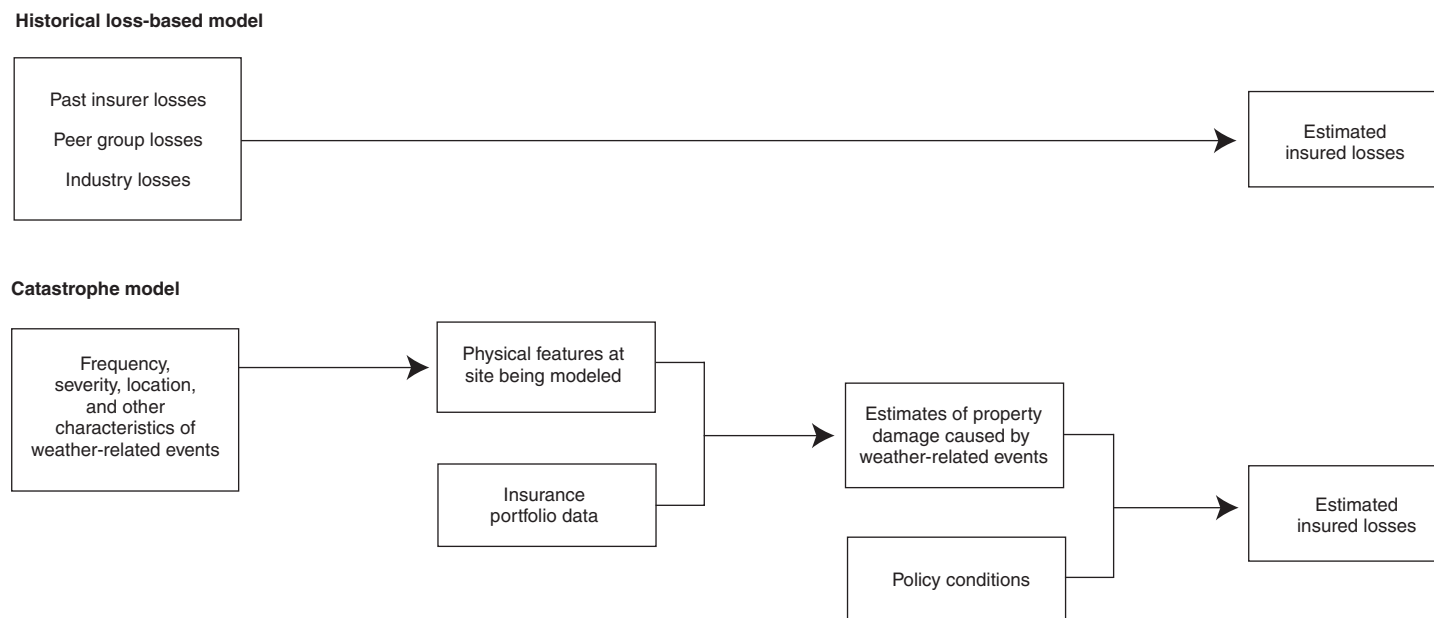
Additionally, insurers monitor their exposure to catastrophic weather-related risk using sophisticated computer models called "catastrophe models."<sup>34</sup> AAA emphasizes the shortcomings of estimating future catastrophic risk by extrapolating solely from historical losses and

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<sup>34</sup>There are three main catastrophe modeling firms: AIR Worldwide, Risk Management Solutions, and EQECAT. Although many of the insurers we interviewed use models from these firms, two of the eleven insurers have developed their own catastrophe models.

endorses catastrophe models as a more rigorous approach.<sup>35</sup> Catastrophe models incorporate the underlying trends and factors in weather phenomena and current demographic, financial, and scientific data to estimate losses associated with various weather-related events. According to an industry representative, catastrophe models assess a wider range of possible events than the historical loss record alone. These models simulate losses from thousands of potential catastrophic weather-related events that insurers use to better assess and control their exposure and inform pricing and capital management decisions. Figure 10 illustrates the difference between estimating future catastrophic losses using historical data versus catastrophe models.

**Figure 10: Modeling Potential Catastrophe Losses**



Sources: Adapted from the American Academy of Actuaries and Towers Perrin.

<sup>35</sup>American Academy of Actuaries, *Catastrophe Exposures and Insurance Industry Catastrophe Management Practices* (Washington, D.C.: American Academy of Actuaries, June 10, 2001), [http://www.actuary.org/pdf/casualty/catastrophe\\_061001.pdf](http://www.actuary.org/pdf/casualty/catastrophe_061001.pdf) (downloaded Jan. 3, 2007), 10-12.

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To determine what major private insurers are doing to estimate and prepare for risks associated with potential changes in climate arising from natural or human factors, we contacted 11 of the largest private insurers operating in the U.S. property casualty insurance market. Representatives from each of the 11 major insurers we interviewed told us they use catastrophe models that incorporate a near-term higher frequency and intensity of hurricanes. Of the 11 private insurers, 6 specifically attributed the higher frequency and intensity of hurricanes to the Atlantic Multidecadal Oscillation, which—according to NOAA—is a 20- to 40-year climatic cycle of fluctuating temperatures in the north Atlantic Ocean. The remaining 5 insurers did not elaborate on the elements of climate change driving the differences in hurricane characteristics.

Industry reports indicate that insurance companies' perception of increased risk from hurricanes has prompted them to reduce their near-term catastrophic exposure, in both reinsurance and primary insurance coverage along the Gulf Coast and eastern seaboard. For example, a recent industry analysis from a leading insurance broker reported that reinsurance coverage is substantially limited in the southeastern United States and that reinsurance prices have more than doubled from 2005 to 2006, following a record-setting hurricane season.<sup>36</sup> According to the Insurance Information Institute, a leading source of information about the insurance industry, primary insurance companies have also raised prices in coastal states to cover rising reinsurance costs.<sup>37</sup> Additionally, a recent report co-authored by a major international insurance company cites several examples of large primary insurers either limiting coverage or

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<sup>36</sup> Guy Carpenter, *The World Catastrophe Reinsurance Market: Steep Peaks Overshadow Plateaus* (New York, N.Y.: Guy Carpenter, September 2006), <http://www.guycarp.com/portal/extranet/insights/reports.html?vid=30> (downloaded Jan. 3, 2007).

<sup>37</sup> Insurance Information Institute, *Catastrophes: Insurance Issues* (New York, N.Y.: Insurance Information Institute, November 2006), <http://www.iii.org/media/hottopics/insurance/xxx/> (downloaded Jan. 3, 2007).

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withdrawing from vulnerable areas such as Florida,<sup>38</sup> the Gulf Coast, and Long Island.<sup>39</sup>

As private insurers limit their exposure, catastrophic risk is transferred to policyholders and the public sector. Insurance companies transfer risk to policyholders by increasing premiums and deductibles, or by setting lower coverage limits for policies. Insurers can also transfer risk to policyholders by passing along the mandatory participation costs of state-sponsored insurance plans.<sup>40</sup> For example, after the 2004 hurricane season, insurers assessed a surcharge of about 7 percent to every policyholder in Florida to recoup the cost of insurers' participation in the state-sponsored wind insurance plan. The public sector assumes management of weather-related risk at the local, state, and national level by providing disaster relief and recovery, developing mitigation projects, appropriating funds and, ultimately, providing insurance programs when private insurance markets are not sufficient or do not exist.

In addition to managing their aggregate exposure on a near-term basis, some of the world's largest insurers have also taken a long-term strategic approach to changes in catastrophic risk. For example, major insurance and reinsurance companies, such as Allianz, Swiss Re, Munich Re, and Lloyds of London, have published reports that advocate increased industry awareness of the potential risks of climate change and outline strategies to address the issue proactively. Moreover, 6 of the 11 private insurers we interviewed provided one or more additional activities they have undertaken when asked if their company addresses changes in climate through their weather-related risk management processes. These activities include monitoring scientific research (4 insurers), simulating the impact of a large loss event on their portfolios (3 insurers), and educating others

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<sup>38</sup>Allianz Group and World Wildlife Fund, *Climate Change and Insurance: An Agenda for Action in the United States* (New York, N.Y.: Allianz Group and World Wildlife Fund, October 2006), [http://www.allianz.com/en/allianz\\_group/sustainability/insight/studies\\_and\\_reports/page1.html?hits=reports](http://www.allianz.com/en/allianz_group/sustainability/insight/studies_and_reports/page1.html?hits=reports) (downloaded Jan. 4, 2007).

<sup>39</sup>The report notes that these decisions were due, in part, to state restrictions on rate increases that are designed to maintain insurance prices that are affordable, but may not accurately reflect the true potential for loss faced by the insured.

<sup>40</sup>Thirty-one states have FAIR plans, and six southern states have state-sponsored wind insurance plans that pool resources from insurers to cover the cost of coverage for their participants.

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in the industry about the risks of climate change (3 insurers), among others.

Furthermore, recent research on insurers' activities to address climate change outlines several other actions that private sector companies are taking, such as developing specialized policies and new products, evaluating risks to company stock investments, and disclosing to shareholders information about company-specific risks due to climate change.<sup>41</sup> Additionally, concern over the potential impacts of climate change on the availability and affordability of private insurance has led state insurance regulators to establish a task force to formally address the issue. The report, issued by the NAIC, is expected to be published in the summer of 2007.

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### Major Federal Insurers Have Taken Little Action to Prospectively Assess Potential Increases in Catastrophic Risk Associated with Climate Change

The goals of the major federal insurance programs are fundamentally different from those of private insurers. Specifically, whereas private insurers stress the financial success of their business operations, the statutes governing the NFIP and FCIC promote affordable coverage and broad participation by individuals at risk. Although both programs manage risk within their statutory guidelines, unlike the private sector, neither program is required to limit its catastrophic risk strictly within the programs' ability to pay claims on an annual basis. One important implication of the federal insurers' risk management approach is that they each have little reason to develop information on their long-term exposure to the potential risk of increased low-frequency, high-severity weather events associated with climate change.

The statutes governing the NFIP and FCIC promote broad participation over financial self-sufficiency in two ways: (1) by offering discounted or subsidized premiums to encourage participation and (2) by making additional funds available during high-loss years.<sup>42</sup> For example, discounted insurance premiums are available under the NFIP for some older homes situated within high flood risk areas where insurance would

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<sup>41</sup>Evan Mills and Eugene Lecomte, *From Risk to Opportunity: How Insurers Can Proactively and Profitably Manage Climate Change* (Boston, MA: Ceres, August 2006), [http://www.ceres.org/pub/docs/Ceres\\_Insurance\\_Climate\\_%20Report\\_082206.pdf](http://www.ceres.org/pub/docs/Ceres_Insurance_Climate_%20Report_082206.pdf) (downloaded Jan. 3, 2007), 34.

<sup>42</sup>Note that the federal government covers most, but not all, payments in the event of loss under the FCIC—insurance providers also share in the risk, as described in detail in appendix III.

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otherwise have been prohibitively expensive. FEMA is also authorized to borrow additional federal funds for the NFIP on an as-needed basis, subject to statutory limits, to cope with catastrophes.<sup>43</sup> One effect has been that the NFIP's exposure has expanded well beyond the ability to pay claims in high-loss years.

Similar to the discounted premiums offered by the NFIP, the FCIC's subsidized premiums are designed to make crop insurance available and affordable to as many participants as possible. For example, the FCIC is mandated to provide fully subsidized catastrophic coverage for producers in exchange for a minimal administrative fee, as well as partial subsidies for additional levels of coverage. Also like the NFIP, the FCIC is authorized to use additional federal funds on an as-needed basis during high-loss years—although, unlike the NFIP, the FCIC is not required to reimburse those additional funds.

Unlike the private sector, the NFIP and the FCIC can use additional federal funds, and so neither program is required to assess and limit its catastrophic risk strictly within its ability to pay claims on an annual basis. Instead, each program manages its risk to the extent possible, within the context of its broader purposes, in accordance with its authorizing statutes and implementing regulations.<sup>44</sup> For example, the FCIC uses coverage limits, exclusions, and premium rates to meet their statutory goal of a long-term loss ratio no greater than 1.075—including premium subsidies.<sup>45</sup> Although the program has experienced high-loss years that required additional federal funds, over time, these high-loss years have been offset by low-loss years, which have allowed the program to meet its goal and build reserves.<sup>46</sup>

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<sup>43</sup>The Congress increased the NFIP's borrowing authority from \$1.5 billion to approximately \$20.8 billion in the wake of unprecedented losses associated with the 2005 hurricane season.

<sup>44</sup>A detailed description of each program's risk management practices can be found in appendixes II and III for the NFIP and FCIC, respectively.

<sup>45</sup>Loss ratio, an indicator used to evaluate program performance, is calculated by dividing claims paid by total premiums collected. A loss ratio greater than 1.00 indicates that the program paid more in claims than was collected in premiums.

<sup>46</sup>The FCIC's average loss ratio from 1995 through 2005 was 0.91. From 1981 through 1994, it was 1.47. See appendix III for more information on the FCIC's performance.



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By developing a goal to generate sufficient revenue to pay for an average loss year, the NFIP has also been able to generate a surplus in low-loss years despite borrowing funds in high-loss years. In the past, the program has been able to repay borrowed funds with interest to the Department of the Treasury, however, it is unlikely FEMA will be able to repay the nearly \$21 billion borrowed following the 2005 hurricane season based on the program's current premium income.

Although neither program faces the potential of financial ruin like the private sector, both programs have occasionally attempted to estimate their aggregate losses from potential catastrophic events. For example, FCIC officials stated that they had modeled past events, such as the 1993 Midwest floods, using current participation levels to inform negotiations with private crop insurers over reinsurance terms. NFIP and FCIC officials explained that these efforts were informal exercises and were not performed on a regular basis. FCIC officials also said they use a hurricane model developed by NOAA to inform pricing decisions for some commodities such as citrus crops, according to FCIC officials. However, unlike the catastrophic risk faced by private insurers, hurricane damages have not been a primary source of crop insurance claims.

According to NFIP and FCIC officials, their risk management processes adapt to near-term changes in weather as they affect existing data. As one NFIP official explained, NFIP is designed to assess and insure against current—not future—risks. Over time, agency officials stated, this process has allowed their programs to operate as intended. However, unlike the private sector, neither program has conducted an analysis to assess the potential impacts of an increase in the frequency or severity of weather-related events on their program operations over the near- or long-term.

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### Information on Federal Agencies' Long-term Exposure to Catastrophic Risk Could Better Inform Congressional Decision Making

While comprehensive information on federal insurers' long-term exposure to catastrophic risk associated with climate change may not inform the NFIP's or FCIC's annual operations, it could nonetheless provide valuable information for the Congress and other policymakers who need to understand and prepare for fiscal challenges that extend well beyond the two programs' near-term operational horizons. We have highlighted the need for this kind of strategic information in recent reports that have expressed concern about the looming fiscal imbalances facing the nation. In one report, for example, we observed that, "Our policy process will be

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challenged to act with more foresight to take early action on problems that may not constitute an urgent crisis but pose important long-term threats to the nation's fiscal, economic, security, and societal future."<sup>47</sup> The prospect of increasing program exposure, coupled with expected increases in frequency and severity of weather events associated with climate change, would appear to pose such a problem.

Agency officials identified several challenges that could complicate their efforts to assess these impacts at the program level. Both NFIP and FCIC officials stated there was insufficient scientific information on projected impacts at the regional and local levels to accurately assess their impact on the flood and crop insurance programs. However, members of the insurance industry have analyzed and identified the potential risks climate change poses, despite similar challenges. Moreover, as previously discussed, both the IPCC and CCSP are expected to release significant assessments of the likely effect of increasing temperatures on weather events in coming months.

The experience of many private insurers, who must proactively respond to long-term changes in weather-related risk to remain solvent, suggests the kind of information that might be developed to help congressional and other policymakers in assessing current and alternative strategies. Specifically, to help ensure their future viability, a growing number of private insurers are actively incorporating the potential for climate change into their strategic level analyses. In particular, some private insurers have run a variety of simulation exercises to determine the potential business impact of an increase in the frequency and severity of weather events. For example, one insurer simulated the impact of large weather events occurring simultaneously. A similar analysis could provide the Congress with valuable information about the potential scale of losses facing the NFIP and FCIC in coming decades, particularly in light of the programs' expansion since 1980.

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## Conclusions

Recent assessments by leading scientific bodies provide sufficient cause for concern that climate change may have a broad range of long-term consequences for the United States and its citizens. While a number of key uncertainties regarding the timing, location, and magnitude of impacts

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<sup>47</sup>GAO, *21st Century Challenges: Reexamining the Base of the Federal Government*, GAO-05-325SP (Washington, D.C.: February 2005), 77.

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remain, climate change has implications for the fiscal health of the federal government, which already faces other significant challenges in meeting its long-term fiscal obligations. NFIP and FCIC are two major federal programs which, as a consequence of both future climate change and substantial growth in exposure, may see their losses grow by many billions of dollars in coming decades.

We acknowledge that to carry out their primary missions, these public insurance programs must focus on the near-term goals of ensuring affordable coverage for individuals in hazard-prone areas. Nonetheless, we believe the two programs are uniquely positioned to provide strategic information on the potential impacts of climate change—information that would be of value to key decision makers charged with such a long-term focus. Most notably, in exercising its oversight responsibilities, the Congress could use such information to examine whether the current structure and incentives of the federal insurance programs adequately address the challenges posed by potential increases in the frequency and severity of catastrophic weather events. While the precise content of these analyses can be debated, the activities of many private insurers already suggest a number of strong possibilities that may be applicable to assessing the potential implications of climate change on the federal insurance programs.

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## Recommendation for Executive Action

We recommend that the Secretary of Agriculture and the Secretary of Homeland Security direct the Administrator of the Risk Management Agency and the Under Secretary of Homeland Security for Emergency Preparedness to analyze the potential long-term implications of climate change for the Federal Crop Insurance Corporation and the National Flood Insurance Program, respectively, and report their findings to the Congress. This analysis should use forthcoming assessments from the Climate Change Science Program and the Intergovernmental Panel on Climate Change to establish sound estimates of expected future conditions. Key components of this analysis may include: (1) realistic scenarios of future losses under anticipated climatic conditions and expected exposure levels, including both potential budgetary implications and consequences for continued program operation and (2) potential mitigation options that each program might use to reduce their exposure to loss.

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## Agency Comments and Our Evaluation

We provided a draft of this report to the Departments of Agriculture (USDA), Commerce, Energy, and Homeland Security (DHS) for their review. DHS agreed via email with the report's recommendation, noting that conducting an assessment of the impact of climate change beyond FEMA's current statistical modeling (which is based on historical loss experience) could be helpful if resources were available to pursue such an analysis.

USDA also agreed with the report's recommendation, and commented on the presentation of several findings. (See app. V for the letter from the Under Secretary for Farm and Foreign Agricultural Services and GAO's point-by-point response.) In particular, USDA disagreed that it had thus far taken little action to prospectively assess potential increases in catastrophic risk associated with climate change. USDA explained that RMA does assess both the current and long-term exposure of the crop insurance program to catastrophic weather events, noting specifically that RMA (1) updates and publishes total program liability on a weekly basis and (2) estimates expected changes in liability up to 10 years ahead through its baseline projections. We acknowledge these activities, but believe it is important to note that they are limited in scope, focusing almost exclusively on retrospective measures of performance and not on the potential for increasingly frequent and intense weather-related events. These events, including drought and heavy precipitation events, are the key events acknowledged by USDA as posing catastrophic risk to the crop insurance program. Moreover, other RMA efforts to capture changes in weather-related risk rely on data reflecting what has been experienced in the past, not on what could be experienced in the future.

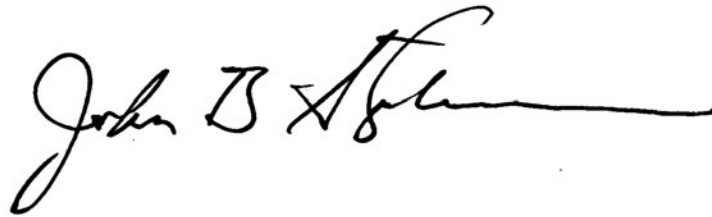
The Department of Commerce neither agreed nor disagreed with the report's findings, but instead offered several comments on the presentation of several issues in the draft (particularly the depth in which several issues are discussed) as well as technical comments. We have incorporated these comments as appropriate and address them in detail in appendix VI. Notably, the Department of Commerce underscored the vulnerability of high-risk coastal development, stating that such vulnerabilities will only be amplified by climate change-related increases in the frequency or severity of weather-related events.

Finally, the Department of Energy elected not to provide comments on the draft.

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As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to the Secretaries of Agriculture, Commerce, Energy, and Homeland Security, as well as other interested parties. We also will make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at <http://www.gao.gov>.

If you or your staff has any questions regarding this report, please contact me at (202) 512-3841 or [stephensonj@gao.gov](mailto:stephensonj@gao.gov). Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors are listed in appendix VII.

A handwritten signature in black ink, reading "John B. Stephenson". The signature is written in a cursive style with a long horizontal flourish extending to the right.

John B. Stephenson  
Director, Natural Resources and Environment

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# Appendix I: Scope and Methodology

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We were asked us to (1) describe what is known about how climate change might affect insured and uninsured losses, (2) determine insured losses incurred by major federal agencies and private insurers and reinsurers resulting from weather-related events, and (3) determine what major federal agencies and private insurers and reinsurers are doing to assess and manage the potential risk of increased losses due to changes in the frequency and severity of weather-related events associated with climate change.

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## Scientific Literature

To address the first objective, we reviewed and summarized existing literature from significant policy-oriented scientific assessments from reputable international and national research organizations including the Intergovernmental Panel on Climate Change, National Academy of Sciences, and the multifederal agency U.S. Climate Change Science Program, as specified in table 3. It was beyond the scope of this report to independently evaluate the results of these studies.

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**Table 3: Key Policy-Oriented Scientific Assessments Reviewed by GAO**

Organization	Publication
Intergovernmental Panel on Climate Change (IPCC)	<ul style="list-style-type: none"><li>• <i>Climate Change 2007: The Physical Science Basis, Summary for Policymakers</i> (2007)</li><li>• <i>Climate Change 2001: Synthesis Report</i> (2001)</li><li>• <i>Climate Change 2001: The Scientific Basis</i> (2001)</li><li>• <i>Climate Change 2001: Impacts, Adaptation &amp; Vulnerability</i> (2001)</li></ul>
Climate Change Science Program (CCSP)	<ul style="list-style-type: none"><li>• <i>Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences, Synthesis and Assessment Product 1.1</i> (2006)</li></ul>
National Academy of Sciences (NAS)	<ul style="list-style-type: none"><li>• <i>Surface Temperature Reconstructions for the Last 2,000 Years</i> (2006)</li><li>• <i>Understanding and Responding to Climate Change: Highlights of National Academies Reports</i> (2006)</li><li>• <i>Radiative Forcing of Climate Change: Expanding the Concept and Addressing Uncertainties</i> (2005)</li><li>• <i>From Climate to Weather: Impacts on Society and Economy—Summary of a Forum, June 28, 2002, Washington, D.C.</i> (2003)</li><li>• <i>Understanding Climate Change Feedbacks</i> (2003)</li><li>• <i>Abrupt Climate Change: Inevitable Surprises</i> (2002)</li><li>• <i>Climate Change Science: An Analysis of Some Key Questions</i> (2001)</li></ul>

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Source: GAO.

Note: Publication year follows publication title in parentheses.

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## Insured Loss Data

To address the second objective, we analyzed insured loss data from January 1, 1980, through December 31, 2005, from the Federal Emergency Management Agency (FEMA) for the National Flood Insurance Program (NFIP); the Department of Agriculture’s Risk Management Agency (RMA) for the Federal Crop Insurance Corporation (FCIC); and the Property Claim Services (PCS) for private property insurance. Through electronic testing and other means, we assessed the reliability of each of the data sets to determine whether the data were sufficiently reliable for our purposes. Specifically, we interviewed the sources for each of the data sets to gather information on how records were collected, processed, and maintained. Because not all catastrophes are weather-related, we excluded all events attributable to terrorist acts, tsunamis, earthquakes, and other nonweather-related losses, based on discussions with the data provider. To adjust for the general effects of inflation over time we used the chain-weighted gross domestic product price index to express dollar amounts in inflation-adjusted 2005 dollars. We reviewed any changes in data collection methodologies that have occurred over time, and evaluated the effect of any changes on our ability to report losses. We believe that these data are sufficiently reliable for the purpose of describing insured losses. We note, however, that these data likely understate the actual insured losses.

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## PCS

PCS data are estimates of insured losses, or claims paid by private insurance companies, for catastrophe loss events for the 50 states, as well as the District of Columbia, Puerto Rico, and the U.S. Virgin Islands. PCS defines “catastrophes” as events that, in their estimation, affect a significant number of policyholders and that cause more than \$25 million in damages. To identify catastrophes, PCS reviews daily weather reports and wire service news stories to determine if potentially damaging weather has occurred anywhere in the nation. PCS contacts adjusters, insurance claims departments, or public officials to gather additional information about the scope of damage and potential insured losses for events. Damages associated with a single storm event are grouped together as a single catastrophe, even if they are separated by distance. PCS obtains its insured loss data from information reported by insurers. PCS estimates include losses under personal and commercial property insurance policies covering real property, contents, business interruption, vehicles, and boats. PCS estimates also typically include amounts paid by state wind pools, joint underwriting associations, and certain other residual market mechanisms, such as Fair Access to Insurance Requirements (FAIR) plans. However, PCS estimates do not include damage to uninsured or self-insured property including uninsured publicly

owned property and utilities; losses involving agriculture, aircraft and property insured under NFIP or certain specialty lines (such as ocean marine), or loss adjustment expenses. Generally, PCS finalizes its estimates within 6 months of the occurrence of a PCS-identified catastrophe, according to company documents. PCS does not independently verify or audit the accuracy of the reported losses. Thus, loss totals are the best estimates of primary insurers compiled by PCS professionals, and may or may not accurately and completely reflect actual industry-insured losses. Nevertheless, PCS has determined their data to be very close to other independent estimates. PCS officials said that, when compared with state insurance commissioners' estimates based on all loss data from insurance companies following particularly large catastrophes, PCS data are within 3 to 5 percent of actual amounts. For the data used in our review, company officials told us that most estimates included in the data provided to us are final, except the 2005 hurricanes.

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**NFIP**

NFIP data are actual claim payment totals, not estimated amounts. NFIP data represent the budget outlays that satisfy claims submitted by NFIP policyholders to their participating program companies. The companies report these data to the NFIP on a monthly basis. According to a senior program official, the Department of Homeland Security performs periodic audits of company records reported to NFIP. Although nearly all claims in the NFIP data we reviewed are considered closed by the agency (and, therefore, final), a small portion of claims associated with 2004 and 2005 hurricane season are not reflected in data we reviewed, according to the agency's database manager.

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**FCIC**

The loss data provided by FCIC represent the actual amount paid to policyholders, not estimates. FCIC data represent the budget outlays that satisfy claims submitted by policyholders to their participating insurance companies. Participating insurance companies submit claims information for processing through a computerized validation system. Automated processing of claims information occurs annually for a period going back 5 years, but agency officials said that indemnities may have changed after automated processing closed in very specific cases, such as settlement of litigation or arbitration cases.



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### Identifying Insured Losses Associated with Hurricanes

To determine the insured losses associated with major and nonmajor hurricanes, we identified losses associated with hurricanes in both the PCS and NFIP data sets. We used the name and year of each hurricane to link loss records to information from the National Oceanic and Atmospheric Administration (NOAA) on the peak intensity of each hurricane at or near landfall.

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### Independent Studies

We supplemented our descriptive analysis with a review of existing literature and the views of subject area experts on the primary drivers of changes in the weather-related loss record in general. Given the data challenges faced by natural hazard researchers, the data sets used in these studies are generally different.

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### Interviews with Major Insurers

To address the third objective, we conducted semistructured interviews with officials from the NFIP, RMA, and a nonprobability sample of the largest private property/casualty primary insurance and reinsurance companies as defined by national market share. In the private sector, 11 out of 14 potential respondents elected to participate, drawing from companies in the United States, Europe, and Bermuda. Although the results from this sample should not be generalized to represent all insurance companies, the companies we interviewed represent about 45 percent of the total domestic insurance market. In developing our semistructured questionnaire, we reviewed existing literature on risk assessment and management practices, GAO guidance on risk management, and interviewed subject area experts knowledgeable about the insurance industry and federal insurance programs. Insurance industry experts included representatives from insurance brokers, catastrophe modeling firms, industry associations, the Insurance Information Institute, and academics. To reduce response error, we pretested our questions for clarity, relevancy, and sensitivity with representatives from several insurance industry associations, including the American Insurance Association, the National Association of Mutual Insurance Companies, the Property Casualty Insurance Association of America, and the Reinsurance Association of America. On the basis of feedback from the pretests, we modified the questions as appropriate. We distinguished proactive risk management responses to climate change from other responses according to whether insurers indicated that they were adjusting their activities based on projected changes in underlying weather trends rather than adapting only as changes in weather conditions reveal themselves in historical data. During our interviews, some private insurers attributed their actions to changes in the Atlantic Multidecadal Oscillation (AMO).

Because NOAA considers the AMO to be a climatic cycle, we categorized the actions of these insurers as responding to climate change.

We asked the participating federal agencies and private insurance and reinsurance companies to identify individuals knowledgeable about their weather-related risk management practices for our interviews. Based on these criteria, we spoke with a range of senior officials and representatives that included actuaries, underwriters, catastrophe specialists, regulatory affairs and counsel. During the interviews, we asked a series of questions about risk assessment and management practices for weather-related risk, significant drivers of changes to past and future weather-related risk, respondents' perception of and actions to address climate change in their risk management processes, and risk management best practices that might be transferable to federal insurers.

We also interviewed officials from rating agencies, catastrophe modeling firms, insurance industry associations, the National Association of Insurance Commissioners, and universities to provide additional context for respondents' statements. To supplement our interviews, we reviewed documentary evidence of risk management practices from federal agencies, studies from subject area experts, industry reports, publicly available insurance company documents, and previous work from GAO to provide context and support for respondents' statements.

We performed our work between February 2006 and January 2007 in accordance with generally accepted government auditing standards.

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# Appendix II: National Flood Insurance Program

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Floods are the most common and destructive natural disaster in the United States. According to NFIP statistics, 90 percent of all natural disasters in the United States involve flooding. Because of the catastrophic nature of flooding and the inability to adequately predict flood risks, private insurance companies largely have been unwilling to underwrite and bear the risk of flood insurance. As a result, flooding is generally excluded from homeowner policies that cover damages from other types of losses, such as wind, fire, and theft.

The NFIP was established in 1968 to address uninsured losses due to floods. Prior to the establishment of the NFIP, structural flood controls on rivers and shorelines (e.g., dams and levees) and disaster assistance for flood victims were the federal government's primary tools for addressing floods. The Mississippi River Commission, created in 1879 to oversee the development of a levee system to control the river's flow, was the first of these federal efforts to address flooding. Due to the limited effectiveness of structural flood controls, continued development in flood-prone areas, and a desire to reduce postdisaster assistance payments, the Congress began examining the feasibility of prefunding flood disaster costs via federal insurance in the 1950s. Although the first federal flood insurance program authorized by the Congress in 1956 failed due to lack of funding, a series of powerful hurricanes and heavy flooding on the Mississippi River in the early 1960s prompted the Congress to revisit the issue and direct the Department of Housing and Urban Development (HUD) to conduct a feasibility study of a federal flood insurance program. The 1966 HUD feasibility study helped lead to the passage of the National Flood Insurance Act of 1968,<sup>1</sup> which authorized the creation of the NFIP.<sup>2</sup>

Since its inception, the NFIP has undergone several major changes in response to significant flood events. Hurricane Agnes in 1972 led to the mandatory flood insurance requirements on certain persons in flood-prone areas included in the Flood Disaster Protection Act of 1973, which also significantly increased coverage limits in a further effort to increase participation.<sup>3</sup> Following the Midwest floods of 1993, the Congress enacted the National Flood Insurance Reform Act of 1994, which strengthened

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<sup>1</sup>Pub. L. No. 90-448, 82 Stat. 573.

<sup>2</sup>Senate Committee on Banking and Currency, *Insurance and Other Programs for Financial Assistance to Flood Victims*, 89th Cong., 2d Sess., 1966, Committee Print.

<sup>3</sup>Pub. L. No. 93-234, 87 Stat. 975 (1973).

lender compliance requirements with mandatory purchase provisions requiring mortgage-holders in flood-prone areas to purchase flood insurance and prohibited flood disaster assistance for properties that had not maintained their mandatory coverage.<sup>4</sup> In 2004, recognizing that losses from repetitive flooding on some insured properties was straining the financial condition of the NFIP, the Congress passed the Flood Insurance Reform Act of 2004, which provided NFIP with additional tools to reduce the number and financial impact of these properties.<sup>5</sup> These tools include: increased authorization of funding for mitigation of repetitive loss properties and statutory authority to penalize policyholders who refuse government assistance to mitigate certain structures that have been substantially or repetitively damaged by flooding, among others. Recently, the Congress has begun exploring additional changes to the NFIP to address the financial and operational challenges presented by the 2005 hurricane season.

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## How the Program Works

FEMA, within the Department of Homeland Security (DHS), is responsible for the oversight and management of the NFIP.<sup>6</sup> Under this program, the federal government assumes the liability for covered losses and sets rates and coverage limitations, among other responsibilities.

The NFIP combines three elements: (1) property insurance for potential flood victims, (2) mapping to identify the boundaries of the areas at highest risk of flooding, and (3) incentives for communities to adopt and enforce floodplain management regulations and building standards (such as elevating structures) to reduce future flood damage. The effective integration of all three of these elements is needed for the NFIP to achieve its goals of

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<sup>4</sup>Pub. L. No. 103-325, 108 Stat. 2255 (1994).

<sup>5</sup>The Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004, Pub. L. No. 108-264, 118 Stat. 712.

<sup>6</sup>In March 2003, FEMA and its approximately 2,500 staff became part of the Department of Homeland Security (DHS). Most of FEMA—including its Mitigation Division, which is responsible for administering the NFIP—is now part of the department's Emergency Preparedness and Response Directorate. However, FEMA retained its name and individual identity within the department. Under a reorganization plan proposed by the current Secretary of DHS, the Emergency Preparedness and Response Directorate would be abolished, and FEMA would report directly to the Undersecretary and Secretary of DHS.

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- providing property flood insurance coverage for a high proportion of property owners who would benefit from such coverage,
  - reducing taxpayer-funded disaster assistance when flooding strikes, and
  - reducing flood damage through floodplain management and the enforcement of building standards.

Over 20,000 communities across the United States and its territories participate in the NFIP by adopting and agreeing to enforce state and community floodplain management regulations to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners and other property owners in these communities. As of 2005, the program had over 4.9 million policyholders, representing about \$875 billion in assets. Homeowners with mortgages from federally regulated lenders on property in communities identified to be in high flood risk areas are required to purchase flood insurance on their dwellings. Optional, lower cost coverage is also available under the NFIP to protect homes in areas of low to moderate risk. The mandated coverage protects homeowners' dwellings only; to insure furniture and other personal property items against flood damage, homeowners must purchase separate NFIP personal property coverage.

Prior to the 2005 hurricanes, NFIP had paid about \$14.6 billion in flood insurance claims, primarily from policyholder premiums that otherwise would have been paid through taxpayer-funded disaster relief or borne by home and business owners themselves. According to FEMA, every \$3 in flood insurance claims payments saves about \$1 in disaster assistance payments, and the combination of floodplain management and mitigation efforts save about \$1 billion in flood damage each year.

To make flood insurance available on “reasonable terms and conditions to persons who have need for such protection,”<sup>7</sup> the NFIP strikes a balance between the scope of the coverage provided and the premium amounts required to provide that coverage. Policy coverage limits arise from statute and regulation, including FEMA’s standard flood insurance policy (SFIP), which is incorporated in regulation and issued to policyholders when they purchase flood insurance. As of 2006, FEMA estimated 26 percent of its policies were subsidized, and 74 percent were charged “full-risk premium”

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<sup>7</sup>42 U.S.C. § 4001(a)(4).

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rates. In 1981, FEMA set the operating goal of generating premiums at least sufficient to cover losses and expenses relative to the “historical average loss year.” However, the heavy losses from the 2005 hurricane season may increase the historical average loss year to a level beyond the expected long-term average. In light of this, FEMA is currently revisiting the use of the historical average loss year as a premium income target.

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## Risk Assessment Practices

The NFIP uses hydrologic models to estimate loss exposure in flood-prone areas, based on the method outlined in the 1966 HUD report, *Insurance and Other Programs for Financial Assistance to Flood Victims*.<sup>8</sup> These techniques of analysis were first developed by hydrologists and hydraulic engineers to determine the feasibility of flood protection.

The hydrologic method uses available data on the occurrence of floods and flood damages to establish both the frequency of flood recurrence and the damage associated with a flood of a given height. The NFIP augments available flood data with detailed engineering studies, simulations, and professional judgment to establish the scientific and actuarial basis for its risk assessment process and rates.

Flood-elevation frequency data for specific communities is published in Flood Rate Insurance Maps, which differentiate areas based on their flood risk. These maps are the basis for setting insurance rates, establishing floodplain management ordinances, and identifying properties where flood insurance is mandatory.

To estimate expected annual losses and determine the basis for rate setting, NFIP combines flood-elevation frequency data with depth-damage calculations to estimate a range of flood probabilities and associated damages. Each possible flood is multiplied by the expected damage should such a flood occur, and then each of these is added together. The total of each possible flood’s damage provides an expected per annum percentage of the value of property damage due to flooding. This expected damage can then be converted to an expected loss per \$100 of property value covered by insurance. This per annum expected loss provides the fundamental component of rate setting. Rates are also adjusted to

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<sup>8</sup>Senate Committee on Banking and Currency, *Insurance and Other Programs for Financial Assistance to Flood Victims*.

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incorporate additional expense factors, such as adjustment costs and deductibles.

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## Program Funding

To the extent possible within the context of its broader purposes, the NFIP is expected to pay operating expenses and flood insurance claims with premiums collected on flood insurance policies rather than with tax dollars. However, as we have reported, the program is not actuarially sound by design because the Congress authorized subsidized insurance rates to be made available for policies covering certain structures to encourage communities to join the program. As a result, the program does not collect sufficient premium income to build reserves to meet the long-term future expected flood losses.<sup>9</sup> FEMA has statutory authority to borrow funds from the Department of the Treasury to keep the NFIP solvent.<sup>10</sup> Prior to the 2005 hurricane season, FEMA had exercised its borrowing authority four times, when losses exceeded available fund balances. For example, FEMA borrowed \$300 million to pay an estimated \$1.8 billion on flood insurance claims resulting from the 2004 hurricane season. Following hurricanes Katrina, Rita, and Wilma, FEMA estimates it will need to borrow nearly \$21 billion dollars to cover outstanding claims. Although FEMA has repaid borrowed funds with interest in the past, FEMA does not expect to be able to meet the \$1 billion in annual interest payments for these borrowed funds.

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<sup>9</sup>GAO, *Flood Insurance: Information on the Financial Condition of the National Flood Insurance Program*, [GAO-01-992T](#) (Washington, D.C.: July 19, 2001).

<sup>10</sup>See 42 U.S.C. § 4016.

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# Appendix III: Federal Crop Insurance Corporation

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In general, farm income is determined on the basis of farm production and prices, both of which are subject to wide fluctuations due to external factors. Because a substantial part of farming depends on weather, farm production levels can vary substantially on an annual basis. Commodity prices are also subject to significant swings due to supply and demand on the domestic and international markets. The Congress created FCIC in 1938 to administer a federal crop insurance program on an experimental basis to temper the weather effects of the dust bowl and the economic effects of the Great Depression.<sup>1</sup>

The federal crop insurance program protects participating farmers against financial losses caused by droughts, floods, or other natural disasters. Until 1980, the federal crop insurance program was limited to major crops in the nation's primary production areas. The Federal Crop Insurance Act of 1980 expanded crop insurance both in terms of crops and geographic areas covered.<sup>2</sup> The expansion was designed to allow the disaster assistance payment program provided by the government under previous farm bills to be phased out. To encourage participation, the 1980 act required a 30 percent premium subsidy for producers who purchased coverage up to the 65 percent yield level. Despite the subsidies, program participation remained low, and the Congress authorized several ad hoc disaster payments between 1988 and 1993. Congressional dissatisfaction with the size and frequency of these payments prompted the Congress to pass the Federal Crop Insurance Reform Act of 1994, which mandated participation in the crop insurance program as a prerequisite for other benefits, including agriculture price support payments.<sup>3</sup> The 1994 act also introduced catastrophic risk protection coverage, which compensated farmers for losses exceeding 50 percent of their average yield at 60 percent of the commodity price. Premiums for catastrophic risk protection coverage were completely subsidized, and subsidies for other coverage levels were also increased.

As part of the 1996 Farm Bill, the Congress created the Office of Risk Management under the U.S. Department of Agriculture (USDA), and USDA established RMA to administer the FCIC insurance programs, among other

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<sup>1</sup>Federal Crop Insurance Act, tit. V, 52 Stat. 72 (1938) (codified as amended at 7 U.S.C. §§ 1501-1524).

<sup>2</sup>Pub. L. No. 96-365, 94 Stat. 1312 (1980).

<sup>3</sup>Pub. L. No. 103-354, 108 Stat. 3178 (1994).



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things.<sup>4</sup> The Congress also required the creation of a revenue insurance pilot project and repealed the mandatory participation provision of the 1994 Act. However, participation in the crop insurance program has not necessarily precluded the need for further disaster assistance. For example, due to low commodity prices in 1997 and multiple years of natural disasters, the Congress enacted an emergency farm financial assistance package totaling almost \$6 billion in 1998, which included over \$2 billion in crop disaster payments, and an \$8.7 billion financial assistance package in 1999 that included \$1.2 billion in crop disaster payments.

In 2000, the Congress enacted the Agricultural Risk Protection Act, which further increased subsidies for insurance above the catastrophic risk protection coverage level, subsidized a portion of the cost of revenue insurance products, improved coverage for farmers affected by multiple years of natural disasters, required pilot insurance programs for livestock farmers, and authorized pilot programs for growers of other commodities not currently covered, gave the private sector greater representation on the FCIC Board of Directors, reduced eligibility requirements for permanent disaster payment programs for noninsured farmers, and provided new tools for monitoring and controlling program abuses, among other provisions.<sup>5</sup> These changes required \$8.2 billion in additional spending from fiscal years 2001 through 2005.

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## How the Program Works

RMA has overall responsibility for supervising the federal crop insurance program, which it administers in partnership with private insurance companies. Insurance policies are sold and completely serviced through approved private insurance companies that have their losses reinsured by USDA. These companies share a percentage of the risk of loss or opportunity for gain associated with each insurance policy written. In addition, RMA pays companies a percentage of the premium on policies sold to cover the administrative costs of selling and servicing these policies. In turn, insurance companies use this money to pay commissions to their agents who sell the policies and fees to adjusters when claims are filed. RMA oversees the development of new insurance products and the expansion of existing insurance products to new areas to help farmers reduce the chance of financial loss.

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<sup>4</sup>Pub. L. No. 104-127, 110 Stat. 888 (1996).

<sup>5</sup>Pub. L. No. 106-224, 114 Stat. 358 (2000).

The USDA determines whether the federal crop insurance program will insure a commodity on a crop-by-crop and county-by-county basis, based on farmer demand for coverage and the level of risk associated with the crop in the region, among other factors. Over 100 crops are covered; major crops such as grains are covered in almost every county where they are grown, and specialty crops such as fruit are covered in some areas. For many commodities, producers may also purchase revenue insurance. Based on commodity market prices and the producer's production history, producers are assigned a target revenue level. The producer receives a payment if their actual revenue falls short of the target level, whether the shortfall was due to low yield or low prices. Premiums for revenue insurance are subsidized at the same level as traditional crop insurance policies.

Farmers' participation in the federal crop insurance program is voluntary, but the federal government encourages it by subsidizing the insurance premiums. Participating farmers are assigned a "normal" crop yield based on their past production history and a commodity price based on estimated market conditions. The producer selects both the percentage of yield to be covered and the percentage of the commodity price received as payment if the producer's losses exceed the selected threshold. Premium prices increase as levels of yield and price coverage rise. However, all eligible producers can receive fully subsidized catastrophic risk protection coverage that pays producers for losses exceeding 50 percent of normal yield, at a level equal to 55 percent of the estimated market price, in exchange for a \$100 administrative fee. Producers who purchase this coverage can buy additional insurance at partially subsidized rates up to 85 percent of their yield and 100 percent of the estimated market price.

As an alternative, the Group Risk Plan provides coverage based on county yields rather than a producer's actual production history. If county yield falls below the producer's threshold yield (a percentage of the historical county yield), then the producer receives a payment.

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## Risk Assessment Practices

RMA's risk assessment/rate-setting methodology is complex because the risk of growing a particular crop varies by county, farm, and farmer. Because of all the possible combinations involved, hundreds of thousands of rates are in place. Each year, RMA follows a multistep process to establish rates for each crop included in the program. The process involves establishing base rates for each county crop combination and adjusting these basic rates for a number of factors, such as coverage and

production levels. In addition, rates are adjusted to account for the legislated limitations in price increases.

For each crop, RMA extracts data on counties' crop experience from its historical database. The data elements for each crop, crop year, and county include (1) the dollar amount of the insurance coverage sold, (2) the dollar amount of the claims paid, and (3) the average coverage level. The historical data are adjusted to the 65 percent coverage level (the most commonly purchased level of coverage) so that liability and claims data at different coverage levels can be combined to develop rates. Using the adjusted data, FCIC computes the loss-cost ratio for each crop in each county. The loss-cost ratio is calculated by dividing the total claim payments by the total insurance in force; the result is stated as a percentage.<sup>6</sup> To reduce the impact a single year will have on the average loss-cost ratio of each county, RMA caps the adjusted average loss-cost ratio for any single year at 80 percent of all years.<sup>7</sup> To establish the base rate for each county, the average for all the years since 1975 is calculated using the capped loss-cost ratios and a weighting process to minimize the differences in rates among counties.

Rates are further adjusted by: a disaster reserve factor, a surcharge for catastrophic coverage for each crop based on pooled losses at the state level,<sup>8</sup> a prevented planting factor, farm divisions, crop type, and differences in both average yield and coverage levels.<sup>9</sup>

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<sup>6</sup>For example, if the claims paid in 1 year totaled \$7.36 and the insurance in force was \$100, the loss-cost ratio is 7.36 percent. The percentage represents the rate that would need to be charged per \$100 of insurance coverage if total premiums are to equal the total claim payments for that year. In this example, the 7.36 percent indicates that a rate of \$7.36 was required per \$100 of insurance coverage sold.

<sup>7</sup>The excess of losses above the capped amount is pooled at the state level and reallocated to the counties. According to FCIC, this procedure is intended to reduce the variation of rates from one year to the next.

<sup>8</sup>The surcharge is established by pooling the amount of insurance in force and the claim payments for capped years with the highest loss-cost ratios in each county that were not factored into the county unloaded rates at the state level. These data are used to calculate a statewide surcharge for catastrophic coverage (pooled claims payments divided by pooled insurance in force). If the pooled losses at the state level exceed five points, the excess is returned to the counties and included in the county unloaded rate.

<sup>9</sup>Prevented planting factor adds a provision for losses due to crops that were never planted because of external factors not directly related to yield loss.

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## Program Funding

The crop insurance program is financed primarily through general fund appropriations and farmer-paid premiums. In addition to the premiums paid by producers, FCIC receives an annual appropriation to cover necessary costs for the program's premium subsidies, excess losses, delivery expenses, and other authorized expenses. According to USDA budget documents, for fiscal year 2005, insurance premium and administrative fee revenue from farmers was approximately \$2.1 billion, and gross claims equaled almost \$3.3 billion. Total government operating costs in fiscal year 2005 were approximately \$3 billion.

RMA is required to set crop insurance premiums at actuarially sufficient rates, defined as a long-run loss ratio target of no more than 1.075. From its initial expansion in 1981 through 1994, the crop insurance program had an average loss ratio of 1.47 and paid roughly \$3.2 billion in claims excess of subsidized premium income during that period.<sup>10</sup> From 1995 to 2005, the program had an average loss ratio of 0.91, and collected roughly \$2.7 billion in subsidized premium excess of claims during that period. Excluding subsidies and measuring performance on the basis of a producer premium, from 1981 to 1994, the crop insurance program averaged a loss ratio of 1.93 and paid roughly \$5.2 billion in claims excess of producer premium over that period; from 1995 to 2005, the program averaged a loss ratio of 2.15 and paid roughly \$14.2 billion in claims excess of a producer premium during that period.

Generally, producers can purchase crop insurance to insure up to 85 percent of their normal harvest (yield), based on production history. In 2007, the USDA expects the FCIC to provide \$48 billion in risk protection on 287 million acres nationwide, which represents approximately 80 percent of the nation's acres planted to principal crops. The USDA estimates this level of coverage will cost the federal government \$4.2 billion in 2007.

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<sup>10</sup>The Federal Crop Insurance Reform Act of 1994 mandated participation in the program to receive other commodity support payments, although this requirement was rescinded in 1996.

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# Appendix IV: Consensus Statement among Participants at 2006 Munich Re Workshop

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Munich Re, one of the world's largest reinsurance companies, and the University of Colorado jointly convened an international workshop on climate change and disaster loss trends in May 2006 in Hohenkammer, Germany. The workshop brought together 32 experts in the fields of climatology and disaster research from 13 countries. White papers were prepared and circulated by 25 participants in advance of the workshop and formed the basis of the discussions. In the course of the event, participants developed a list of statements that each represent a consensus among participants on issues of research and policy as related to the workshop's two central organizing questions: (1) What factors account for increasing costs of weather related disasters in recent decades? and (2) What are the implications of these understandings, for both research and policy?

Consensus (unanimous) statements of the workshop participants:

1. Climate change is real, and has a significant human component related to greenhouse gases.
2. Direct economic losses of global disasters have increased in recent decades with particularly large increases since the 1980s.
3. The increases in disaster losses primarily result from weather related events, in particular storms and floods.
4. Climate change and variability are factors which influence trends in disasters.
5. Although there are peer reviewed papers indicating trends in storms and floods there is still scientific debate over the attribution to anthropogenic climate change or natural climate variability. There is also concern over geophysical data quality.
6. IPCC (2001) did not achieve detection and attribution of trends in extreme events at the global level.
7. High quality long-term disaster loss records exist, some of which are suitable for research purposes, such as to identify the effects of climate and/or climate change on the loss records.
8. Analyses of long-term records of disaster losses indicate that societal change and economic development are the principal factors responsible for the documented increasing losses to date.

9. The vulnerability of communities to natural disasters is determined by their economic development and other social characteristics.
10. There is evidence that changing patterns of extreme events are drivers for recent increases in global losses.
11. Because of issues related to data quality, the stochastic nature of extreme event impacts, length of time series, and various societal factors present in the disaster loss record, it is still not possible to determine the portion of the increase in damages that might be attributed to climate change due to greenhouse gas emissions.
12. For future decades the IPCC (2001) expects increases in the occurrence and/or intensity of some extreme events as a result of anthropogenic climate change. Such increases will further increase losses in the absence of disaster reduction measures.
13. In the near future the quantitative link (attribution) of trends in storm and flood losses to climate changes related to greenhouse gas emissions is unlikely to be answered unequivocally.
14. Adaptation to extreme weather events should play a central role in reducing societal vulnerabilities to climate and climate change.
15. Mitigation of greenhouse gas emissions should also play a central role in response to anthropogenic climate change, though it does not have an effect for several decades on the hazard risk.
16. We recommend further research on different combinations of adaptation and mitigation policies.
17. We recommend the creation of an open-source disaster database according to agreed upon standards.
18. In addition to fundamental research on climate, research priorities should consider needs of decision makers in areas related to both adaptation and mitigation.
19. For improved understanding of loss trends, there is a need to continue to collect and improve long-term and homogenous data sets related to both climate parameters and disaster losses.
20. The community needs to agree upon peer reviewed procedures for normalizing economic loss data.

# Appendix V: Comments from the U.S. Department of Agriculture

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



United States Department of Agriculture

Office of the Secretary  
Washington, D.C. 20250

FEB 23 2007

Mr. John B. Stephenson  
Director  
Natural Resources and Environment  
Government Accountability Office  
441 G Street N.W.  
Washington, D.C. 20548

Dear Mr. Stephenson:

Enclosed is the Farm and Foreign Agricultural Service's response to the draft report titled, "CLIMATE CHANGE: Financial Risks to Federal and Private Insurers in Coming Decades are Potentially Significant." Thank you for the opportunity to provide comments. If you have any questions regarding our response, please contact Michael Hand at 202-720-0642.

Sincerely,

A handwritten signature in cursive script, appearing to read "Mark Keenum".

Mark Keenum  
Under Secretary  
Farm and Foreign Agricultural Services

Enclosure

An Equal Opportunity Employer

**U.S. Department of Agriculture  
Response to the  
U.S. Government Accountability Office *Draft Report* GAO-07-285  
“CLIMATE CHANGE: Financial Risks to Federal and Private Insurers in Coming  
Decades are Potentially Significant”**

**February 8, 2007**

Weather-related events have caused billions of dollars in damage over the past decade. GAO examined actions taken by private and Federal insurers to address the potential increase in losses. As a result of the study, *GAO recommends that the United States Department of Agriculture (USDA), specifically the Risk Management Agency (RMA), analyze the potential long-term implications of climate change using forthcoming assessments from the Intergovernmental Panel on Climate Change to establish sound estimates of expected future conditions.*

**USDA Response**

USDA is in general agreement with GAO's recommendation.

**Specific Comments**

Although USDA agrees with GAO's recommendation, we do not agree with some of the conclusions drawn within the report.

See comment 1.

Much of the focus of this report is with losses related to coastal weather events, especially hurricanes. However, the main cause of catastrophic losses for the crop insurance program is drought in the nation's interior. This is why the loss experience of the crop insurance program is distinct from the loss experience described in the report for the National Flood Insurance Program and property and casualty losses for private insurers.

See comment 2.

The increase in crop insurance indemnities over time reflects the rapid growth of the crop insurance program, not an increase in either the frequency and/or severity of catastrophic weather events. In fact, the severity of loss for the crop insurance program, as measured by the loss ratio, has been generally lower in the 1990's and 2000's than in the 1980's. Thus, if anything, the frequency and severity of catastrophic loss events for the crop insurance program appears to be decreasing.

See comment 3.

USDA does not agree that it has "taken little action to prospectively assess potential increases in catastrophic risk associated with climate change." RMA tracks total program liability – a definitive measure of the total value at risk from climatic weather events. This number is updated on a weekly basis and is available on RMA's public website.



See comment 4.

RMA also estimates expected changes in liability up to 10 years ahead through RMA's baseline projections. Therefore, RMA *does* assess the long-term, as well as current, exposure of the crop insurance program to catastrophic weather events.

GAO's draft report treats the recurring 20- to 40-year Atlantic hurricane cycle as synonymous with climate change. However, other parts of the report describe climate change in terms of a long-run progression, such as global warming, that leads to an increase in frequency and severity of weather events. Referring to the normal cycle of Atlantic hurricanes as climate change appears to be inconsistent with how climate change is described in other parts of the report.

See comment 5.

When GAO surveyed private insurers about what they are doing to estimate and prepare for the risks of climate change, they found that insurers were using catastrophe models that incorporate the hurricane cycle. RMA also incorporates hurricane risk into premium rates for several of its insured commodities. However, rather than focusing on short-term fluctuations in the hurricane cycle, RMA uses historical hurricane data that spans several cycles.

The following are GAO's comments on the U.S. Department of Agriculture's letter dated February 23, 2007.

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## GAO Comments

1. We agree that the loss experiences of NFIP, FCIC, and private insurers are distinct and sought to reflect these distinctions in our draft report. For example, we acknowledged on page 23 of the draft the specific distinction USDA highlights—that the main cause of catastrophic losses for FCIC is drought in the nation's interior (see pages 24 and 25 of this document). Despite these and other differences, however, we believe the report's findings and underlying message are still applicable to the NFIP, the FCIC, and private insurers.
2. Our analysis of insured losses does not attempt to attribute increases in past losses to changes in the severity of weather events in the data sets we reviewed, as implied by the comment. Moreover, we acknowledge that the increase in FCIC's losses (indemnities) largely reflected the rapid growth of the crop insurance program. However, given the IPCC's projections for potential increase in the frequency and severity of weather-related events—including those that affect crops—we believe that limiting an evaluation of FCIC's *future* weather-related risk to the program's loss ratio—which only captures *historical* performance of the program based on past climatic and market conditions—to be a potentially misleading metric upon which to make a prospective assessment.
3. We acknowledged these activities in the draft report. However, we believe that USDA's actions are limited in scope, focusing almost exclusively on actuarial performance and not on the potential implications of climate change for FCIC's operations (i.e., changes in the frequency and severity of weather-related events, weather variability, growing seasons, and pest infestations). Accordingly, we believe the program should do more to prospectively assess the implications of climate change.
4. We employed the IPCC's definition of climate change, which includes statistically significant variations in climate, brought on by factors that are both internal and external to the earth's climate system, and that persist over time—typically decades or longer. Under this definition, the Atlantic hurricane cycle, as with other significant variations that are understood to be internal to the earth's climate system, can be considered climatic changes. Our use of the definition was corroborated by a senior NOAA scientist.

5. We updated our discussion of FCIC's modeling activities (see page 36) to reflect this hurricane model. However, as stated on page 22, 75 percent of FCIC's claims were associated with drought, excess moisture, and hail from 1980 to 2005, whereas hurricanes were associated with a much smaller portion of FCIC's claims during this period. Accordingly, we believe that if more sophisticated, prospective risk assessment techniques (such as those used in FCIC's hurricane model) were applied to drought, moisture, and hail events, it would allow for a far more useful assessment of the potential implications of climate change for FCIC's operations.

# Appendix VI: Comments from the Department of Commerce

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



UNITED STATES DEPARTMENT OF COMMERCE  
The Under Secretary of Commerce  
for Oceans and Atmosphere  
Washington, D.C. 20230

FEB 26 2007

Mr. John B. Stephenson  
Director  
Natural Resources and Environment  
U.S. Government Accountability Office  
441 G Street, NW  
Washington, D.C. 20548

Dear Mr. Stephenson:

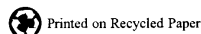
Thank you for the opportunity to review and comment on the Government Accountability Office's draft report entitled *Climate Change: Financial Risks to Federal and Private Insurers In Coming Decades are Potentially Significant* (GAO-07-285). Enclosed is the National Oceanic and Atmospheric Administration's comments on the draft report.

Sincerely,

A handwritten signature in cursive script that reads "Conrad C. Lautenbacher, Jr.".

Conrad C. Lautenbacher, Jr.  
Vice Admiral, U.S. Navy (Ret.)  
Under Secretary of Commerce for  
Oceans and Atmosphere

Enclosure



THE ADMINISTRATOR



Department of Commerce  
National Oceanic and Atmospheric Administration  
Comments on the Draft GAO Report Entitled  
“Climate Change: Financial Risks to Federal and Private Insurers  
In Coming Decades are Potentially Significant”  
(GAO-07-285/March 2007)

General Comments

The Department of Commerce (DOC) appreciates the opportunity to review this report. The issues covered in the report are very important and reflect the real world intersection between science, policy, and economics.

See comment 1.

We have three major comments on the structure of the report. First, GAO should provide a clear definition of the phrase “climate change” at the beginning of its report. While it is addressed on page 2, DOC recommends the authors refer to the definition provided by the 2007 Intergovernmental Panel on Climate Change (IPCC) Working Group 1:

**IPCC Working Group 1 Climate Change Definition**

Climate change refers to a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

See comment 2.

The second comment is directed to page 2 of the report and relates to the discussion of frequency and intensity of weather phenomenon. The authors write:

“Regardless of the cause, increasing temperatures—accompanied by changes in other aspects of the climate—may impact communities and, by extension, the insurance industry by altering the frequency or severity of weather-related events such as hurricanes, tornadoes, severe thunderstorms and hail events, and wildfires.”

While DOC recognizes the IPCC’s Fourth Assessment Report was not available at the time of GAO’s review, the issue of frequency and intensity has been well discussed in the scientific community, and policy makers would benefit from drawing information from the IPCC’s Summary for Policy Makers for Working Group 1. According to page 10 of this summary, “there is insufficient evidence to determine whether trends exist... in small scale phenomena such as tornadoes, hail, lightning, and dust storms.” The authors could state the frequency of heavy precipitation events has increased over most land areas... (page 8). On hurricanes, IPCC notes an increase in “intense tropical cyclone activity,” but also mentions “there is no clear trend in the annual numbers of tropical cyclones,” which refers to frequency. Tropical cyclones projections are addressed on page 16 of the summary, where the IPCC projects future tropical cyclones will become more intense, but there is less confidence in projections of a global decrease in numbers of tropical cyclones.

See comment 3.

Further, DOC notes the report could be strengthened by a discussion of what is meant by “altering the frequency or severity of weather-related events” and how this is linked to risk. For example, altering either the frequency or severity of high impact extreme weather-related events could result in a five fold increase in risk for what has been considered a 500-year event (i.e., probability of occurring in a given year = 1/500) shifts under climate change to be a 100-year event (i.e., probability of occurring in a given year = 1/100).

See comment 4.

The third comment is the report should examine coastal development impacts more rigorously. The National Oceanic and Atmospheric Administration (NOAA) has done work that uses data from the Bureau of the Census to show coastal communities have seen population growth of nearly 40 million people from 1970 to 2000. The authors refer to Roger Pielke, Jr.’s work on coastal impacts, but cite it only to show that more intense hurricanes tend to have higher impacts. Pielke, Jr., and others, including Chris Landsea of NOAA and Kerry Emanuel of Massachusetts Institute of Technology, have examined hurricanes, climate change, and development, and found coastal development has increased the vulnerability to winter storm surge, wind damage, and hurricanes. These vulnerabilities, due to high risk coastal development, will only be amplified by climate change related increases in the frequency or severity of high impact extreme weather-related events.

The authors cite anecdotal evidence, such as increased development in the area hit by Hurricane Andrew, but the report lacks analysis of the long term trends and does not quantify what portion of the increase in losses is attributable to societal change and economic development as referenced on page 58 in the Munich Re consensus statement. This would be useful information for policy makers.

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The following are GAO's comments on the Department of Commerce's letter dated February 26, 2007.

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## GAO Comments

1. We agree that a clear and accurate definition of *climate change* is a necessary prerequisite for any discussion of the issue. While a variety of definitions for the term are in use, we did not attempt to independently define the term. Rather, we relied upon the IPCC's most current publicly-available definition.
2. We revised the introductory statement referred to in Commerce's comments for editorial purposes (see page 2). To the extent practicable, we also incorporated the Working Group I Summary for Policymakers of the IPCC's *Fourth Assessment Report* into the detailed discussion of the potential changes in the frequency and severity of weather-related events identified in the 2001 *Third Assessment Report* (see pages 8 to 13).
3. We included an elaboration on page 14 of how altering the frequency and severity of weather-related events is linked to risk.
4. It was outside the scope of this report to conduct our own quantitative trend analysis of the relative roles of societal factors (such as development or agricultural prices) and climate change in shaping the increases in weather-related insured losses observed in the data. In response to the comment, however, we clarified which studies we reviewed that addressed this question, both for coastal hazards (such as hurricanes) and inland hazards (such as drought and excess moisture).

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# Appendix VII: GAO Contact and Staff Acknowledgments

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## GAO Contact

John Stephenson, (202) 512-3841, or [stephensonj@gao.gov](mailto:stephensonj@gao.gov)

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## Staff Acknowledgments

In addition to the individual named above, Steve Elstein, Assistant Director; Chase Huntley; Alison O'Neill; Michael Sagalow; and Lisa Van Arsdale made key contributions to this report. Charles Bausell, Jr.; Christine Bonham; Mark Braza; Lawrence Cluff; Arthur James, Jr.; Marisa London; Justin Monroe; and Greg Marchand also made important contributions to this report.

We also wish to give special tribute to our dear friend and colleague, Curtis Groves, who died many years too soon after a long battle with multiple myeloma near the conclusion of our work.



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# Related GAO Products

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