U.S. Insurance Industry Perspectives on Global Climate Change

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Synopsis

In this report we explore the disposition of the U.S. insurance community regarding the question of global climate change. To provide some context, we examine the history of insurance, insurance regulation, the role of government insurance and disaster relief, the relationship between insurer insolvencies and weather-related events, the emerging capital market alternatives to finance risk, and insurers' perception of and participation in climate science and catastrophe modeling. While it is generally recognized that weather-related catastrophe losses have been rising dramatically in recent years, the role of climate change in past or future trends is a subject of much uncertainty for insurers. Our in-depth interviews with insurance executives and extensive review of the literature found that insurers have assumed positions on all points of the public policy compass. This report has been prepared in the spirit of fostering improved understanding and communication among the insurance and non-insurance communities, and perhaps a higher level of interaction than has been seen thus far.

The world's nations have endured nearly one trillion dollars in economic losses (and 560,000 fatalities) due to 8,800 natural disasters over the past fifteen years. Three-quarters of the loss costs were weather-related, and a fifth were insured. Over the past 50 years, the number of weather-related natural disasters has been steadily rising, as have the total and insured losses. Nearly 60% of these losses are visited on U.S.-based companies, and between 1970 and 1999 losses (adjusted for inflation) grew nine-times faster than population. Meanwhile, the insured fraction of total losses has increased steadily, as has the size of those losses in relation to premium income.

Weather-related events touch almost all types of insurance providers, although the degree of vulnerability varies substantially. Property insurers are more vulnerable than are life and health insurers, and within the diverse property segment some insurance lines are more vulnerable than others. While the total available reserves are large compared to catastrophe losses experienced in the past, not all of these funds are available to pay such losses. In fact, about 90% of these reserves are associated with types of insurance that have relatively little if any weather-related exposure (e.g., workers compensation, medical malpractice, liability).

The effects of increased losses can lead to pressure on insurance reserves and prices, sensitivity of insurers' stock prices to major weather-related events, and an increasing number of insolvencies. Large and small insurers alike have been impacted by weather extremes and will be more so in the future if the frequency or intensity of weather-related events increases. The continued insurability of such risks is a central question, especially given that most experts project increases in extreme events going forward.

One of the vexing dilemmas facing insurers is the difficulty of disentangeling the causes of weather-related loss events. This is especially true for those potentially related to human-induced climate change versus natural climate cycles, and those having to do with human activity that could accelerate or dampen the process (demographic trends, increasing property values, disaster mitigation efforts, etc.). In many cases, upward trends in losses have shown to be a product of both human and climatological factors, but an in-depth understanding is hampered by technical complexity and insufficient information. Compounding the problem, climate change research is rarely conducted with insurers in mind.

The words "Climate Change" stir anxieties and arouse controversies among insurers. While a number have given some attention to the issue, the vast majority of individual firms and most trade organizations have not indicated an opinion (at least not in a public forum). A few have taken definitive positions that there is a material threat, while others have adopted equally strong views to the contrary. Some have elected to pursue research and the fortification of society against climate change, and others to adopt a "wait-and-see" stance. U.S. insurer involvement in

the issue was greater in the mid-1990s than it is today, with many insurers paralyzed by conflicting reportage on the topic and skeptical about the political and scientific assessments of climate change.

Insurers have a number of tools for reducing their financial vulnerability. These include purchasing reinsurance, raising rates, non-renewal of existing policies, and the cessation of writing new policies. They may also limit their liability by capping amounts of insurance available, placing special limits of liability on coverage, providing coverage on an "actual cash value" basis (taking deductions for depreciation holders and/or betterment) instead of paying for the replacement cost, and increasing the deductibles paid by their customers. They may also pool their risks and strive to increase their investment income, and, if sufficiently burdened, reduce dividends to shareholders and/or policyholders. Implementing some of these measures may require legislative or regulatory action and present possible political and market risks. Meanwhile, insurers—in consort with other parties—also possess a diverse toolkit of engineering approaches to managing and minimizing the losses caused by natural hazards. These include use of geographic information systems to better understand and pinpoint risks, land-use planning, flood control programs, early warning systems, sustainable forest management, coastal defense, and wind-resistant construction techniques supported by building codes. However, some within the industry question whether even the combined effect of these types of loss control are sufficient.

Insurers are also able to transfer loss costs to governments, self-insureds, consumers, and the capital markets. Insurers point out, rightfully, that not all risks are commercially insurable in a market economy. Seeking reductions in private sector insurance coverage for climate- and weather-related hazards produces increased pressure on government to assume the associated risks. Governments, however, have repeatedly shown reluctance to increase their existing insurance exposures and liabilities for providing disaster relief. This tension is a central dilemma facing society in the face of rising catastrophe losses.

Although the notions of risk management and loss prevention are embedded in the historical fiber of the insurance industry, U.S. insurers have yet to fully extend this thinking to the matter of climate change. Insurers have treated loss control as a relatively "local" enterprise, whereas it would entail a rather dramatic shift in self-perception for insurers to engage in the activity at a (literally) global scale. Moreover, we have seen no quantitative analyses of how climate changes could effect the "probable maximum loss" estimates upon which insurance pricing and planning rest.

With some notable exceptions, the preponderance of existing U.S. insurer activities fall in the area of pre- and post-disaster loss mitigation, rather than involvement in climate science or mitigating the potential effects of climate change itself. An important semantic point is that while the climate-change research community uses the word "mitigation" to refer to measures that promise to *reduce the process* of climate change, the insurance community uses the term to refer to measures that *reduce the likelihood of losses* from climate-related (and other) events.

Nonetheless, many of the insurance executives we interviewed exhibit a genuine desire to make a contribution toward safe-guarding the public and their policyholders. However, most claim to lack the scientific knowledge needed to participate in the climate-change debate. Ironically, some stridently declare a lack of expertise and in the same breath state with authority that climate change is not taking place.

Over the past decade, U.S. insurers, to their credit, have been involved in a large number of activities in which the question of weather-related losses (and in some cases climate change itself) have been addressed. While this evidences considerably more involvement than many outside the insurance community are aware of, what does not emerge is a sense that these events have built upon one another towards some sort of consensus on the matter or towards a coordinated plan of action extending beyond preliminary discussion and fact-finding activities.

Given the potential for disruption caused by climate change, it is notable how limited U.S. insurer activities have been (at least as is evidenced in the public record) to analyze the problem. At the highest level, we discern three basic types of "perceptual

barriers" to more in-depth insurer involvement and collaboration with non-insurer groups. These include: (1) uncertainties regarding the science of climate change, (2) distrust, emanating from parochialism and provincialism among stakeholders; and (3) lack of knowledge and the failure to fully understand stemming from insufficient dialog among stakeholder groups. Underlying these, we identify an extensive series of barriers that fall into the categories of "legal and regulatory", "technical and informational", "economic and market", and "political".

We touch on the sometimes remarkable differences between the activities and statements of U.S. and non-U.S. insurers. These include the relative weight of green marketing and green politics, the role of governments in natural disasters, conceptual approaches to loss prevention and mitigation, and the perception of new business *opportunities* presented by climate change risks. Likewise the regulatory and tax-law environment, as well as the tone and tenor of government relations with insurers, and differences in corporate culture and the timeframes with which insurers measure their futures can differ dramatically among countries. It was 28 years ago that European insurers first articulated concern about climate change (16 years before their U.S. colleagues first publicly addressed the issue). Yet, it is also fair to say that, in a few select ways, U.S. insurers are ahead of their European counterparts.

Non-insurer organizations in the U.S. often evidence little appreciation for differences in conditions faced by U.S. and overseas insurers. Although generally well intentioned, we find that efforts to involve insurers in the climate change discussion have met with very limited success. We believe that the problem stems in part from non-insurers' lack of knowledge about the intricacies of the insurance business, i.e., its history, regulation; the common misperception that insurers are a monolithic group and occasional overstatement of the facts on climate change. Meanwhile, mutual understanding is also hampered by insurer perceptions that these groups are politically rather than scientifically motivated or that non-insurers cannot bring true value to their core business.

It appears that differences in worldview and analytical orientation have served to separate many insurers and non-insurers on the question of climate change. Some of these differences may prove irreconcilable, but others certainly stand to be bridged through increased mutual understanding and interdisciplinary, cooperative research and inquiry. Both communities—and their constituencies—no doubt stand to benefit from engaging with the other in a more comprehensive dialog. From various quarters within the insurance community, we are already hearing a call for a more holistic approach, one that integrates no-regrets environmental protection with the discipline of disaster risk management.

Executive Summary

Globally, society has endured nearly one trillion dollars in economic losses[1] due to natural disasters over the past fifteen years alone—about a fifth of which were insured and three-quarters of which were due to weather-related events. These losses—also evidenced over a longer 50-year timeframe—are on the rise, as is the share of premium revenue represented by these losses. A multiplicity of factors contribute to the scale and rate of change in losses, ranging from economic and demographic trends, to market factors, to changes in the nature of natural disasters themselves.

In recent years, various parties outside the insurance community—e.g. government entities, scientists, and environmental groups—have sought to engage the $2.2-trillion-dollar global insurance industry[2] in the climate change discussion. Among these non-insurance groups, some have argued that climate changes could expose insurers to devastating losses. Others have alerted insurers to new business opportunities and other co-benefits stemming from climate change mitigation. Although well-intentioned, these efforts have generally met with limited success. We believe that the problem stems in part from non-insurers' lack of knowledge about the intricacies of the insurance business, e.g., its history and regulation; a misperception that insurers are a monolithic group; and lack of awareness of the variety of risk management tools available to insurers. Non-insurers also tend to have an incomplete grasp of past and present insurer involvement in the issue of climate change, and of the different political and market conditions faced by overseas insurers who appear to be more involved in the issue. On the other side of the divide, insurers—like any specialized community—do not always embrace multi-stakeholder collaborations. Some insurers also perceive the non-insurer groups as politically rather than scientifically motivated, and as insensitive to their basic needs and constraints as businesses. With these differences in mind, this report has been prepared in the spirit of fostering improved understanding and communication within and among these communities.

While our central focus is on the U.S. insurance community, we also focus on the government sector as insurer and regulator of insurers, and thus an integral part of the risk-management equation.

Where applicable we draw upon experiences of overseas insurers and upon global insurance data. It is worth bearing in mind that as the insurance market becomes increasingly interconnected, national borders will play a reduced role in characterizing the industry and the risks it faces. U.S. insurers collected $35 billion in premiums for overseas insurance sales in 1997 (approaching 15% of total premiums), and this business has been growing faster than overall premiums in recent years. Overseas insurers can also be impacted by events within the U.S. As a case in point, largely as a result of the U.S. environmental liability crisis (Superfund), natural disasters, and various oil industry disasters, Lloyd's of London experienced a pronounced 13-year period of mostly negative profitability from 1980 to 1993.

[1] According to Munich Re, total economic losses are dominated by direct damages, defined as damage to fixed assets (including property or crops), capital, and inventories of finished and semi-finished goods or raw materials which occur simultaneously or as a direct consequence of the natural phenomenon causing a disaster. Economic loss data can also include indirect or other secondary damages such as business interruptions or temporary relocation expenses for displaced households. More loosely-related damages such as impacts on national GDP are not included. In the U.S., Property Claim Services (PCS) definitions of losses set minimum thresholds for inclusion of $5 million up to 1996, and $25 million subsequently. As a result, no winter storms were included in the statistics for the 46-year period of 1949-1974, and few were included thereafter (Kunkel *et al.* 1999). Although large in aggregate, highly diffuse losses due to structural damages from land subsidence would also rarely be captured in these statistics. Similarly, weather-related vehicle losses are typically not captured in the statistics. Thus the totals presented here are underestimates of actual losses.

[2] This includes premiums collected by the two major branches of the industry: property/casualty and life/health insurers. The relative sizes of these branches, and the relevance of climate-related losses for each are discussed in this report.

Approach and Organization of the Report

This report focuses primarily on factors shaping U.S. property/casualty insurer perspectives on the matter of climate change, with a central aim to help-foster a higher level and quality of understanding and interaction between the insurance and non-insurance communities. The life/health segment is treated only peripherally, although it too is vulnerable to weather and climate-related loss events.

While this report is intended primarily to help orient non-insurers to the insurance market, it may also serve insurers who have not already explored the climate change question in depth.

To initiate our inquiry, we touch upon the history of insurance and the organizational structure and regulation of the business. We examine numerous important chapters in the history of insurance, including the advent of the multi-peril policy and "Standards of Insurability" that determine whether insuring a risk is seen as commercially viable.[3]

We then review the various potential causes of change in the patterns of weather-related losses and loss costs, including the impact of increasing and shifting populations and exposures. We also discuss the function and relevance of government insurance and public policies that interact with the private-sector insurance marketplace. We survey the emerging non-insurance alternatives for financing risk, and describe the challenges insurers face in seeking regulated rates that are adequate to pay future losses. We review the trend towards "cash flow-underwriting" and related concerns about the future availability and viability of reinsurance. We also identify factors and barriers that shape the minds and attitudes of insurance leaders. In addition—in the main text with additional key material in Appendix B—our review considers insurer's interaction with the science of climate and catastrophe modeling.

At the core of the report, we present the results of interviews with 17 insurance executives to explore insurer perspectives in-depth. A number of those interviewed requested anonymity, and we respect that in our account. This report is also underpinned by a review of over 300 publications from the scientific and insurance trade literature.

A note about our approach is in order. Our aim is to describe the historic and present-day disposition of the U.S. insurance community regarding the question of climate change. In the course of our interviews and other information-gathering activities, we received input from several dozen insurance firms and organizations. In these discussions, we encountered tremendous variability in the nature and degree of interest in the climate change issue. Our intention is to synthesize, analyze, and report all that we learned for the benefit of the reader. The result naturally depicts a diversity of opinions and perspectives, rather than a polished and internally consistent "position". This is not intended as a criticism of insurers, but rather as a stock-taking exercise that will help all concerned parties more forward in a constructive fashion. The knowledge base from which we could draw is by definition limited to what insurers would share with us verbally or what is documented in the public domain. A number of leaders in the insurance and financial services communities were invited to provide peer review comments on a draft of this manuscript, and we are grateful to those who took the time to do so.

[3] The standards of insurability include: (1) There should be a large number of homogeneous exposures to permit the operation of the theory of probability and setting of actuarial rates (law of large numbers). (2) The occurrence should be fortuitous: i.e. the timing or the severity of the loss should be out of the control of the insured. (3) The peril must produce a loss definite in time and amount. The insurer must be able to verify the loss promptly and measure its magnitude. (4) The insured group of risks must not be exposed to an incalculable catastrophe hazard. There must not be a significant concentration of values in vulnerable areas. (5) The premium must be reasonable in relation to the potential financial loss (priced to attract purchasers), and, simultaneously, develop the actuarially sound premiums necessary to cover the losses while providing for insurer solvency.

History Shapes the Minds and Attitudes of Insurers

Formal insurer attention to weather-related losses is a relatively recent development in the history of the U.S. property/casualty insurance industry. Historically focused on insuring a single peril, "fire", it was only within the last fifty years that U.S. underwriters engaged extensively in insuring other causes of natural hazard events. Natural disaster loss mitigation, in practice, has not reached the level of refinement as it has in the case of fire. Since broadening their focus from insuring only fire, insurers have assumed a potpourri of losses from weather-related events, such as hurricanes, cyclones, tornadoes, severe windstorms, hail and ice storms, rainstorms, floods, tidal surges, heat waves, soil subsidence, erosion, etc. Compared to the fire peril, only fragmented knowledge and few underwriting criteria exist for these events.

Events have shown that these hazards can cause catastrophic direct loss and significant consequential losses such as, fires and wildfires, business interruption, food spoilage, and losses associated with additional living expenses. Climate change (be it natural or caused by human activities) increases actuarial uncertainty and therefore financial risks for insurers.

Insurers have had considerable involvement with "loss prevention" and it is in fact an integral part of their history, via fire safety programs and the like. Insurance loss prevention, however, has generally focused on arming the individual against risk rather than reducing the risk itself. Stated another way, insurer catastrophe loss mitigation efforts have striven to lessen structural and content losses, but generally, exclusive of the "fire peril", have not attempted to eliminate or reduce the root peril or hazard causing the occurrence.

Going forward, it must be kept in mind that insurers face many issues and pressures aside from the question of potential changes in natural catastrophes, some of which are perceived as more pressing. Examples include current trends towards consolidation and convergence between banking and insurance — although these too can have beneficial or adverse impacts on a firm's financial fitness and vulnerability to catastrophes, a point that has not gone unnoticed by insurers.

Government's role in providing insurance and disaster prevention/recovery aid is an important and growing part of the equation. Discussion and analysis of insurance and climate change thus must weigh the nature and importance of government involvement. According to one estimate, U.S. government disaster-related payments amounted to $119 billion ($1993) for the 1977-1993 period. If climate risks rise, insurers will likely look to governments to play an increasing role in assuming those perils and/or hazards that produce catastrophic losses. However, government's past and current efforts to limit and even reduce financial support following natural disasters indicates their ambivalence toward assuming additional risks. As evidence of the challenges facing the U.S. government, their insurance programs for crop and flood have not been able to attain solvency. The current-day debate over federal catastrophe reinsurance further evidences the difficulty in finding an acceptable balance for risk sharing between the public and private sectors.

Insurer Vulnerability to Climate Change is Real, but Difficult to Quantify

There is a clear upward trend in global weather-related losses, even when adjusting for inflation. An "average" year these days produces 5.5-times as many weather-related natural disasters, globally, than 40 years ago, resulting in 13.6-times the insurance losses, adjusted for inflation, or $9.2 billion per year in the 1990s. In the fifteen-year period between 1985 and 1999 over 8,800 weather-related catastrophes took place around the world. Globally, 31% of the total economic costs and 58% of the associated

insurance losses were visited on U.S. insurers. During this period, the ratio of global property insurance premium income to losses fell three-fold.

Over the past three decades, the majority of global insurance losses were absorbed by U.S.-based companies, and catastrophe losses (adjusted for inflation) grew by over seven-fold — i.e. nine-times faster than population. The ratio or premiums to catastrophe losses fell by six-fold in the U.S. over this period (and briefly by 20-fold following Hurricane Andrew).

Irrespective of the causes of past losses, a problem looking forward is that academic climate science is rarely designed to address the exact questions of importance to insurers. The growing popularity of catastrophe ("CAT") models is a step in the right direction, but these models are predicated largely on historical data rather than scenarios incorporating future climate change, and there is regulatory resistance to the use of these models for setting insurance premiums.

For insurers, vulnerability can be broadly viewed in terms of the relationship between probable maximum losses (PMLs), the sector's capacity to pay for these losses, and its ability to recharge depleted reserves and surplus (net assets), taken together with the predictability and uncertainty of such events. The cyclic nature of the insurance industry (prices and reserves) intrinsically leads to periods of higher-than-average vulnerability. While the ultimate manifestation of impacts for an insurer is insolvency (bankruptcy), catastrophes can disrupt insurance markets and harm insurance companies and consumers even in cases where all claims are paid. We have seen no quantitative analyses of the potential effects of climate change on PMLs.

The insurance sector is extremely diverse, with most branches vulnerable to climate/weather-related losses but to significantly varying degrees. Meaningful analyses must pinpoint the most vulnerable industry segments. Based on experience to-date, the property/casualty (P/C) segment is more vulnerable to weather-related events than the life/health segment. The single-most vulnerable sub-segment appears to be property insurance for structures. Other segments, such as personal automobile insurance, have more limited exposure. Less obvious vulnerabilities include impacts such as those from increasing lightning strikes on machinery breakdown and business interruption insurance.[4] As an indication of the diversity of indirect effects, industry groups have even cited social or economic instabilities caused by climate change as a potential trigger for "political risk" insurance claims, although the likelihood and magnitude of such losses is relatively low. Other types of insurance (e.g. medical malpractice) are unaffected by weather.

Before liquidating assets to pay losses, insurers can utilize "reserves". Reserves are formed based on historic loss experience and are not allowed to include extraordinary losses that might be expected in the future. According to A.M Best Co., as of 1999, property/casualty insurer reserves totaled $345 billion. While this amount is large compared to catastrophe losses experienced in the past, most of these funds are not available to pay such losses. In fact, the majority of these reserves are associated with types of insurance that have relatively little if any weather-related exposure (e.g. workers compensation, medical malpractice, liability). Reserves for the most vulnerable lines: commercial multi-peril and homeowners multi-peril were approximately $37 billion (11% of the total), with an additional $6 billion provided through reinsurance.

Overall capacity, measured in terms of surplus ("net assets"), varies considerably over time with the industry's core business and the performance of the financial markets in which many of their assets are located. A significant increase was seen during the 1990s, thanks to regular growth and the bull market.

While much emphasis is placed on the largest and most destructive weather events, often referred to as "mega-catastrophes" within the insurance community, small weather-related losses are also important. In fact, such small events represent one-half of all weather-related insurance losses.

Further complicating matters, from an actuarial standpoint, climate changes can imply greater statistical uncertainty (unpredictability) concerning potential losses and an unclear "pathway" between

[4] Lightning has been cited as responsible for five percent of (presumably property) insurance claims (Kithil 1995), which would be approximately $9 billion annually. Reve and Toumi (1999) have shown that a 1-degree-C increase in average wet-bulb temperature can be accompanied in mid latitudes by a 40% increase in lightning. Price and Rind (1993) found that in a $2xCO_2$ climate with a 4.2-degrees-C warming, global cloud-to-ground lightning strikes would increase by 72% over continential regions.

present and future climate regimes. This uncertainty in and of itself represents an adverse and undesirable aspect of climate change.

One of the vexing dilemmas is that it is not easy to disentangle the relative causes of these losses, especially those potentially related to human-induced climate change (versus natural climate cycles) and those related to human activity that could accelerate the adverse effects of natural phenomenon. These adverse effects include demographic trends, increasing property values, etc.[5] In many cases, upward trends in losses have shown to be a product of both human and climatological factors.

On the other hand, considerable human efforts are made to avert or reduce natural disaster impacts, including mitigation along coastlines, cloud seeding to divert hail storms, improved building codes, tightened zoning, improved weather forecasting and storm warning systems, and public spending on disaster preparedness and recovery. While rarely if ever quantified or otherwise factored into studies of human versus natural causes of loss growth, these efforts can offset or obscure otherwise visible effects of climate change.

Comprehensive analyses of global insurance sector vulnerability to past or future climate changes have not been undertaken. A recent paper addressing this question was prepared by the American Insurance Association. AIA, a national trade organization of primarily large U.S. property-casualty insurers—representing approximately 20% of annual premium revenues for this segment—estimated that: 17% of U.S. insurance P/C premiums are associated with types of insurance with "significant" exposure to weather-related loss, 2% with "moderate" exposure, 66% with "minor" exposure,[6] 9% with "minor to no" exposure, and 4% with "no" exposure (AIA 1999).[7]

Studies such as AIAs are an important starting point, and highlight the need for segmenting and taking into account the financial complexity and diversity of the insurance sector, rather than regarding it as a monolith. Their study also points out the dominant role of hurricanes in the overall picture of weather-related losses in the U.S. and that a connection between hurricanes and climate has not been established. Moreover, the study notes the importance of proactive land-use planning and that certain measures normally thought of as climate change "mitigation" (e.g. emissions reduction achieved through public transportation or reduced highway speed limits) can also offer benefits to insurers by reducing everyday risks.

Individual firms may become insolvent long before losses approach the industry's aggregate capacity, even at a level of a $10-$20 billion-loss event in the case of the U.S. While reinsurers offer additional capacity, a general consensus as of the late 1990s suggested that the capacity of insurers and reinsurers to absorb a single major catastrophe, without major disruption, is distinctly limited as well.

The threat of insolvency is often assumed to apply exclusively to small firms. Following Hurricane Andrew, however, we observed that the country's largest homeowner property insurer, State Farm Fire & Casualty, was brought to the brink of insolvency, necessitating a rescue by its parent (State Farm Group). The same fate met Allstate, the nation's second largest homeowner insurer. Of the nearly 700 U.S. insurer insolvencies between 1969 and 1999, about 10% were primarily due to natural catastrophes, and for an unknown additional share catastrophes were a contributing but not primary factor.

Most analyses focus on single loss events, while in reality insurers can be faced with sequential losses or other sources of financial stress. Multiple extreme events in close spatial or temporal proximity constitute low-probability, high-consequence events for the industry. Severe non-weather-related events (e.g.

[5] Studies by Easterling *et al.* (2000), Changnon *et al.* (1997), and Pielke and Landsea (1998) have attempted to disentangle factors underlying the upward trend in weather related catastrophe claims (see Appendix B).

[6] This large segment is predominantly vehicle insurance. In the U.S., 16% of automobile accidents are attributed to adverse weather condition (NHTSA 1999), as are one-third of the accidents in Canada (White and Etkin 1997) and 43% in the U.K. (Barker *et al.* 1998). Vehicles also sustain insurance losses from natural disasters, averaging 10% of all catastrophe losses, or $3.4 billion and 1.7 million claims between 1/1996 and 9/2000, with auto losses in individual events ranging as high as 55% of the total. (PCS 2000).

[7] The full report can be found in Appendix E. The most sensitive customer segments are residential and commercial property, ocean marine, crop and farm-owners, and flood. Crop insurance and residential flood insurance are largely insured or reinsured by government. The paper did not evaluate other measures of vulnerability, such as profitability or solvency at the level of the firm or exposures according to other metrics, e.g. in terms of total insured property values for which the at-risk insurers are responsible—e.g. $4 trillion in insured property in the Gulf and Atlantic coastal counties of the U.S. (Hooke 2000). Losses from crop and flood insurance excluded because the risk is assumed by the federal government.

earthquakes), could also deplete a significant proportion of insurer reserves.

Moreover, vulnerability arises from the relative health of the insurance and broader financial sectors and markets prevailing at the time of a major catastrophic loss event. Major market fluctuations can have an adverse impact on insurer solvency. In the event of catastrophic losses, insurers may need to liquidate investments (a part of "surplus") in order to generate loss compensation. Coinciding broad-based stresses on the industry can directly influence vulnerability by eroding surplus. Such past or potential sources of stress include: major tobacco-related claims, the crisis in liability insurance (especially the "long-tail" U.S. Superfund and asbestos claims), increased competition from Internet sales, Internet privacy liability,[8] or world events such as the Asian financial crisis or elevated energy prices.

Insurance prices and stock values have exhibited sensitivity to disaster events. Aside from issues of solvency, past extreme weather events clearly have measurable short- to medium-term impacts on the availability of insurance and reinsurance following the disaster event and on insurance industry-wide profitability.

An overarching issue is that, from an actuarial standpoint, future disaster trends that develop in an unpredictable, non-linear manner can imply greater statistical uncertainty (unpredictability) of potential losses. This can present a material impediment to setting actuarially sound rates. Interrelated vulnerabilities arise from regulatory uncertainties, e.g. the inflexibility sometimes exhibited when insurers propose withdrawing from markets or raising insurance prices. Overlaid upon the preceding uncertainties, future climate and weather regimes will not necessarily represent a simple extrapolation of the risks as they are known today, and exposures are steadily increasing as people continue to move into harm's way.

Insurers Have Tools for Managing and Spreading Risk

Insurers have many tools for reducing their financial vulnerability to losses. These include financial mechanisms such as increasing surplus, raising prices, or denying policy renewals and new policies. Insurers can also limit the maximum losses that can be claimed by paying for the depreciated value of damaged property instead of the new-replacement value, by reducing dividends paid to shareholders, or by tightening deductibles (raising the floor or redefining them in percentage terms instead of fixed amounts). However, for technical as well as political reasons, insurance regulators have shown limited willingness to grant such allowances.

Similarly, insurers—in consort with other parties—spread risks through engineered risk management approaches, including use of geographic information systems to better understand and pinpoint risks, land-use planning, flood control programs, early warning systems, sustainable forest management, coastal defense, and wind-resistant construction techniques supported by building codes.

Insurers also spread risks among themselves by pooling risks via so-called Residual Market Mechanisms (FAIR Plans, Beach and Windstorm Plans, and Joint Underwriting Associations). These mechanisms represented insured property value (exposure) of $24 billion in 1970, rising to $285 billion in 1998.

Insurers also utilize mandated Guaranty Funds (a.k.a. "Insolvency Funds") through which solvent insurers must contribute to the payment of claims when member insurers become insolvent. Guaranty Funds were originally intended for small, specialized, and geographically concentrated firms but there has been a trend towards insolvencies and corresponding demand for guaranty fund resources among larger and more diversified companies. Payments from these funds have grown substantially in recent decades, with net assessments of $6.3 billion over the 1969-

[8] In the insurance trade press, the specter of Internet privacy litigation has been likened to the pollution liability (Superfund) crisis.

1998 period, and as much as $0.9 billion in a single year. Of the 25 largest U.S. P/C insolvencies (amounting to $5 billion in unpaid claims), only 29% of the losses were recoverable through guaranty funds and national capacity was only $3.4 billion as of 1998. Insurers who are not directly impacted by a catastrophic event, can thus experience a liability through their participation in Guaranty Funds.

Insurers spread risk even more widely by purchasing reinsurance, wherein reinsurers essentially assume a portion of the risks in exchange for part of the premium. Reinsurance is certainly a moderating force with respect to many of these vulnerabilities, although it is not a panacea. For example, an analysis conducted by the Swiss Reinsurance company concluded that the presence of reinsurance coverage for natural disasters in 14 major markets around the world (U.S. $53 billion) was insufficient.

Insurers can also spread risks to points entirely outside of the insurance industry. This is being promoted through a family of financial instruments collectively referred to as Alternative Risk Transfer (ART). These mechanisms include contingent surplus notes, catastrophe equity put options, catastrophe bonds, and catastrophe options. There are widely disparate views within and outside of the insurance sector concerning the potential for and efficacy of these instruments.

Lastly, many risks are passed to the government sector (including the local, state, and federal levels). Government has assumed the role of insurance provider in the past for risks that private insurers find uninsurable. These include certain crop and flood risks. Governments also provide disaster preparedness and recovery services, e.g. through the Federal Emergency Management Agency (FEMA) or the Small Business Administration's (SBA) disaster recovery loan program. The question of who assumes disaster risks is a "hot potato" tossed back and forth between insurers and the government.

While the above-mentioned tools have served society well and their value should not be underestimated, it is also clear that the specter of natural disasters is a growing concern for insurers and that existing risk management and spreading mechanisms are constantly being tested.

The Words "Climate Change" Stir Anxieties and Arouse Controversies among Insurers

U.S. insurers contend that they are interested in, and are constantly striving to acquire a better understanding of extreme natural hazard events. Yet, most stridently assert that they are not experts on climatological or meteorological matters. They vigorously resist being thrust into a role that would have them commenting on issues or problems on which they lack expertise. Insurers maintain that they have expertise in matters of loss control, reduction and/or prevention, and it is in this area that they view themselves as making a major contribution particularly relating to extreme events.

On the question of climate change, U.S. insurers can be found on all points of the public policy compass. While a number have given some attention to the issue, the vast majority of insurers and many trade organizations have not publicly indicated an opinion. A few have taken definitive positions believing that there is a material threat, while others have taken equally strong views to the contrary. Some have elected to pursue the fortification of society against natural perils, and others to adopt a "wait-and-see" stance.

Although the notions of risk management and loss prevention are embedded in the historical fiber of the insurance industry, U.S. insurers have yet to extend this thinking to the matter of climate change. Insurers have historically treated loss control as a relatively "local" enterprise, whereas it would entail a rather dramatic shift in self-perception for insurers to engage in the activity at a (literally) global scale. Relevant insurer activities fall in the (important) area of pre- and post-disaster loss mitigation, rather than understanding climate science or engaging in the

public policy discussion about mitigating the potential effects of climate change itself. Note that while the climate-change research community uses the word "mitigation" to refer to measures that promise to reduce the threat of climate change, the insurance community uses the term to refer to measures that reduce the likelihood of losses from climate-related (and other) events.

Over the past decade, U.S. insurers have been involved in a large number of activities in which the questions of weather-related losses—and in some cases climate change itself—were addressed. While this history evidences considerably more activity than many outside the insurance community might expect, what does not emerge is a sense that these events have built upon one another towards some sort of consensus on the matter or towards a coordinated plan of action extending beyond preliminary discussion and fact-finding stages. One very positive characteristic of some past efforts is their multidisciplinary approach, in which partnerships with groups outside the insurance sector have been profitably created. However, many barriers remain unresolved, and these cross-cutting partnerships are more the exception than the rule.

The responses of the insurance executives we interviewed paint a picture of insurers who exhibit a genuine desire to make a meaningful contribution toward safeguarding the public and their policyholders. However, most claim to lack the scientific knowledge needed to participate in the climate-change debate. Some stridently declare a lack of expertise and, in the same breath paradoxically state with authority, that climate change is not taking place. Some view the happenings to be "an accident of nature" while others subscribe to the theory that climate change is a cyclical event. Still others support the proposition that the earth's inhabitants, through the burning of fossil fuels and destruction of the rain forests, are contributing to the phenomenon.

Government's role in providing resources for disaster preparedness and recovery and in providing insurance products related to natural disasters is bound to be a moderating factor in insurers' perception of climate-related business risks. The stance of state and federal government (as insurance regulators) is thus fundamental to insurers' outlook, as is the federal government's position in international negotiations on climate change.

Government-sponsored coverage of climate related risks like crop and flood insurance has also insulated U.S. insurers from the full scope of climate related risks,[9] although private insurers do absorb considerable flood losses and some perceive this risk to be growing in the face of climate change. Partially as a result, U.S. insurer attention to climate science has focused largely on wind-related hazards (particularly hurricanes).[10] Relatively little effort has been spent on evaluating other climate-related risks. This narrow focus is justified to a degree given the dominance of windstorms in insurance claims in recent decades, but it also predictably leads to a less-than-comprehensive perspective on the climate change phenomenon.

Many (Surmountable) Barriers Exist

Based on our in-depth interviews and our other research, we offer two ways of analyzing the barriers to more proactive involvement of insurers in the climate change issue. At the highest level, we discern three basic types of "perceptual barriers":

- Uncertainties regarding the science of climate change
- Distrust, parochialism, and provincialism among stakeholders
- Lack of knowledge, and failures of understanding

[9] Total estimated losses from the 1988 U.S. drought were $56 billion, and those from the 1993 Mississippi River Valley floods were $23 billion ($1998). Combined U.S. flood losses for the period 1987-1997 amounted to approximately $65 billion, inflation-corrected to 1995 dollars (Rosenzweig *et al.* 2000).

[10] And, ironically, the U.S. is in a period of reduced hurricane activity, possibly as a consequence of climate change.

stemming from insufficient dialog among stakeholder groups

Underlying these perceptual barriers, we identify a series of barriers and influences that fall into the categories of "legal and regulatory", "technical and informational", "economic and market", and "political".

Legal and regulatory barriers include a lack of imperative from regulators and resistance to new modeling techniques — the taxation of reserve funds set aside for future losses — disallowed recovery of R&D costs — prohibitions against raising prices or withdrawing from at-risk markets mandated involvement in climate change mitigation — and concern that negative experiences such as those with Superfund (liability for pollution) and OSHA (liability for customer emissions reductions or monitoring) will be repeated.

Technical and informational barriers include imperfect data on historical losses — scientific uncertainties and unfounded claims (on both sides of the issue), often amplified by the media — limited ability of climate models to generate results in timeframes and spatial scales that are applicable to insurers — absence of in-house climate expertise — inability of the industry's retrospective "CAT" (catastrophe) models to evaluate prospective scenarios of future climates affected by greenhouse-gas emissions or other causes — and unknown or unfamiliar risk-management characteristics of climate change mitigation technologies.

Economic and market barriers include "supply side" issues such as: more pressing market conditions, competition, and consolidation — the perception that future loss costs are easily recovered through rate and/or deductible increases — soft market conditions that make it particularly difficult for insurers to spend money on research and to differentiate rates to reward environmentally friendly practices among their customers — perception of an immense capacity of alternative risk financing mechanisms — the presence of risk-pooling systems and government-financed insurance and loss-reducing programs that insulate insurers from some of the most uncertain kinds of natural disaster events. There is also suspicion that reinsurers are exaggerating climate change warnings to sell more of their product, and a proactive versus reactive "corporate culture" among some insurers. The economic barriers also include "demand-side" issues such as: lack of imperatives from shareholder and consumer groups — the virtual absence of demand for "green products" and associated corporate behavior in the insurance marketplace — aversion to climate change politics among customers that produce greenhouse-gas emissions — and a host of reasons that encourage insurance buyers to underestimate their true exposures.

Political barriers include the fact that insurance is not a "polluting" industry — peer pressure from major industries participating in the Global Climate Coalition — a general desire to avoid involvement in government initiatives — a specific negative perception of the United Nations (thus tainting the UNEP Insurance Industry Initiative) — concern about identifying their concern only to become the object of tightened solvency requirements or scrutiny and criticism and expectations on the part of environmental activists — regulatory pressure to assume uninsurable risks — becoming the object of a tug-of-war between government, industry, and consumer groups — and competing "social causes" and limited funds to support them.

U.S. insurers are generally not experts in climate-change economics, and some perceive the reduction of greenhouse gases as an unaffordable public policy. It is also notable that U.S. insurers have yet to publicly discuss the potential business opportunities that climate change avoidance/mitigation may offer to them and others in the business community.

Similarities and Differences between U.S. and Non-U.S. Insurers

One need not look far to find statements that highlight remarkable differences between most U.S. and non-U.S. insurers on the question of climate change. The differences are characterized in part by the tendency for non-U.S. insurers to believe that full scientific certainty is not necessary before precautionary sort of precautionary action is justified, and that current-day escalation of weather-related losses is due in part to climate change and in part to natural variability and cycles.

Environmental groups and others eager to see insurers engage in the climate change discussion are quick to point to the proactive words and deeds of non-U.S. insurers as evidence that U.S. insurers are lagging behind their peers. However, non-insurers seldom recognize fundamental differences in conditions faced by the two groups. These include the status of "green marketing" as a factor in consumer expectations, the availability of government insurance for climate-related natural disasters, conceptual approaches to loss prevention and mitigation, regulatory and tax-law environment, tone and tenor of government relations with insurance firms, and differences in corporate culture and the timeframes with which insurance companies measure their futures.

Members of the U.S. insurance community (and others) often equate "overseas" insurer activity on climate change with that of the United Nations Insurance Industry Initiative, and imprecisely characterize it as a "European" initiative. While born in Europe, among the 27 countries represented, the initiative is heavily populated by non-European insurers—especially from Japan and other parts of Asia. Among these, it is notable that a number of developing nations are active in the initiative. This may reflect the particular vulnerability of developing countries to weather-related disasters. Moreover, climate change concerns were expressed by non-U.S. insurers as long as 28 years ago, long before the founding of the UNEP initiative. Nonetheless, the UNEP initiative has probably made a strategic mistake in not working harder to include U.S. insurers, especially in the formative stages of the initiative, and by not making a greater effort to work with the U.S. insurers who have become signatories to date.[11]

While it is clear that the vast majority of U.S. insurers have expressed little or no interest in participating in the UNEP initiative, the presence of a few insurers goes largely un-noted. These companies include The HSB Group, Employers Re, and AON (one of the world's largest insurance brokers). Several non-U.S. members are owned by U.S. insurance companies or are in significant partnerships with them, and, conversely, some non-U.S. members own large U.S. operations.

From some standpoints, the differences between U.S. and non-U.S. insurers may be smaller than or even opposite to that suggested by initial impressions. Non-U.S. insurers, especially from Europe, are known for their high-profile proclamations and involvement in climate change negotiations (see Appendix H), but few have implemented concrete activities focusing on their internal operations or consumer products. Meanwhile, some of today's most creative insurer-based initiatives on no-regrets energy-efficiency and renewable energy are in fact emanating from U.S. insurers.

[11] In this regard, it is important to note that the U.S.-based Employers Re was originally welcomed onto the UNEP Initiative's Steering Group, but they later resigned, apparently in the face of pressure from their owner, GE Capital.

Some Guidelines for Successful Insurer/Non-Insurer Interactions

Given the preceding discussion, following are some general constructive steps for non-insurance communities wishing to engage with insurers in discussions concerning climate change and climate change mitigation:

- Become a student of the insurance and risk management sectors. Understand the realities and constraints of their business and regulatory environment. State-level rate making, taxation, and investment regulations may limit the degree and/or form of potential insurer involvement. Understand how the Standards of Insurability define when private sector insurance is viable and when it is not.
- Understand the high level of diversity within the insurance community. It is hardly a monolith, and effective interactions must properly synchronize with the appropriate types of insurance companies and the appropriate units within them.
- Appreciate that insurers' primary historical and contemporary orientation to natural disasters focuses largely on pre-event preparedness and post-event recovery (a.k.a. "mitigation"). The notion of intervening in the events themselves (e.g. via the reduction of greenhouse gases) may be viewed by insurers as outside of the traditional conception of insurance and risk management, and not a part of their core business mission.
- Recognize that jargon-filled scientific explanations of climate change can be difficult for the average insurer (and many others!) to grasp, and few climate scientists spend time translating their work into a form tailored for insurers. While within the industry individuals and organizations can be found that devote considerable time and effort to following the climate change discussion, the average insurer is not familiar with the issues.
- Support expansion and extension of current climate science research such that it yields results that are more tailored for the insurance sector.
- Design climate change mitigation and "sustainable development" proposals such that they benefit insurers' core business objectives, e.g. by reducing the likelihood of claims, creating new profit centers, helping to retain customers, increasing market share, avoiding unintended liabilities or uncertainties, and not alienating policy holders.
- Seek input from insurers on future propositions regarding climate policy, especially if they involve new types of financial and contractual arrangements that may create new forms of liabilities (or business opportunities) for insureds.
- Consider the risk-management characteristics (beneficial or adverse) of carbon reduction technologies, whether they have to do with energy management, energy supply, or forest management and agriculture.
- Understand the relative and intertwined roles of insurer and government-provided disaster preparedness and recovery, as well as insurance products.
- Review and understand past governmental interactions with insurers on matters concerning the environment (particularly Superfund). New propositions perceived or intended to follow that model are likely to invoke the antipathy of insurers.

From various quarters within the insurance community, we are already hearing calls for a more holistic approach, one that integrates environmental protection with the discipline of disaster risk management. The notion of sustainability is a compelling one, and it has been grasped by many fields and disciplines as a framework for planning for the long-term health and viability of the industry. It is appealing for business-sector applications insofar as in its fullest form it calls for both business sustainability and environmental sustainability, as opposed to a rarified ecological construct separated from economics. Insurers should not be expected to champion this goal unilaterally, but rather as an important partner in a broader mosaic of public and private interests.

Differences in worldview and analytical orientation have served to separate many insurers and non-insurers on the question of climate change. Some of these differences may be immutable, but others certainly can be bridged through increased mutual understanding and interdisciplinary, cooperative research and inquiry. Both communities—and their constituencies—no doubt stand to benefit from engaging with the other more than has been the case until now.

1 Setting the Stage: Insurance, Natural Disasters, and Climate Change in Context

"Global warming could be a tempest in a teapot, or it could mean Chicken Little was right."
— *Steven Feldman, Editor, Risk Management Magazine*

"Although the direct link between societal and biological impacts and climate change is often difficult to make, a growing body of evidence linking climatic and biological changes suggests systemic global increases in both the frequency and impact of extreme weather and climate events."
— *Easterling, Meehl, Parmesan, Changnon, Karl, and Mearns*

The American Insurance Association (AIA) believes that advocates of aggressive climate change action have overestimated the vulnerability of the U.S. property-casualty insurance industry to climate change.
— *American Insurance Association*

"Catastrophes present a significant threat to the U.S. economy and to the domestic property-casualty insurance industry, raising both insolvency and insurance availability concerns."
— *Ross J. Davidson, Vice President, Corporate Finance, USAA Insurance*

"The recent severe catastrophe losses, along with the realization that even larger catastrophes are possible, have caused great stresses in property/casualty insurance markets."
— *Insurance Services Office*

"We live in a time when the increasing frequency and severity of natural disasters is a near certainty."
— *Jack Webber, President Home Insurance Federation of America*

"There exists an upward trend for flood risk . . . In addition to the impact of climate change, the global hydrological system is directly feeling the consequences of human activities, including river regulations, land use, deforestation and large scale river diversions."
— *Arkwright Mutual Insurance Company*

"The insurance and reinsurance industry, in many respects, is looking forward to the next big disaster . . . "
— *Lee McDonald, Editor, Best's Review*

The words "Climate Change" stir anxieties and arouse controversies among insurers. Natural disasters clearly have impacts on insurers—nearly $1 trillion over the past decade and a half—and some current trends are worrisome. U.S. insurers contend that they are interested in, and are constantly striving to acquire a better understanding of extreme natural hazards. Yet—with some important exceptions—most stridently assert that they are not experts on climatological or meteorological matters. They vigorously resist being thrust into a role that would have them commenting on issues or problems on which they lack expertise. However, insurers maintain that they have deep insight into matters of loss prevention, and it is in this area that they view themselves as making a major contribution, particularly relating to extreme events. Non-insurers have been largely unsuccessful in engaging insurers in a broader discussion on climate change. This report has been prepared in the spirit of fostering improved understanding and communication among the insurance and non-insurance communities, and perhaps a higher level of interaction than has been seen thus far.

A Roadmap

In this report we examine some of the myriad factors that contribute to establishing the mindsets and attitudes of property/casualty insurers toward climate change. We review the history of property insurance in America, the structural organization of companies, the regulation of insurers, the standards of insurability, and the capital market alternatives for financing the risks and losses. A summary of current and historical loss trends provides additional context.

To provide a proper backdrop on the role of insurers in the scientific investigation of climate change, we offer an overview of the theory behind and interrelations among climate models used by the climatology community and catastrophe models used by the insurance community. The report also provides a discussion of barriers that can deter U.S. insurer involvement in the climate change discussion.

We collected information from a range of sources, including in-depth interviews with 17 insurer chief executive officers, presidents and senior officers; reviewed over 300 articles and reports from the scientific and insurance trade literature; and built on our previous research and writings on the subject (Schanzenbacher and Mills 1997; Mills 1998a and 1998b; Lecomte and Gahagan 1998; Lecomte *et al.* 1998; Peara and Mills 1999; Peara 1999).

While this report is intended primarily to help orient non-insurers to the insurance market, it may also serve insurers who have not already explored the climate change question in depth.

Non-Insurers Seeking to Engage with The Insurance Community

Various parties outside the insurance community (e.g. government entities, scientists, and environmental groups) have sought to engage the insurance industry in the climate change discussion.

Among these non-insurance groups, some have argued that climate changes could expose insurers to devastating natural disaster losses. Others have alerted insurers to new business opportunities, synergisms, and "no-regrets" co-benefits stemming from climate change mitigation. Although well intentioned, these efforts have generally had limited success.

We believe that the problem stems in part from non-insurers' lack of knowledge about the intricacies of the insurance business, e.g., its history and regulation, and a misperception that insurers are a monolithic group.. Non-insurers also tend to have an incomplete grasp of past and present insurer involvement in the issue.

Meanwhile, insurers—like many who work in specialized fields—are not quick to embrace "outsiders". While there are notable exceptions, by and large insurers do not readily include outside groups in discussions about strategic issues, especially pertaining to climate change. Some overzealousness on the part of environmentalists has compounded the problem, as suggested by the following quotation from one of the major insurance trade associations:

> **The American Insurance Association (AIA) believes that advocates of aggressive climate change action have overestimated the vulnerability of the U.S. property-casualty insurance industry to climate change.**
>
> —*American Insurance Association (1999)*

The present report has been prepared in the spirit of fostering improved understanding and communication among these communities, and perhaps a higher level of interaction than has been seen thus far.

Scale and Diversity of the Insurance Community

Insurance is perhaps the world's largest industry, with $2.2 trillion in premium revenues globally in 1998 (Table 1). In that year, property/casualty companies had annual premium income of $891 billion (42% of the total), while life/health companies had premium income of $1,264 billion. With about 40% of global insurance premiums, North America is the largest regional market.

As of 1998, U.S. life insurers had over $2.8 trillion in assets (ACLI 1999). Among the institutional sources of funds in the U.S. money and capital markets, insurers ranked third (providing $204 billion, or 13% of new funds in 1998) after mutual funds and commercial banks (ACLI 1999). In 1999, U.S. life insurers had $226 billion in mortgage assets (III 2000c). Real estate directly owned by U.S. insurers (primarily life insurers) in the same year was valued at $59 billion. Insurers accounted for $1.6 trillion (14%) of the total assets and reserves of the major pension and retirement programs in the U.S. as of 1998 (ACLI 1999). The U.S. insurance market supports over 2.3 million workers (III 1999). The rapidly growing self-insurance sector (which spans both property/casualty and health) is approaching the size of the property/casualty market.

Despite these impressive numbers, it is a mistake to regard the "industry" as a monolith. It is composed of thousands of firms and is supported by significant allied industries such as brokers, agents, and risk managers, representing 746,000 workers in 1998 (III 1999). Within the property/casualty segment are many individual lines, each with their own types and degree of exposure to weather-related events (Table 2). In fact, the term "insurance community" much more effectively captures the essence of the insurance sector.

Table 1. World insurance market: 1998 (Swiss Re 1999b).

Total Market	Premiums in 1998 (in millions of USD)	Real Growth 1997/1998 (%)	1998 Share of World Market (%)	1998 Premiums as % of GDP	1998 Premiums per Capita (USD)
America	817,858	4.9	37.95	7.72	1,021.2
North America	779,593	4.8	36.17	8.97	2,592.1
Latin America	38,265	7.2	1.78	1.95	76.5
Europe	699,474	3.4	32.45	6.93	613.5
Western Europe (1)	684,848	3.4	31.78	7.31	1,466.2
Eastern Europe	14,626	2.0	0.68	2.05	22.5
Asia	571,272	-3.4	26.51	7.80	35.8
Japan	453,093	-3.8	21.02	11.73	3,584.3
South and East Asia	107,430	-2.4	4.98	3.82	34.2
Middle East	10,749	3.7	0.50	1.65	42.1
Africa	28,792	22.1	1.34	4.84	36.2
Oceania	37,872	11.3	1.76	9.40	1,378.3
World	2,155,269	2.3	100.00	7.44	271.0
Industrialised Countries (2)	1,955,406	2.3	90.73	8.78	2,131.8
Emerging Markets (3)	199,863	3.0	9.27	2.96	37.4
OECD (4)	2,016,084	2.0	93.54	8.51	1,804.5
G7 EU (5)	1,725,007	1.4	80.04	8.93	2,497.7
EU (6)	672,939	3.1	31.22	7.35	1,651.3
NAFTA (7)	785,901	4.9	36.46	8.25	1,959.9
ASEAN (8)	11,711	-9.5	0.54	2.56	26.1

Table 1 (cont'd)

Property/Casualty	Premiums in 1998 (in millions of USD)	Real Growth 1997/1998 (%)	1998 Share of World Market (%)	1998 Premiums as % of GDP	1998 Premiums per Capita (USD)
America	439,133	1.1	49.28	3.96	548.3
North America	411,561	0.9	46.19	4.52	1,368.4
Latin America	27,573	4.7	3.09	1.40	55.1
Europe	297,126	-0.3	33.34	2.86	252.9
Western Europe (1)	286,221	-0.2	32.12	2.96	593.6
Eastern Europe	10,905	-2.1	1.22	1.53	16.8
Asia	132,252	-4.1	14.84	1.80	12.0
Japan	91,991	-5.4	10.32	2.38	727.7
South and East Asia	33,020	-1.7	3.71	1.17	10.5
Middle East	7,241	1.0	0.81	1.11	28.3
Africa	7,125	2.9	0.80	1.20	9.1
Oceania	15,476	6.8	1.74	3.66	536.5
World	891,112	-0.1	100.00	2.99	125.7
Industrialised Countries (2)	805,249	-0.2	90.36	3.51	867.3
Emerging Markets (3)	85,864	0.8	9.64	1.27	16.1
OECD (4)	825,744	-0.2	92.66	3.44	730.4
G7 EU (5)	709,568	-0.6	79.63	3.63	1,013.9
EU (6)	271,342	-0.3	30.45	3.01	675.5
NAFTA (7)	415,017	0.9	46.57	4.36	1,035.0
ASEAN (8)	4,973	-10.1	0.56	1.07	10.9

Life/Health	Premiums in 1998 (in millions of USD)	Real Growth 1997/1998 (%)	1998 Share of World Market (%)	1998 Premiums as % of GDP	1998 Premiums per Capita (USD)
America	378,725	9.8	29.96	3.42	472.9
North America	368,032	9.7	29.11	4.04	1,223.7
Latin America	10,693	14.0	0.85	0.54	21.4
Europe	402,348	6.3	31.83	4.07	360.6
Western Europe (1)	398,627	6.2	31.53	4.35	872.7
Eastern Europe	3,721	15.8	0.29	0.52	5.7
Asia	439,020	-3.2	34.73	5.99	23.8
Japan	361,102	-3.4	28.56	9.35	2,856.6
South and East Asia	74,410	-2.7	5.89	2.65	23.7
Middle East	3,507	9.7	0.28	0.54	13.7
Africa	21,668	29.6	1.71	3.63	27.1
Oceania	22,396	14.6	1.77	5.74	841.7
World	1,264,156	4.1	100.00	4.32	145.3
Industrialised Countries (2)	1,150,157	4.1	90.98	5.11	1,264.5
Emerging Markets (3)	113,999	4.8	9.02	1.69	21.3
OECD (4)	1,190,340	3.5	94.16	5.07	1,074.1
G7 EU (5)	1,015,439	2.9	80.33	5.30	1,483.8
EU (6)	401,597	5.8	31.77	4.34	975.8
NAFTA (7)	370,884	9.9	29.34	3.89	924.9
ASEAN (8)	6,738	-9.1	0.53	1.48	15.2

Notes:
[1] Including Malta, Turkey and Cyprus
[2] North America, Western Europe, Japan, Oceania
[3] Latin America and Caribbean, Central and Eastern Europe, South and East Asia, Middle East, Africa
[4] 29 Members
[5] US, Canada, UK, Germany, France, Italy, Japan
[6] 15 members
[7] US, Canada, Mexico
[8] Singapore, Malaysia, Thailand, Indonesia, the Philippines, Vietnam. The three remaining members, Brunei, Laos and Myanmar are not included. Negative growth includes transitory effect of Asian financial crisis.

Table 2. Direct U.S. property/casualty premiums written by line of business: 1997.

Line of Business		Premium ($ million)
Automobile		
Personal Automobile	$114,806	
Commercial Automobile	18,493	
Total		$133,299
Homeowners Multiperil		$28,943
Fire (exclusive coverage)		$4,786
Commercial Multiperil		
Liability	$11,338	
Non Liability	9,404	
Total		$20,752
Other Liability (including products)		$24,532
Medical Malpractice		$5,862
Inland Marine		$6,794
Ocean Marine		$1,802
Crop Multiperil		$1,500
Farmers Multiperil		$1,457
Workers Compensation		$26,142
Accident & Health		$5,987
Mortgage/Financial Guarantee		$3,186
Fidelity/Surety		$3,724
Other		$9,803
Total		$278,569

Source: Best's Review – P/C, 7/98

Natural Disasters and Climate Change: The Trillion-Dollar Question

Insurers are keenly aware of the consequences of natural disasters, but most are uncertain about the role of human-induced climate changes. One insurance trade journal editor summed up the insurance industry's dilemma by saying:

> **"Global warming could be a tempest in a teapot, or it could mean Chicken Little was right."**
>
> — *Steven Feldman, Editor, Risk Management Magazine (1999)*

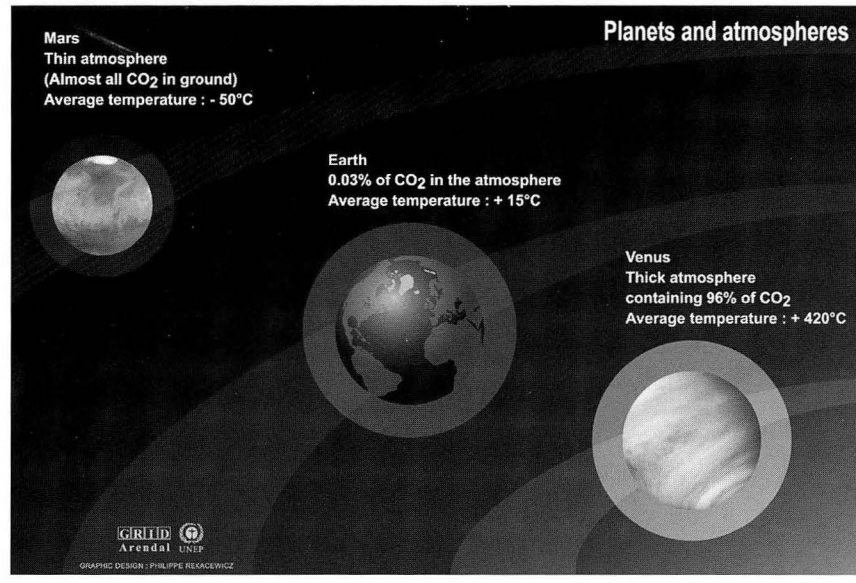
Human-Induced Climate Change

The "greenhouse effect" is a natural phenomenon in which atmospheric gases trap some of the incoming solar energy, thereby making the surface of the planet a habitable spherical island within the cold and desolate environment of space (Figures 1 and 2). While the blanket of natural greenhouse gases helps keep the earth warm, it also gradually releases a good share of the incoming solar energy, thereby keeping the earth from overheating.

CO_2 is Key to Atmospheric Temperature

Figure 1.

A planet's climate is decided by its mass, its distance from the sun and the composition of its atmosphere. Mars is too small to keep a thick atmosphere. Its atmosphere consists mainly of carbon dioxide, but the atmosphere is very thin. The atmosphere of the Earth is a hundred times thicker. Most of Mars' carbon dioxide is frozen in the ground. Mars' average surface temperature is about –50°C. Venus has almost the same mass as Earth but a thicker atmosphere, composed of 96% carbon dioxide. The surface temperature on Venus is +460°C. Earth's atmosphere is 78% nitrogen, 21% oxygen, and 1% other gases. Carbon dioxide accounts for just 0.03-0.04% of Earth's atmosphere. Without the greenhouse gases, Earth' s average temperature would be roughly –20°C. The climate on Mars and Venus is very stable and highly predictable. The Earth's climate is unstable and rather unpredictable as compared with that of the other two planets.

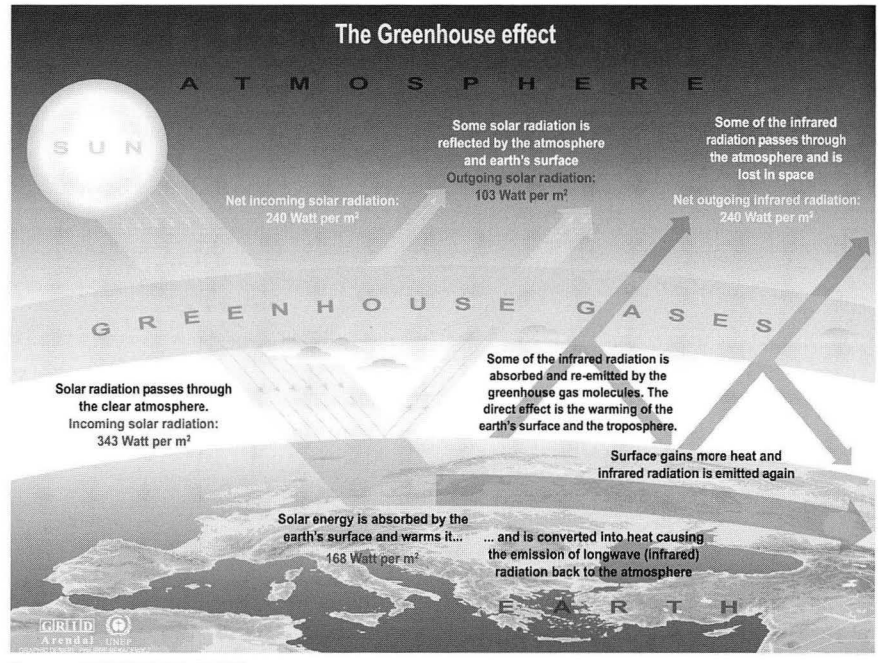


Source: UNEP/GRID (2000)

Heat-trapping Effect of Greehouse Gases

Figure 2.

The Earth has a natural temperature control system: the greenhouse effect. Certain atmospheric gases are critical to this system and are known as greenhouse gases. On average, about one third of the solar radiation that hits the earth is reflected back to space. Of the remainder, some is absorbed by the atmosphere but most is absorbed by the land and oceans. The Earth's surface becomes warm and as a result emits infrared radiation. The greenhouse gases trap the infrared radiation, thus warming the atmosphere. Naturally occurring greenhouse gases include water vapor, carbon dioxide, ozone, methane, and nitrous oxide, and together create a natural greenhouse effect. However, human activities are causing greenhouse gas levels in the atmosphere to increase.



Source: UNEP/GRID (2000)

Over 100 years ago, Svante Arrhenius—a Swedish chemist—first identified the risk of global climate change caused by humankind's emissions of greenhouse gases (Arrhenius 1896) (Figure 3a-f). The process centers on an excess accumulation of greenhouse gases like carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons, caused by fossil fuel burning, industrial activity, resource extraction and deforestation which impedes the normal outflow of heat from the earth, thereby causing an increase in terrestrial and ocean temperatures, glacial retreat, and numerous other climate changes. Levels of the most important gas, carbon dioxide, will double within the first half of this century (IPCC 1996). A succession of international political summits and scientific and media reports have elevated climate change to one of the chief environmental concerns.

Interestingly, the earliest documented statement of insurer concern about global climate change dates back nearly 30 years:

> **"Investigations into the overall trend of claims experience are indispensable.... Such investigations involve a study of . . . the rising temperature of the earth's atmosphere, changes in the earth's atmosphere due to the large-scale increases in areas irrigated and cultivated . . . [and to] the pollution of the earth's atmosphere, e.g. rise in the CO_2 content of the air causing a change in the absorption of solar energy."**
>
> — *Munich Re (1973)*

Although scientists cannot be 100-percent certain that human influences are the cause of these changes, consensus on this point has been increasing over the past decade (IPCC 1996). National Oceanic and Atmospheric Administration (NOAA) statistics indicate that for every month from January of 1997 through October of 1998, a new record for global temperatures was set. Recent paleo-climatic research indicates that 1998 not only broke century-long records for heat, but millennial records as well (*ENN* 12/22/98).

Many of the most respected climatologists note that scientific progress in this area continues to corroborate and reinforce the notion that climate changes are already visible in the form of changes in extreme events, and the trend and correlation is likely to grow even stronger, as stated in a recent article in the prestigious *Science* magazine:

> **"Although the direct link between societal and biological impacts and climate change is often difficult to make, a growing body of evidence linking climatic and biological changes suggests systemic global increases in both the frequency and impact of extreme weather and climate events."**
>
> — *Easterling, Meehl, Parmesan, Changnon, Karl, and Mearns (2000)*

The article's respected authors find that greater temperature and precipitation extremes, fewer cold waves, and more drought are "very likely" in tomorrow's climate and that it is "likely" that we will witness fewer frost days, more wet spells, and more El Niño-like conditions (Table 3).

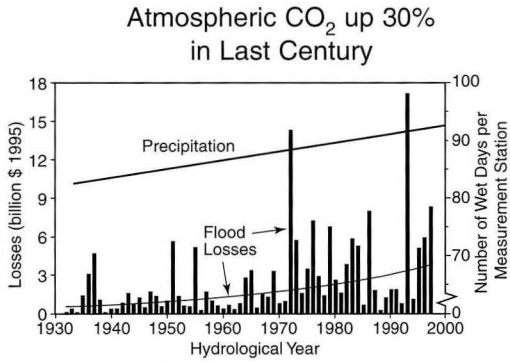
Some climate changes can be beneficial to human health and settlements, while others can be detrimental (Ross 2000). For example, a reduced frequency of frost days will lead to fewer insurance losses. Some atmospheric phenomenon may serve to offset impacts of global warming.[12] Evaluating the net effect of such complex earth-atmosphere interactions is no small task.

For example, more precipitation is not necessarily beneficial for agriculture if it occurs, as is expected, in the form of more intense rainfall events. More summertime heat could also mean drier soil conditions, pest infestations, etc. Polar accumulations of snow are mostly projected for high elevations; serious temperature increases are being observed in lower elevation polar regions causing permafrost melt (road, pipeline and agricultural disruption) and catastrophic insect infestations felling huge tracts of forests (Stevens 1998). Snow melt conditions are projected to be especially severe in the Pacific Northwest which relies on water retention in the form of ice and snow for spring melt and summer river flow. Other projections are for more rain and less retention as snow in the winter, thereby resulting in flooding and greater heat in the summer, and creating stress on salmon, agriculture and other water intensive demands (Mazza 1999; Leung and Ghan 1999; Miles *et al.* 1998).

[12] E.g. the possible role of increased clouds and the ocean's heat-absorbing capacity in tempering warmth and CO_2 build-up; potential increased snowfall in polar regions, compensating for polar melting; the benefits to agriculture from warming, increased moisture and increased carbon dioxide.

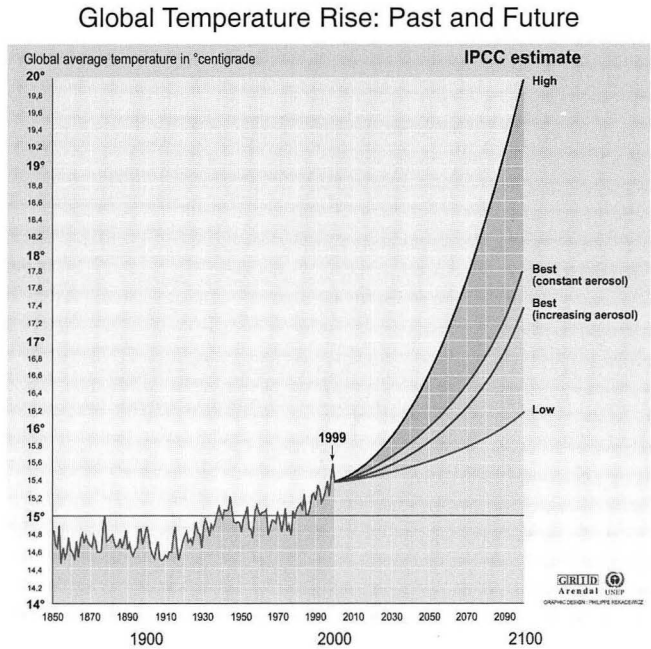
Figure 3a-f. The Greenhouse Effect and Relevance for Insurers.

Carbon dioxide is the primary greenhouse gas, and emissions have been rising since the industrial revolution (a). The resulting temperature change (b) drives many other climate and weather-related factors that influence phenomenon of importance to insurers. These include increased precipitation and flooding due to an enhanced hydrological cycle (c), sea level rise through the expansion of warmer seas and increased runoff from land areas (d), increased lightning frequency associated with increased temperature and storminess (e), and more wildfire due to hotter days, reduced soil and vegetation moisture, increased winds and lightning (f).



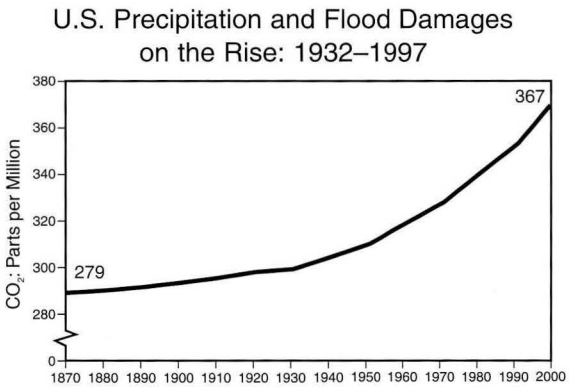
Source: Pielke and Downton (2000)

a. The Earth's atmospheric concentration of carbon dioxide (CO_2) has increased from a pre-industrial concentration of about 279 ppmv to about 367 ppmv at present (ppmv= parts per million by volume). CO_2 concentration data from before 1958 are from ice core measurements taken in Antarctica and from 1958 onwards are from the Mauna Loa measurement site. It is evident that the rapid increase in CO_2 concentrations has been occurring since the onset of industrialization. The increase has closely followed the increase in CO_2 emissions from fossil fuels.



Source: UNEP/GRID (2000)

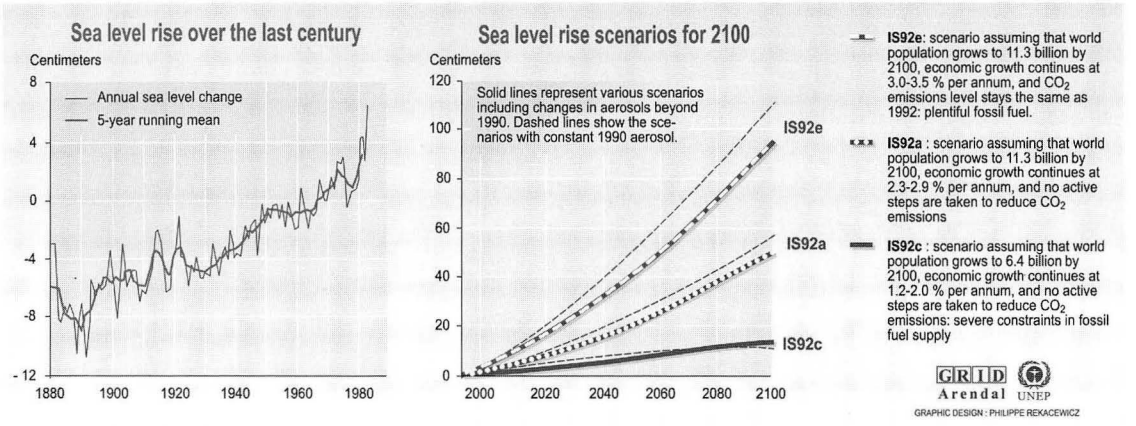
b. The figure shows the combined land-surface air and sea surface temperatures (degrees Centigrade) 1856 to 1999, relative to the average temperature between 1961 and 1990. The mean global surface temperature has increased by about 0.3 to 0.6°C since the late 19th century and by about 0.2 to 0.3°C over the last 40 years, which is the period with most reliable data. Recent years have been among the warmest since 1860 – the period for which instrumental records are available. Warming is evident in both sea surface and land-based surface air temperatures. Urbanization in general and desertification could have contributed only a small fraction of the overall global warming, although urbanization may have been an important influence in some regions. Indirect indicators such as borehole temperatures and glacier shrinkage provide independent support for the observed warming. It should also be noted that the warming has not been globally uniform. The recent warming has been greatest between 40°N and 70°N latitude, though some areas such as the North Atlantic Ocean have cooled in the recent decades.



Source: UNEP/GRID (2000)

c. Upward trend in inflation-corrected, flood-related losses in the U.S. (insured and uninsured): 1932-1997 (left-hand scale). A trend is also visible when results are normalized to per-capita losses and correlates to an increase in precipitation (righthand scale).

Sea-level Rise Due to Global Warming: Past and Future

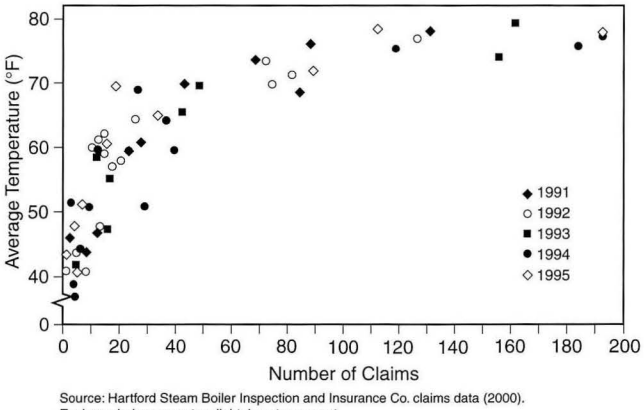


Source: UNEP/GRID (2000)

d. Over the last 100 years, the global sea level has risen by about 10 to 25 cm. It is likely that much of the rise in sea level has been related to the concurrent rise in global temperature over the last 100 years. On this time scale, the warming and the consequent expansion of the oceans may account for about 2-7 cm of the observed sea level rise, while the observed retreat of glaciers and ice caps may account for about 2-5 cm. Other factors are more difficult to quantify. The rate of observed sea level rise suggests that there has been a net positive contribution from the huge ice sheets of Greenland and Antarctica, but observations of the ice sheets do not yet allow meaningful quantitative estimates of their separate contributions. The ice sheets remain a major source of uncertainty in accounting for past changes in sea level because of insufficient data about these ice sheets over the last 100 years.

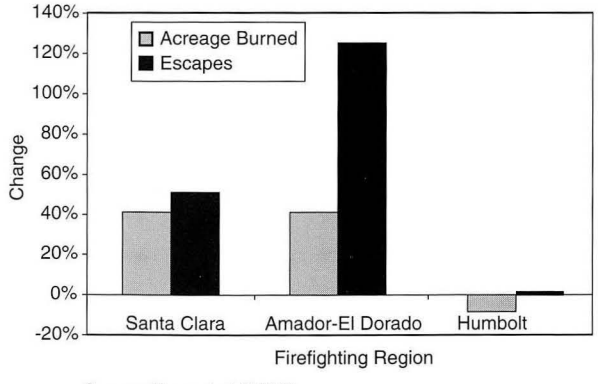
e. Lightning-related insurance losses (due to equipment breakdown and electricity service disruption) correlate strongly to temperature. An additional issue is that peak lightning periods occur in summer, when electricity reliability problems are likely to cause other business interruption losses, as suggested by the illustration. Climate change can be expected to increase lightning events and the associated insurance losses.

U.S. Lightning-related Insurance Claims Rise with Temperature: 1990–1995



Source: Hartford Steam Boiler Inspection and Insurance Co. claims data (2000). Each symbol represents a lightning storm event.

California Wildfires Rise in Some Regions under Double Carbon Dioxide



Source: Torn *et al.* (1998)

f. Under climate change, wildfire damage would increase in intensity and severity in some regions, as shown by the rise in acreage burned and catastrophic "escaped" fires in California under double-carbon dioxide conditions. These values capture the extent of fire damage given maximum use of California's existing fire-suppression infrastructure. Note that "escapes" represent a very small percentage of total fires, but the majority share of fire-related damages.

Table 3. Changes in climate extremes: historic and prospective.

Type of Extreme	Observed (20th century)	Projected (end of 21st Century)	Resulting Losses	Insurance Impacts[3]
Simple extremes based on climate statistics				
Higher maximum temperatures	Very likely	Very likely	Extreme heat events; power outages; heat deaths or illness; wildfire; avalanche; ground subsidence; vector-borne disease; crop damages; business disruption	P, H, L, BI
More hot summer days	Likely	Very likely	Extreme heat events; power outages; heat deaths or illness; wildfire; ground subsidence; crop damages; business disruption	P, H, L, BI
Increase in heat index[2]	Likely	Very likely	Heat deaths or illness	H, L
Higher minimum temperatures	Virtually certain	Very likely	Reduced freeze damage and crop loss	P, CH
Fewer frost days	Virtually certain	Likely[1]	Reduced freeze damage and crop loss	P, CH
Increased intensity of precipitation events	Likely	Very likely	Flood; property damage; crop/hail damage; mudslide; avalanche; roadway hazards; business disruption	P, H, L, BI, CH, AL, A
Complex event-driven climate extremes				
More heat waves	Possible	Very likely[1]	Extreme heat events; power outages; heat deaths or illness; wildfire; ground subsidence; crop damages; business disruption	P, H, L, BI, CH
Fewer cold waves	Very Likely	Very likely[1]	Reduced freeze damage, mortality, health problems	P, H, L, CH
More drought	Unlikely	Very likely	Crop damages; water quality	CH, H
More wet spells	Likely	Likely	Flood; property damage; crop damage; mudslide; avalanche; roadway hazards	P, H, L, BI, CH, AL, A
More frequent and intense tropical storms	Unlikely	Possible	Damage to property, crops; power outages; tidal surges / coastal erosion; vehicle damages	P, L, BI, CH, AL, A
More intense mid-latuitude storms	Possible	Possible	Damage to property, crops; power outages; tidal surges / coastal erosion; vehicle damages	P, L, BI, CH, AL, A
More intense El Niño events	Possible	Possible	Property damage, business interruptions, crop/hail, roadway hazards	P, H, L, BI, CH, AL, A
More frequent El Niño-like events	Likely	Likely[1]	Property damage, business interruptions, crop/hail, roadway hazards	P, H, L, BI, CH, AL, A

Notes:

Columns 1-3 are from Easterling *et al.* (2000). The uncertainties for current conditions are virtually certain: >99%, Very likely: 90-99%, Likely: 67-90%, Possible: 33-66%, Unlikely: 10-33%, Very unlikely: 1-10%, Improbable <1%.

For prospective estimates the likelihoods are based on modeling results.

[1]No direct modeling analyses, but these changes are physically plausible on the basis of other simulated model changes.

[2]A combined index of temperature and humidity

[3]Key for insurance impacts:

P = Property (personal or commercial)
H = Health
L = Life
BI = Business interruption
CH = Crop/hail
AL = Additional living expense for temporary housing
A = Personal automobile

The dynamics of wildfire events provide a good illustration of regional risks. Increased wintertime precipitation leads to a larger (dry) fuel load during fire season (Torn *et al.* 1998).[13] The largest U.S. wildfire insurance losses include $1.8 billion from the Oakland Hills Fire in 1991 and $0.6 billion from the Laguna wildfire in 1993 (in 1998 currencies — III 1999). One reinsurer noted that climate change may have been implicated in the catastrophic Oakland Hills fire (Swiss Re 1992).

There is literature on North Atlantic hurricanes showing that the rapidly increasing losses are due to socioeconomic factors. If anything, hurricanes have declined in frequency. Ironically, this reduction in frequency could be consistent with climate change.[14]

Effects of Natural Disasters on Insurers

Insurers well-understand the serious consequences of natural disasters, both for themselves and for society at large:

> **"Catastrophes present a significant threat to the U.S. economy and to the domestic property-casualty insurance industry, raising both insolvency and insurance availability concerns."**
>
> — *Ross J. Davidson, Vice President, Corporate Finance, USAA Insurance (Davidson 1996)*

With each passing year, threats of global warming and associated climate changes have attained increasing public attention. The impacts on the financial services sector (banking, insurance, etc.) have been discussed by individual firms for over 25 years (Munich Re 1973) and in official international scientific and public policy circles since at least 1995 (Dlugolecki et al. 1996).

Global Loss Trends

There is an indisputable upward trend in weather-related insurance losses (Figure 4). After subtracting the effects of inflation, global weather-related insurance losses from large events[15] have escalated from a negligible level in the 1950s to an average of $9.2 billion per year in the 1990s—or 13.6-fold for the 1960-1999 period where detailed data are available. A comparison of the decades since 1950 reveals that population grew by 2.4-fold during this period and insured losses as a percent of gross domestic product also rose (Swiss Re 1997).

Of 8,820 natural catastrophes analyzed worldwide during this period, 85% were weather-related, as were 75% of the economic losses and 87% of the insured losses (Munich Re 1999b; 2000).

If one includes the smaller (but not all) weather-related loss events—more than 600 of which are documented every year—the losses double (Munich Re 1999). For example, in the fifteen-year period between 1985 and 1999, the world's nations experienced nearly one trillion dollars ($947 billion) in natural catastrophe losses,[16] of which approximately one-fifth ($187 billion) were insured (Munich Re 2000). The effects on insurers are uneven, with different types of events affecting insurers in different

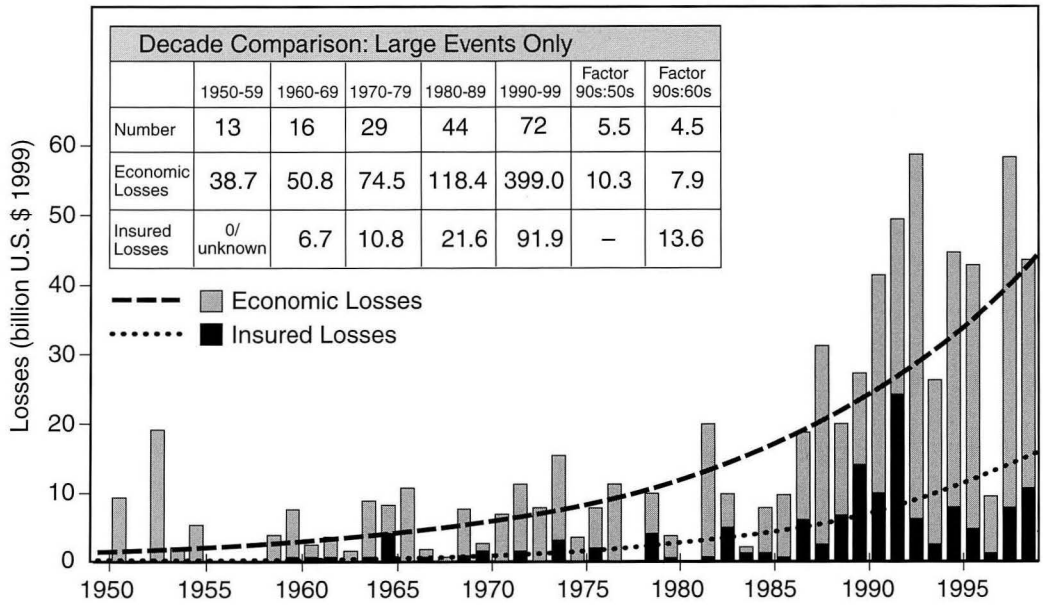
[13]The wildfires of 2000 are projected to result in some $1 billion in losses. The U.S. Government may have to reimburse insurers for losses related to the Los Alamos Fire, given that the fire was started as a part of a controlled burn on public lands (Mitchell 2000).

[14]Hurricanes form through a conjunction of several meteorological factors, in addition to the warmth of the sea surface. For example atmospheric conditions are extremely important. It is quite possible that global warming will result in a change in atmospheric conditions e.g. greater volatility which may result in disrupting the seed of the hurricane cell, thereby impeding the development of a severe cyclone. A second argument on this point is that, statistically, severe hurricanes do not form in El Niño years. If, as seem likely, the Pacific moves towards an almost El Niño phase with intermittent La Niña events, history suggests that this means there will be fewer hurricanes. Earlier studies of El Niño under global warming suggested more persistent and intense El Niño conditions but more recent studies (Timmermann *et al.* 1999; Collins 2000; cited from Meehl *et al.* 2000) have simulated an intensification of both El Niño and La Niña extremes. As mentioned, stronger La Niña events could lead to more disastrous hurricane conditions. Clearly, insurers stand to benefit from better forecasting of ENSO trends. What is less certain is the implications of climate change on severity of hurricanes.

[15]The definition of "large" weather-related events is those in which the response capacity is overtaxed and interregional or international assistance becomes necessary, often in cases where thousands of people are killed, hundreds of thousands homeless, or when the economic loss is substantial (Munich Re 2000). Thus, events that are small but frequent tend to be excluded from these statistics. For example, few of the 1000 or so tornadoes and associated hailstorms causing damage each year in the U.S. are large enough to qualify as "large" events, yet their cumulative cost has been $42 billion over the past 25 years, larger than the costs of hurricanes or earthquakes over the same period (Swiss Re 2000a). Similarly, lightning strikes cause $5-6 billion damages annually (Swiss Re 2000a). As another example, subsidence losses from two droughts during the 1990s in France resulted in losses of FF16 billion (FFR 2000) but these losses are largely absent from the "large" event data series. A similar case involves frequent but relatively small winter storm events in northern latitudes and their losses. Figure 5 includes a fuller range of events, which tend to result in an adjusted loss level approximately twice that indicated by data on "large" events alone. "Large" events represent only 1% of the total number of events.

[16]Per Munich Re's definition, total economic losses are dominated by direct damages, defined as damage to fixed assets (including property or crops), capital, and inventories of finished and semi-finished goods or raw materials which occur simultaneously or as a direct consequence of the natural phenomenon causing a disaster. The economic loss data can also include indirect or other secondary damages such as business interruptions or temporary relocation expenses for displaced households. More loosely-related damages such as impacts on national GDP are not included.

Weather-Related Disaster Losses on the Rise: 1950–1999



Decade Comparison: Large Events Only	1950-59	1960-69	1970-79	1980-89	1990-99	Factor 90s:50s	Factor 90s:60s
Number	13	16	29	44	72	5.5	4.5
Economic Losses	38.7	50.8	74.5	118.4	399.0	10.3	7.9
Insured Losses	0/ unknown	6.7	10.8	21.6	91.9	–	13.6

Source: Munich Re (2000)

Figure 4.

Large weather-related natural disasters 1950–1999. The definition of "large" is given in footnote 15. By including events of all sizes (See Table 4 for the 1985-1999 period) these totals would increase by approximately a factor of two. The cost data are adjusted for inflation. Population growth during the 1950-1999 period was 2.4-fold.

ways (Table 3; Figure 3). These numbers are underestimates, since numerous relatively small events are not systematically recorded.[17]

Some types of losses have grown particularly fast. Storms causing losses in excess of $5 million have grown 60-fold to $6 billion/year in the between the 1950s and the 1990s (Easterling *et al.* 2000).

The insured portion of losses from weather-related catastrophes is on the rise, increasing from a small fraction of the global total economic losses in the 1950s to 19% in the 1990s. These trends would be exacerbated by the trend towards increased vulnerability due to the settlement of populations in harm's way and increasingly sensitive infrastructure (Swiss Re 1998a; Hooke 2000).

Many individual events result in insurance tolls exceeding $1 billion, and the preponderance of these has been visited on the United States (Table 5).

United States Loss Trends

The United States bears an often-disproportionate economic impact from world natural disasters. During the 15-year period 1985-1999, the United States experienced 14% (1,264) of the weather-related catastrophic loss events that occurred globally, 31% ($290 billion) of the economic costs, and 58% ($110 billion) of the insurance losses (Munich Re 1999) (see Table 4). As shown in Figure 5, windstorm is the dominant type of event in the United States by all measures (number, fatalities, economic losses, and insured losses). Insured losses from flood are much more frequent and significant outside the United States, and insurance payments for flood losses represent a much larger share of the total because of the smaller role of government-provided flood insurance in some overseas countries (see Box A).

[17]For example, the insurance industry's Property Claim Services tabulated only those losses of $5 million or more up until 1996 and those of $25 million or more thereafter. As a result, no winter storms were included in the statistics for the 46-year period of 1949-1974, and few did thereafter (Kunkel et al. 1999). Although large in aggregate, highly diffuse losses due to structural damages from land subsidence would also rarely be captured in these statistics. Similarly, weather-related vehicle losses are typically not captured in the statistics.

Table 4. Worldwide losses from natural disasters: 1985-1999 (Munich Re 1999).

	Non-weather-related	Storm	Flood	Other Weather-related	All
Number of events					
Africa	70	230	360	150	810
America: South	130	100	220	160	610
America: North, Central, Caribbean	290	1,180	430	360	2,260
Asia	590	730	930	480	2,730
Australia	80	290	140	90	600
Europe	180	680	440	510	1,810
World	1,340	3,210	2,520	1,750	8,820
US share of world total	**10%**	**22%**	**8%**	**12%**	**14%**
Number of Deaths					
Africa	2,710	1,300	16,250	2,730	22,990
A-South	27,960	590	24,920	2,610	56,080
A-North, Central, Caribbean	10,540	19,420	4,070	3,880	37,910
Asia	127,700	60,000	222,780	19,440	429,920
Australia	200	420	3,290	490	4,400
Europe	320	1,680	1,890	4,320	k8,210
World	169,430	83,410	273,200	33,470	559,510
US share of world total	**0.1%**	**3%**	**0.2%**	**7%**	**1%**
Economic losses (US$bn, original values)					
Africa	1,300	1,270	2,020	2,400	6,990
A-South	4,490	660	9,530	1,730	16,410
A-North, Central, Caribbean	56,800	189,610	34,780	63,220	344,410
Asia	160,490	60,770	190,180	21,500	432,940
Australia	2,540	6,380	2,330	5,060	16,310
Europe	14,640	50,010	41,370	24,100	130,120
World	240,260	308,700	280,210	118,010	947,180
US share of world total	**21%**	**51%**	**11%**	**44%**	**31%**
Insured losses (US$bn, original values)					
Africa	0	260	400	100	760
A-South	240	30	400	100	770
A-North, Central, Caribbean	16,830	84,820	4,650	12,320	118,620
Asia	4,960	14,060	2,600	580	22,200
Australia	1,200	2,720	540	120	4,580
Europe	970	30,870	5,940	2,520	40,300
World	24,200	132,760	14,530	15,740	187,230
US share of world total	**68%**	**59%**	**26%**	**72%**	**58%**

Between the mid-1950s and the mid-1990s, U.S. population grew by 1.5-fold, the number of catastrophes by 5-fold, and catastrophe losses by 10-fold (Easterling *et al.* 2000).

Compared to conditions in the 1970s, the gap between U.S. losses and premium income has narrowed by nearly six-fold over the past 30 years, and, briefly, by as much as 20-fold following Hurricane Andrew in 1992 (Figure 6). In the U.S., the $98 billion in inflation-adjusted insured catastrophe losses in the ten-year period from 1989 to 1998 were nearly twice as high as the total of $49 billion in losses for the 39-year period of 1959 to 1988 (ISO 1999). This corresponds to a 10-fold growth on an annual basis. According to ISO:

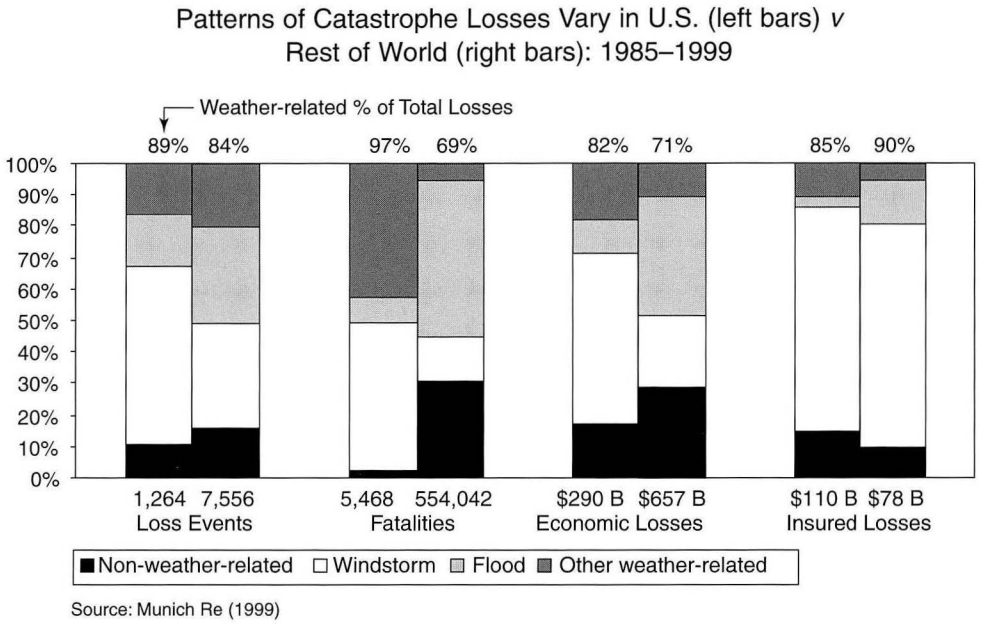
> **"The recent severe catastrophe losses, along with the realization that even larger catastrophes are possible, have caused great stresses in property/casualty insurance markets."**
>
> — *Insurance Services Office (1994a)*

In addition to domestic losses, a given insurer's vulnerability often extends beyond the borders of the country in which it is domiciled. For example, U.S.

Table 5. The 40 most costly insurance losses: 1970-1999 (Swiss Re 2000b).

Insured loss[1] (in USD millions at 1999 prices)	Victims[2]	Date/beginning	Event	Country
19086	38	24.8.1992	Hurricane Andrew	US
14122	60	17.1.1994	Northridge earthquake	US
6906	51	27.9.1991	Typhoon Mireille	Japan
5882	95	25.1.1990	Winter storm Daria	Europe
5664	61	15.9.1989	Hurricane Hugo	Puerto Rico
4500	80	25.12.1999	Winter storm Lothar	Europe
4415	13	15.10.1987	Storms and floods	Europe
4088	64	26.2.1990	Winter storm Vivian	Europe
3622	600	20.9.1998	Hurricane Georges	US, Caribbean
2980	26	22.9.1999	Typhoon Bart hits south Japan	Japan
2831	167	6.7.1988	Explosion on the Piper Alpha oil rig	UK
2716	6425	17.1.1995	Great Hanshin earthquake in Kobe	Japan
2360	70	10.9.1999	Hurricane Floyd over East Coast, Bahamas and Caribbean	US *et al.*
2307	59	4.10.1995	Hurricane Opal	US
2200	45	27.12.1999	Winter storm Martin	France *et al.*
2027	246	10.3.1993	Snowstorms, tornadoes	US
2000	19118	17.8.1999	Earthquake in Izmit	Turkey
1909	4	11.9.1992	Hurricane Iniki	US
1789	23	23.10.1989	Explosion in a petrochemical factory	US
1733	-	12.9.1979	Hurricane Frederic	US
1708	39	5.9.1996	Hurricane Fran	US
1696	2000	18.9.1974	Tropical cyclone Fifi	Honduras
1648	116	3.9.1995	Hurricane Luis	Caribbean
1575	350	12.9.1988	Hurricane Gilbert	Jamaica
148527	54	3.5.1999	Tornadoes in the Mid-West	US
1477	500	17.12.1983	Snow storms, coldwave	US
1476	26	20.10.1991	Forest fires which spread to urban areas, drought	US
1461	350	2.4.1974	Tornadoes in 14 states	US
1398	31	4.8.1970	Hurricane Celia	US
1393	-	25.4.1973	Flooding of the Mississippi	US
1380	-	15.5.1998	Wind, hail and tornadoes (MN, IA)	US
1350	63	17.10.1989	Loma Prieta earthquake	US
1305	12	19.9.1998	Typhoon Vicki	Japan
1263	46	5.1.1998	Coldwave with ice and snow	Canada, US
1247	21	5.5.1995	Wind, hail and flooding (TX, NM)	US
1198	100	2.1.1976	Storms over northwest Europe	Europe
1133	20	17.8.1983	Hurricane Alicia	US
1100	3	26.10.1993	Forest fires which spread to urban areas in California	US
1099	40	21.1.1995	Storms and flooding in the north of Europe	Europe
1067	28	3.2.1990	Winter storm Herta	Europe

[1]Excludes liability damage
[2]Dead or missing



Source: Munich Re (1999)

Figure 5.

Natural disaster frequencies: the United States *v* Rest of World, including number of events, fatalities, economic losses, and insured losses (1985-1999). The global background data are shown in Table 4. Note: "Other" includes weather-related events such as wildfire, landslides, avalanches, extreme temperature events, droughts, lightning, frost, ice/snow damages.

insurers collected $35 billion in premiums for overseas insurance sales in 1997, and such insurance has been growing faster than overall premiums in recent years (III 1999).

Perspectives on Future Losses

Past experience is not a reliable proxy for the patterns of natural disasters under future climates. Whether due to human-induced or natural forces, insurers are faced with the need to better prepare themselves to predict and withstand natural disaster losses (Sarewitz *et al.* 2000).

Worst-case future scenarios would involve multiple, coincident events e.g., consecutive (or overlapping) natural disasters, taking place during a time of weakness in the financial markets. This was witnessed before in the case of the Great Depression and the Great Dust Bowl.

Hybrid events involving multiple sources of insurance losses are of particular concern (Francis and Hengeveld 1998; White and Etkin 1997). This is exemplified in the case of El Niño (ENSO) events—expected to increase under climate change—which can involve various combinations of losses from rain, ice storms, floods, mudslides, and wildfire. Sea-level rise is another multi-faceted risk, with impacts on flood insurance (via inundation and flooding), property insurance (through coastal erosion), and health/crop insurance (through seawater intrusion into fresh groundwater lenses).

Although insurers have a strong tradition of loss prevention and mitigation, undoing human or natural trends towards climate change is clearly no small order. Charles Dudley Warner summed it up well in his famous quote: "Everybody talks about the weather, but nobody does anything about it" (Thorness 1998).

While some members of the insurance community have voiced concerns about climate change, at the other end of the spectrum some even see increased natural disasters as a good thing for the industry as a way of helping to harden a currently soft market and elevating low prices:

> **"The insurance and reinsurance industry, in many respects, is looking forward to the next big disaster . . . "**
>
> — *Lee McDonald, Editor, Best's Review (1998)*

BOX A: Flood Risks and Insurance

Flood is one of the most formidable weather-related hazards. Over the past 15 years, the total economic costs of flooding amounted to $280.2 billion worldwide, of which $31.1 billion were seen in the United States (Munich Re 2000). Of these totals, $14.5 billion were insured worldwide, and $3.8 billion in the U.S. The ten worst floods in recent U.S. history resulted in private insurance claims of U.S.$2.5 billion (nominal dollars), all but one of which took place during the eight-year period of 1989-1996 (Insurance Information Institute 2000). One company—FM Global—reports an average of $100 million in flood insurance losses annually, and they caution that historic flood losses should not be used as a proxy for potential future losses (Hofmann 2000).

Compared with other natural hazards, the scientific community identifies relatively clear connections between flood and climate change (Karl and Knight 1998; Aldred 2000). Climatologists at Arkwright Mutual (part of a recent merger into FM Global), concluded that flood losses have been increasing for physical reasons (in addition to demographic changes) and that climate change could be one factor at work in this change (Zeng and Kelly 1997). Pielke and Downton (2000) have also observed that flood damages are a product of both human and climatological factors. The Association of British Insurers has recently expressed concern about growing flood-related losses under climate change (Business Insurance 2000a). Insurers have cautioned that flood plain maps are out of date and that political pressures can lead to the underestimation of flood risks (Hofmann 2000).

While it is often stated that flood insurance is provided only by government in the U.S. (see Appendix C for details), it is in fact also available from private insurers for automobile and most commercial property risks. In addition, ancillary losses, e.g. business interruption or equipment breakdown are typically commercially insured, even if the direct flood loss is not (Wojcik-Kochaniec 1999). Coastal erosion (related to tidal surges or flooding) is also a growing risk for private insurers and governments alike (Heinz Center 2000).

The Insurance "Industry" is Not a Monolith

Insurers are exposed to a variety of losses from natural disasters. Triggering climate parameters ("perils") include temperature, rainfall, wind, hail, and lightning. Effects triggering insurance loss events ("hazards") include heat waves, droughts, pestilence, frost/ice, ocean storm surges, floods, drought, subsidence, severe windstorms, wildfires, mudslides, vehicle accidents, etc.

The Vulnerability of Property/Casualty v Life/Health Insurers

Of central importance, a correspondingly diverse set of insurance "lines" come into play. These include life, health, commercial property, homeowner property, agriculture, business interruption, event cancellation, marine, aviation, engineering, etc. Business interruption is less-studied and well-documented than many other types of losses, but can be significant in economic terms and in disruption to electricity supply and to the local economy (Stauffer, R.F., Bowers 1998; Carrido 2000).[18]

Some insurers have taken a particularly broad perspective in identifying the potential risks, including impacts on human health, transportation and petrochemical infrastructure, water quality, forests, fisheries, agriculture, the built environment, recreation, and tourism (Ross 2000). Political risk triggered by large-scale environmental disruption has also been identified by insurers (UNEP 1999).

[18]The aftermath of Hurricane Andrew illustrated the complex nature of losses caused by natural disasters. About 20% of insured economic losses were related to business interruption (40% in the case of Hurricane Hugo). Analyses of potential earthquakes have pegged business-interruption losses at 40% of the total economic loss (Gordon and Richardson 1992).

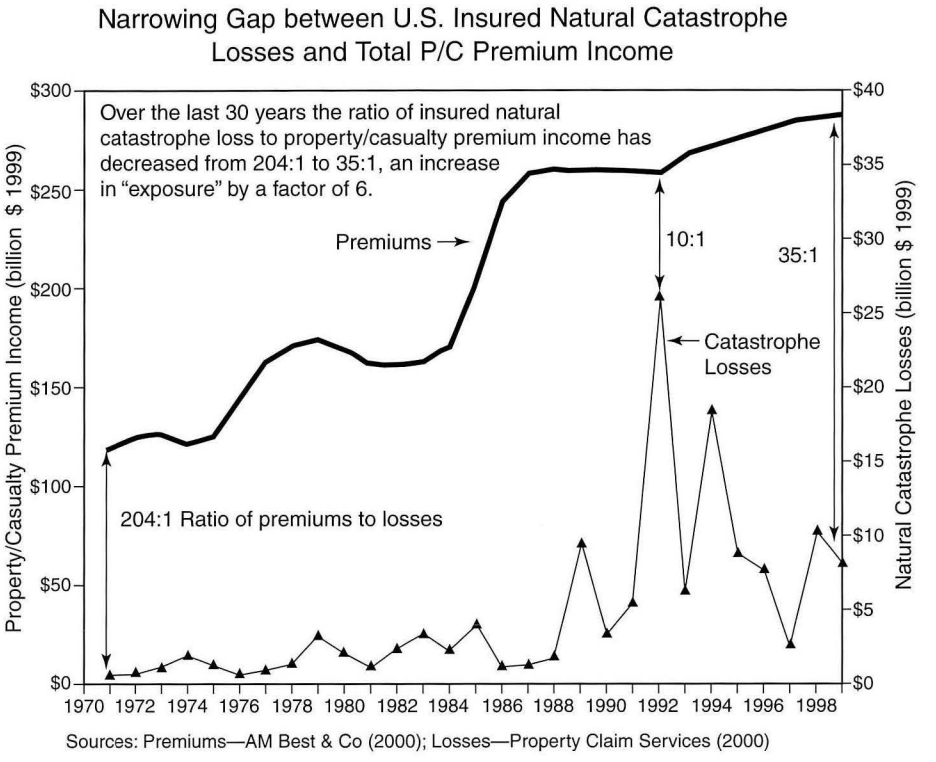


Figure 6.

U.S. property/casualty premium income (left-hand scale) versus insured natural catastrophe losses (right-hand scale). Exposure, measured as the ratio of premiums/losses, rose by a factor of 6 over the period. Small values correspond to relatively high exposure. The exposure ratio ranges from 204:1 in 1971 to 35:1 in 1999, with a peak value of 10:1 in 1992, the year of Hurricane Andrew. Note that the loss data include only major natural catastrophe losses. Premiums include significant revenues from non-weather-related business segments.

While this report focuses primarily on property/casualty insurers, health/life companies also stand to be affected by climate change. While this issue has not been studied nearly as deeply as has the question of effects on property insurers, it is likely—at least in the near term—that property insurers are more vulnerable than life/health companies.

Extreme weather events are particularly correlated with a spectrum of adverse health conditions in developed and developing countries alike, as illustrated by the El Niño/La Niña phenomenon (Epstein *et al.* 1999). Climate- and weather-related risks faced by life/health insurers include home or workplace injuries or death due to natural disasters and extreme weather episodes, propagation of water- or vector-borne diseases, degraded urban air quality, changes in the patterns of allergens, pressure on quality and adequacy of food supplies, reduction of available water (or water quality), and increased vulnerability of populations and property to power outages.

As an illustration, more than 15,000 heat-related deaths are estimated to have occurred in the heat waves of 1980, and over 11,000 in the 1960s (Kunkel *et al.* 1999). Corresponding statistics on hospitalization costs for those who die or recover have not been reported. In some areas, climate changes may yield health benefits, but negative health impacts are expected to outweigh positive ones.

The numbers of people affected by natural disasters have been growing at three-times the global population rate (Bruce 1999). As a specific illustration of the risks, an additional 80 million people are at risk of hunger due to climate changes during this century, and, based on an IPCC scenario, mortalities tied to emissions-based particulates would be between

385,000 and 1,034,000 above business-as-usual levels. World Bank estimates for growth in fossil fuel use at current rates, would yield particulate-related health exposures of $390 billion in 2020 annually (World Bank 1997).

The corporate distinction between life and property insurers is blurring somewhat. As a result of ongoing consolidation in the insurance sector, life and property/casualty companies have been merging. Many of the largest life companies are also among the largest property companies (Appendix A). Life insurers are also major holders of real estate (and providers of mortgage lending) and thus assume the kinds of property risks faced by property insurers. In addition, if life insurer involvement in catastrophe risk securities grows as expected, they may also share property/casualty insurers' exposure to climate extremes.

Climate change could pose greater property and public health risks, especially in emerging insurance markets, where debt burdens stand to hinder public health responses, where infrastructure is less safe, and where food and water adequacy could be challenged by a change in climate (Box B). Such conditions could weaken economies and diminish demand for life insurance products. Leaders in the disaster-relief community recently issued a report on climate change, emphasizing the undesirable interaction between environmental degradation (e.g. deforestation) and climate change events (e.g. flooding). The report found that:

> **"Human-driven climate change and rapidly changing socio-economic conditions have and will continue to set off chain reactions of devastation leading to more behemoth catastrophes."**
>
> — *The International Federation of Red Cross and Red Crescent Societies (IFRC 1999)*

The particular degree of exposure faced by insurers in developing nations may explain, in part, why so many such nations (Argentina, Indonesia, South Africa, South Korea, Tanzania, and Thailand) are represented among the signatories of the United Nations Environment Program's Insurance Industry Initiative. These insurers' interests are likely driven more by the relationship of the issue to the question of ethical/environmental investing and by the potential adverse indirect impacts of climate changes on economic activity overall, than by the direct risks to human health and life.

Others in the health services sector have signaled concern about climate change. Several hundred healthcare providers were signatories of the 12/1/97 *New York Times* letter: "Medical Warning: Global Warming." Other organizations concerned about climate change include, the National Association of Physicians for the Environment, which has promoted energy savings programs as a form of pollution prevention, and Physicians for Social Responsibility, which has a large policy directive on climate change as well. The American Public Health Association also supports a policy statement on climate change (APHA 1997). With regard to private-public collaboration on community health, much of the funding for these initiatives already comes from federal agencies like the Agency for Healthcare Policy Research (Dept. of Health and Human Services), the Centers for Disease Control (CDC), and the National Institutes for Health (NIH), which have research priorities regarding climate change, air pollution or respiratory disease.

Effects of Natural Disasters on Governments

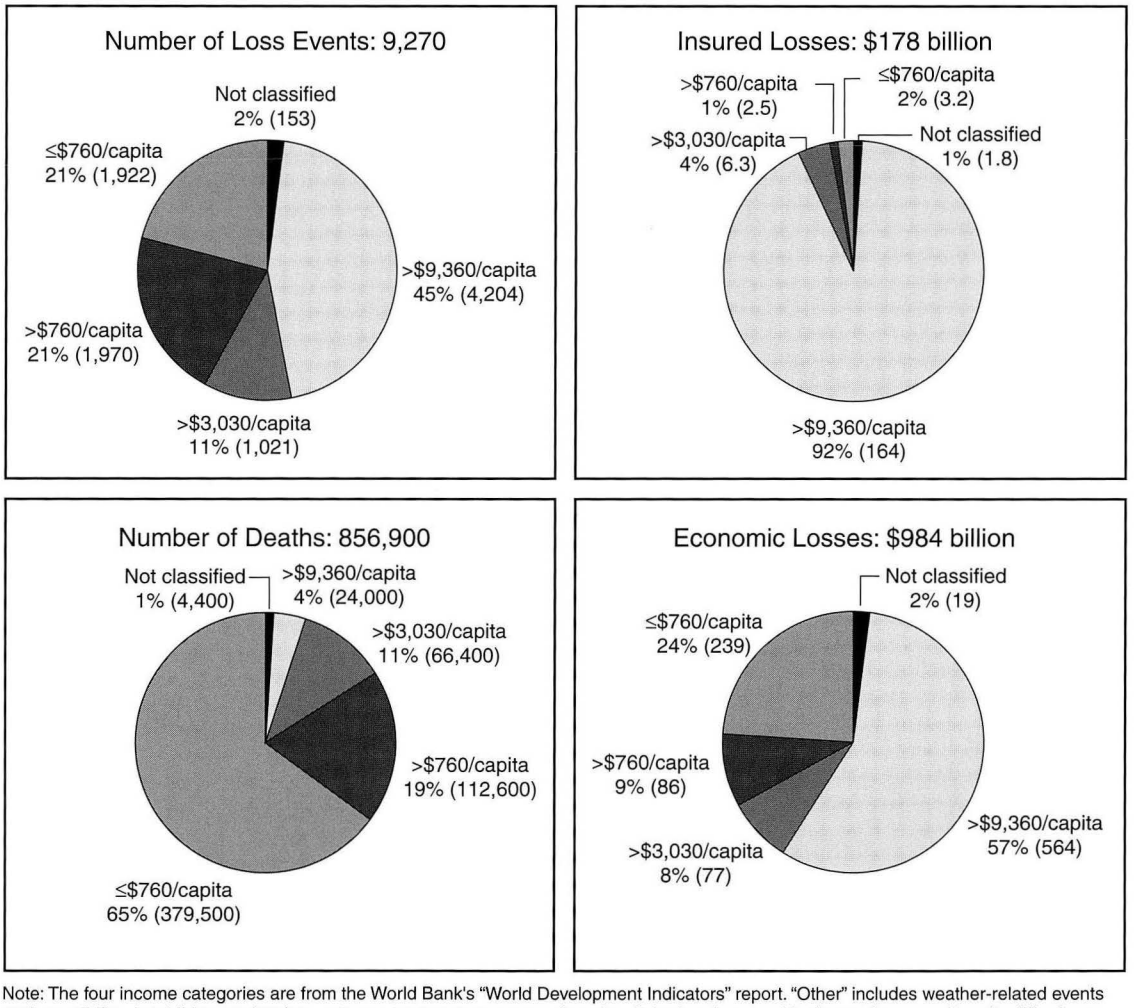
Governments share many of the burdens of natural disaster costs with insurers. In fact, they assume some of the more risky exposures that the private market has deemed uninsurable. This is done through a combination of formalized insurance programs and disaster preparedness and recovery efforts ranging from hazard mapping to forecasting and early warning to emergency aid to financing for post-disaster reconstruction. There is no comprehensive compilation of the various government activities or the costs thereof, but the collective cost appears to be on a par with that paid by insurers.

The costs of natural disasters to government have also increased steadily in recent decades. U.S. crop/hail insurance losses grew 11-fold from an average of $30 million per year in the 1950s to $670 million per year in the 1990s, and inflation-corrected federal relief payments for weather disasters grew 6-fold from the late 1960s to the early 1990s (Easterling *et al.* 2000). Of particular note, between the 1940s and the 1990s flood damages—a major government-paid risk—grew 6-fold, to $6 billion per year (inflation corrected to $1997) (Easterling *et al.* 2000).

BOX B: Economic and Non-Economic Losses in Context

Although this report looks at insurance in a very wealthy nation (the United States), it is important to keep insurance sector impacts in perspective with respect to other metrics of the effect of weather- and non-weather-related natural catastrophe events on humankind. While 45% of the weather-related loss events occurring between 1985 and 1999 took place in wealthy countries, these countries represent 57% of the economic losses, and 92% of the insured losses. In contrast, 65% of the deaths took place in the poorest countries.

Patterns of Catastrophe Losses Vary Widely Between Wealthy and Poor Nations



Note: The four income categories are from the World Bank's "World Development Indicators" report. "Other" includes weather-related events such as wildfire, landslides, avalanches, extreme temperature events, droughts, lightning, frost, and ice/snow damages. Results differ from Table 4 because of mapping of multicountry events to single countries and a different ending date for the historical time series.

Source: Munich Re (1999)

Governments also experience disasters directly (essentially as self-insurer), through their extensive property ownership and the exposures thereof, and through the effects of catastrophic weather events on government operations.

Disentangling the Reasons for Increased Losses

Catastrophe losses are on the rise, and there is general agreement that changes in the frequency and severity of natural disasters is a contributing factor. In the words of one insurance trade organization:

> **"We live in a time when the increasing frequency and severity of natural disasters is a near certainty."**
>
> — *Jack Webber, President Home Insurance Federation of America (Federal News Service 2000)*

However, the vexing dilemma faced in analyzing these data is the difficulty of disentangling the respective causes of losses, especially concerning those potentially related to climatic change versus natural climate cycles and human activity (i.e., activity that could accelerate or dampen the measured impacts of natural phenomena—demographic trends, increasing property values, disaster mitigation, etc.). Few examples of such factorial analyses are available, and such analysis is fraught with uncertainty.

Demographic and Socioeconomic Trends

Numerous socioeconomic factors are in operation that contribute to the upward trend in economic losses. Among these are inflation, population growth, increasing standard of living, concentration of people and values in cities, and urbanization and industrialization of high risk regions. Others are increasing vulnerability of modern societies and technologies (e.g., via our dependence on electricity grids and communications networks), increased penetration of insurance, and changing environmental conditions.

In the two and a half decades following the close of World War II (1945 to 1970), the population in the United States grew significantly, up 32%. Not only was the population growing but so was the building stock. In this time span dwelling ownership and a car for every family became the vogue (Jennings and Brewster 1998).

Meanwhile, a great migration of people took place from the Northeast and Midwest to the "Sunbelt" (NCPI 1989). In the interval 1970 to 1990 the southeastern Atlantic coastal area population had swollen by nearly 75%. Today, 41 million Americans—more than one in seven citizens—live in the over 160 counties that touch the Atlantic and Gulf-state coastlines or major estuaries, and these areas are growing faster than the U.S. average and contain more valuable than average homes (Ullmann *et al.* 2000).

The growth trend will continue according to the U.S. Department of Commerce. By the year 2010, the population growth in regions of the Southeast—states having annual hurricane probabilities of 10 percent or more—is projected to increase by 23% from 64 to 73 million people, compared with 14% percent for the entire U.S. (IIPLR & IRC 1995; AIA 1999).

While the population was increasing dramatically in the Sunbelt and other areas (Phoenix, Arizona, Las Vegas, Nevada and Southern California), it was also increasing (but, more slowly) in Northeastern "Snowbelt" states. Nevertheless, it should be recognized that property values escalated in the Northeastern states because of commercial development, rising demand for property, increasing personal wealth, and inflation.

As a consequence of the sunbelt population explosion, building booms increased the aggregate value of residential and commercial structures. The estimated value of insured coastal property exposure for the "first-tier" counties along the Atlantic and Gulf Coasts as of 1993 was $3.15 trillion (IIPLR & IRC 1995). More people and structures were appearing in harm's way, a fact that until Hurricane Andrew struck in 1992 had gone virtually unnoticed by the insurance community.

Despite the growth in population, roadway and bridge infrastructures and their maintenance did not in all instances keep pace, thus creating new and serious problems during evacuations.

In parallel with the aforementioned trends is the growth in value of individual personal property (referred to as "contents" in insurance parlance). Homes today are the repositories of high-valued electronic equipment (computers, printers, stereo equipment, televisions, electronic games, refrigerators, freezers, telephones, etc.) as well as furniture and clothing and other possessions susceptible to water damage.

The value in terms of insurance exposures of these items has yet to be quantified. For insurance purposes, most household personal property (contents) is established as a percentage of the dwelling's value, which may significantly underestimate the true values.

The Role of Climate Change

American climate scientists have carried out some of the best work to be found on the role of socioeconomic factors versus environmental change in the observed trends (See Appendix B; Changnon and Easterling 2000; Chagnon *et al.* 1997; Pielke and Landsea 1998; Kunkel *et al.* 1999). Yet, many questions and caveats remain including data quality, completeness, and continuity; the lack of regional differentiation; historical data series that encompass only part of the era of rising greenhouse-gas emissions; and difficulty in quantifying the countervailing effect of hazard mitigation efforts. Of particular importance, basic information on increased exposure (e.g., the value of building contents) is not known with any certainty, and thus proxies (such as real GDP growth or population) must be employed in their place.

In some cases, insurers have been directly involved in the above-mentioned efforts, such as Arkwright Mutual Insurance Company (now FM Global) scientists who analyzed flood records at over two thousand U.S. river gauging stations. They identified an upward trend in flood intensity and associated risk, which they ascribe in part to the impact of human-induced climate change (Zeng and Kelly 1997). Pielke and Downton (2000) have observed that flood damages are a product of both human and climatological factors.

The Arkwright insurers also pointed out that local environmental factors such as soil degradation, loss of biodiversity, lack of drinkable water, pollution, deforestation, forests degradation, and land use changes adversely influence the occurrence and the effects of extreme natural events like floods, droughts and storms:

> **"There exists an upward trend for flood risk . . . In addition to the impact of climate change, the global hydrological system is directly feeling the consequences of human activities, including river regulations, land use, deforestation and large scale river diversions."**
>
> — *Arkwright Mutual Insurance Company (Zeng and Kelly 1997)*

Notably, the growth trends in man-made disasters are remarkably constant over the past three decades (Swiss Re 1999b). Similarly, the growth in earthquake and other non-climate-related losses has been one-third to one-quarter that of climate-related losses (Bruce *et al.* 1999). The number of disasters (defined as annual requests for disaster assistance) has roughly doubled in the U.S. since the early 1980s (Anderson 2000).[19]

Other human factors work to *offset* natural trends that may be driving observed losses upwards, i.e., considerable human efforts made each year to avert or reduce natural disaster impacts including mitigation along coastlines, cloud seeding to divert hail storms;[20] improved building codes, tightened zoning; enhanced fire-suppression capacity; mitigating urban heat islands; improved weather forecasts and early-warning systems; and public spending on disaster preparedness, response and recovery. Within the insurance arena, increasing deductibles and withdrawal of coverage from particularly high-risk areas has also reduced observed losses.[21] Natural climate variation (e.g., hurricane cycles, particle-based cooling due to volcanic eruptions) can mask or accentuate climate effects due to human activity. These offsetting factors are rarely mentioned in efforts to isolate the effects of human and natural factors on weather-related losses. Refreshing exceptions are offered by Pielke and Downton (2000) and (Kunkel *et al.* 1999), although data were not available even in these studies to quantify the offsetting effects of human loss-reduction activities. Considerable reductions in loss of life during U.S. disasters—despite the rise in economic and insured losses from those disasters—is one indicator that mitigation has been effective. Concerning flood risks, these leading analysts of socioeconomic drivers of losses note:

[19] These are requests from localities, rather than declarations from the government (trends in which would be suspect due to varying political agendas and influences over time).

[20] In one of the costliest disasters in Canadian history, a September 1991 hail storm in Calgary resulted in an insured loss of $350CD million. Every summer there are 40 or so hailstorms over Alberta and Saskatchewan, costing an average of $100CD million per year through the 1980s. Since a cloud-seeding program was started, in which threatening storm clouds are seeded with particles of silver iodide, no storm has resulted in insurance claims over $0.2 million (Anderson 1999).

[21] Such withdrawls from at-risk markets have been observed in the Carribean, Figi, and Florida (Dlugolecki *et al.* 1996).

"One can easily hypothesize that increasing population and urbanization in the United States has led to a commensurate increase in population at risk. Yet, one can also hypothesize that the various societal responses may have more than compensated for population growth and in fact fewer people are today at risk."

— *Kunkel et al. (1999)*

One attempt to conduct a comprehensive global factorial analysis Munich Re (1999), estimated that overall net economic losses from "great" natural disasters increased two-fold between the 1970s and the 1990s, after adjusting for inflation and for increases in the standard of living (larger homes, more possessions, etc.). This correction explains about one-fourth of the observed increase in insurance losses shown in Figure 4.

2 The Transfer of Risk and Insurance

"As the reality of global warming sets in, the factors that are causing this trend and its effects on extreme weather patterns—from floods to droughts to hurricanes—concerns all businesses and communities."

— *Risk and Insurance Management Society*

"Even the [U.S.] government is starting to feel the financial pinch of disaster aid. ... The enormous size of recent catastrophes and the potential for more of the same have caused the government to reevaluate its role as a provider of disaster relief."

— *Insurance Services Office*

"Existing risk management methods available to insurers, including geographic diversification of risk, traditional reinsurance, loss mitigation, derivative products, and pre- and post-event financing through the capital markets, have not, alone or in combination, been sufficient to solve the entire problem."

— *Ross J. Davidson, Vice President, Corporate Finance, USAA Insurance*

"The capital markets to date have not provided any large degree of new capacity. The capacity that has been provided has been more expensive than what's available in the private reinsurance markets...."

— *Frank Webber, president of the Home Insurance Federation of America*

"Fear of starting up an environmental morass like Superfund might also restrain insurers from action [on climate change]."

— *Bill Thorness, Editor, Claims Magazine*

"We believe... that the Superfund liability system generates more general distaste, distrust, and cynicism with respect to the Federal government than probably any other program."

— *Richard D. Smith, President of the Chubb Group of Insurers*

Since the beginning of recorded history individuals, merchants, and business people have sought ways to reduce their exposure to loss and to transfer risks, both human-induced and natural. In ancient times the primary hazards included the pirates of the seas and those who attacked and robbed caravans. As time passed, and more wealth (real and personal property) was acquired, natural hazards involving fire, wind, and earthquake assumed a prominence, and new formalized systems for spreading and transferring risk emerged, along with a new focus on disaster preparedness and loss prevention. Today's insurance "industry" is hardly a monolith, and the nature and extent of weather-related exposures varies widely among insurance companies. It has come to pass that not all risks are insurable, creating crucial roles for all levels of government and the citizenry in sharing the risks posed by natural hazards and by climate change.

A Glance at the Past

The following historical review and analysis is intended to illuminate the primary factors that influence the mindset and attitude of insurers regarding climate change.[22] The development of an insurer's disposition is, in part, shaped by insurance history, the insurer's organizational structure and nature of its operation (i.e., the dominant line—property, casualty, group health or life—of its book of business), hazards covered, and the extent to which the hazards are regulated. An important factor to mention is how insurer management views regulation, i.e., accepts it as an enabling tool or perceives it as government interference. Attitude is also molded by the education, training, professional background, and political persuasion of those who lead insurer organizations, and molded by the highly competitive nature of the business.

The Dawn of Property Insurance

Historic records demonstrate evidence of a fire insurance association in Hamburg, Germany, known as the *Feuer Casse*, in 1591. While there are numerous accounts of fires that ravaged cities of past eras, the conflagration of London in 1666 is credited with bringing into existence organized fire protection programs and equipment (buckets and ladders). In turn, from the ashes of the London fire evolved the first fire insurance company when Dr. Nicholas Barbon, organized in 1667 a scheme for insuring houses and buildings (Bulau 1953). Thereafter, numerous insurance companies came into existence across Europe.

A little over a century later in 1769, Lloyds of London formed and began its legendary role as the captain of English marine insurance. Later, Lloyd underwriters would become the world's pre-eminent reinsurers. Meanwhile, English companies were underwriting marine insurance in America, and the first U.S. fire insurance company, The Philadelphia Contributionship, was created in Philadelphia in 1752. Following the American Revolution, numerous fire insurance companies came into existence and, as might be expected, their business followed the growth and development of the young nation starting in the Northeast, along the Atlantic Coast and spreading West.

Enter Weather-Related Hazards

It was not until the late 1800s that U.S. insurers began to offer coverage for weather-related risks. In its earliest form, the policy contract provided for insurance against loss by *fire* and *storm* but until 1880 this type insurance was confined to the East. Local or farmers' mutual or cooperative type companies (Roth 1996) sold "storm insurance" on rural properties. A single hazard policy providing *Tornado Insurance* was written in the Mid-West until 1930 when that hazard was added to the Fire Insurance Policy as an *Additional Hazards Supplement Contract.*

At the same time, the hazards of *Explosion, Riot and Civil Commotion, and Aircraft* were added to the Supplemental Contract. The *Additional Hazards* did not significantly increase the exposure of insurers because not many property owners saw a need for this type of insurance and the coverage was not vigorously marketed. In 1938 the Supplemental Contract's name was changed to the *Extended Coverage Endorsement* and it embodied loss caused by the hazards of riot and civil commotion, explosion, vehicle, smoke, aircraft, and wind. Thus, insurers were for the first time, on a broad basis, offering insurance against loss caused by the "wind" phenomenon, a peril that was related to weather, and one that they knew little about. The *Extended Coverage Endorsement* was optional insurance; it was separately priced and could be rejected by the property owner.

Today's multi-peril policies provide coverage for loss caused by many perils, and have indivisible premiums such that the insured cannot accept certain of the perils and reject others. It was only after the 1938 Hurricane (hurricanes were not named until the 1950s) ripped into New England that the *Extended Coverage Endorsement* became popular.

Up to this point the underwriter's primary concern was with the *fire* hazard. Little or no attention

[22]Additional relevant information and insights on the history of insurance are provided by Kunreuther (1998).

was given to the differing criteria considered when insuring property against loss by *wind* or *earthquake*. In the early days of fire insurance, the underwriter considered every aspect of a structure's susceptibility to loss by fire. Its construction, frame or masonry, along with the burning rates of its components was evaluated.

The structure's location to water supply and its relation to fire protection were examined. Its heating and electric systems were assessed. Compliance with the building, fire, and electric codes were scrutinized. The vegetation surrounding the structure and potential for conflagration were considered. Through painstaking analysis, underwriters sought to identify all of the uncertainties with a loss to be caused by fire. The remaining problem for the underwriter was to determine the "insurable value" and to establish a "probable maximum loss" for a given property.

Recently, particularly since Hurricane Andrew on August 24, 1992, underwriters have commenced to reevaluate the vulnerability of property to the other hazards against which insurance is provided. In the case of *wind hazards*, consideration was given to the property's location and to building codes and their enforcement.

Further, there is a growing effort on the part of underwriters to understand the science associated with the peril causing the event. This comprehension is required to establish more sophisticated underwriting prerogatives, to identify the factors that would facilitate the acceptance of the risk, to target loss-reduction measures and to actuarially price the hazard. Underwriting is a selective process where risks are segregated and objectively evaluated according to their exposure to loss or damage. In order for the process to conform to the law, the underwriting prerogatives and actions cannot be "unfairly discriminatory". Finally, underwriters seek to identify and recommend actions that would eliminate or mitigate loss.

From Mono-Line to Multi-Peril Insurers

In the unsophisticated world that had yet to be impacted by the population and building explosions that followed World War II, insurers expanded coverage, didn't significantly alter underwriting standards or criteria, and were at times blindsided by significant losses. After absorbing the losses, they became more attentive to the need to know all aspects of the risks and exposures to be insured. A closer look at some pertinent facts will assist in our understanding of the then-emerging situations, issues, and problems.

Subsequent to the development and implementation of the *Extended Coverage Endorsement* in the 1938 Standard Fire Insurance Policy a statutory contract in 19 states, was modified in 1943 to include coverage against loss by lightning and debris removal (Thomas and Reed 1969). The importance of understanding the statutory nature of the policy is the recognition that its terms and conditions cannot be changed except by legislative fiat at the state level. Policy and endorsement terms and conditions and coverage can be broadened but not be restricted without legislative approval. The Extended Coverage Endorsement was created to cover additional hazards.

Another new endorsement was developed and named the *Additional Extended Coverage Endorsement* (Broad Form). It provided insurance for losses due to water damage from plumbing and heating systems, rupture or bursting of steam or hot water heating systems, vandalism and malicious mischief, glass breakage, falling objects, freezing of plumbing or heating systems, and collapse. Thus, property insurance had evolved to a point where indemnity for loss was being provided for numerous hazards other than fire. With the introduction of the Extended Coverage and the Additional Extended Coverage Endorsement, insurance became available for several weather and climate-related occurrences: wind, freezing and collapse.

By 1955 in all states insurers could obtain multiple line licenses and insure property and casualty lines under the same policy. The multiple-line policy combines, in one policy, the coverage of the fire and allied line (extended and additional extended coverage endorsements), liability (personal injury and property damage) and theft—previously written in separate contracts. Some examples of multiple-line policies include the Homeowners, Special Multi-Peril, Condominium, Farm-owners, and Manufacturers Output Policies.

In prior years, insurers were licensed to write fire or casualty policies but not both. This change started a dramatic revision in the way insurance was marketed. Now casualty insurance companies entered the

fire field and fire insurance companies ventured into the casualty field. Interestingly, this action did not appreciably change the criteria or standards for the underwriting of either fire or casualty insurance. Generally, the fire insurance criteria and standards persisted on the "property coverage," even though new hazards were introduced. Unfortunately, underwriters did not recognize or understand the peculiarities or risks associated with many of the new hazards. The fire criteria and standards in use did not always respond to the new hazards. There was no real comprehension about the dynamics of wind, wind loads, and construction practices that would mitigate the loss potential.

Furthermore, little was known about ground motions or soil conditions and what could be done to make a structure resistant to seismic shock, such as the importance of bolting structures to their foundations and reinforcing cripple and sheer walls. Oceanfront property was viewed as vulnerable to winds but little was understood about the effects of erosion and about the ocean's dynamic equilibrium (Pilkey 1989). Insurers paid huge losses before learning about these subjects and the accompanying uncertainties.

Residual Market Mechanisms: FAIR Plans, Beach and Windstorm Plans, and Joint Underwriting Associations

State and local governments have intervened as architects of systems to formally redistribute losses within the insurance community.

Property Insurance Residual Markets, developed in response to urban riots and civil disorders of the 1960s, have evolved to address various forms of climate related risk. These "Residual Market Mechanisms" (RMMs) include state mandated insurance pooling mechanisms (organizations that serve as an insurer of last resort), which are administered and funded by insurers and are operated under prerogatives limited by government edict (Gastel 1999a). The RMMs utilized in these markets are known as FAIR Plans, Beach or Wind Plans, and/or Joint Underwriting Associations (JUAs).[23] Since their inception in 1970, the RMMs now exist in 33 states, the District of Columbia and Puerto Rico. To obtain and maintain a license to write insurance, the states, where RMMs were created by legislation, require insurer participation. The federal government required participation in residual associations as a prerequisite for obtaining federal riot reinsurance.

Residual Market Mechanisms differ from state to state; some are statewide, while others insure properties in selected, generally high-risk counties. Some provide coverage for a full spectrum of perils while others are limited in the perils they insure. For instance, only a limited number of RMMs issue homeowners policies and only a select few write business interruption insurance.

The RMMs are just one example of government's effort to require insurer participation in hazard coverage. In more recent years, insurers have had to contend with increasing catastrophic hazards and government regulation concerning the coverage of these risks. Since their creation through the close of 1997, the RMMs reflect a statutory underwriting loss of $2.2 billion (Demerjian 1998). While the losses over this approximately 30-year span are significant, they represent a very small fraction of the total losses. In 1970 950,000 policies of this type were issued, whereas in 1997, the number of policies had burgeoned to 2.1 million. The insured property value ("exposure") initially was estimated at $24 billion in 1970, which had swollen to $285 billion (III 1999) at the close of the period (Table 6).[24] Since these associations insure property which is in harm's way some view this situation as a disaster waiting to happen. The bulk of this growth involves dwellings in coastal states subject to the wind (hurricane) hazard.

One instance of the use of FAIR plans for weather-related risks is the case of wildfire in California. Perhaps the most infamous wildfire is the 1991 Oakland/Berkeley Tunnel fire, which produced losses of $1.8 billion (1998$) (Swiss Re 1992). Wildfire is a pervasive risk, affecting nearly every state (U.S. Department of Agriculture 1995; ISO 1997). While

[23]JUAs are unincorporated associations of insurance companies formed to provide a particular form of insurance to the public. JUAs are usually free to set their own rate levels and use whatever coverage forms are deemed proper, subject to approval by state authorities.

[24]As of 1998 the policies in seven coastal state Beach/Wind Plans (one form of RMM) were split approximately 90% dwelling and 10% non-residential, with a total of 663,000 policies and a corresponding exposure of $115 billion (III 1999). Because voters own dwelling properties, the residual markets' policyholders constitute a politically volatile and influential constituency. As of 1998, 1.5 million FAIR Plan policies were in force in 32 states, with a total exposure (insured value) of $170 billion.

Table 6. Insurance provided by FAIR Plans (a) and Beach/Windstorm Plans (b) for 1998.

(a) FAIR Plans

State	Habitational policies	Commercial Policies	Exposure ($1,000)[1]
Ark. (Rural)	NA	NA	NA
California	284,581	13,398	$51,551,933
Connecticut	3,761	452	977,000
Delaware	2,215	60	129,870
D.C.	1,472	411	182,585
Florida (JUA)	441,604	277	40,058,332
Georgia[2]	23,066	769	1,552,263
Hawaii	545	1	36,603
Illinois	12,092	482	491,865
Indiana	2,965	126	176,618
Iowa	1,242	30	36,245
Kansas	3,711	336	104,029
Kentucky	13,210	1,445	NA
Louisiana	67,261	332	4,653,307
Maryland	7,388	246	531,000
Mass.	85,047	1,601	9,874,224
Michigan	152,805	5,401	29,298,755
Minnesota	NA	NA	NA
Miss. (Rural)	NA	NA	NA
Missouri	12,484	1,252	407,141
New Jersey	79,320	4,400	8,543,647
New Mexico	13,247	549	503,798
New York[3]	75,263	11,475	10,049,554
N. Carolina[4]	60,916	3,102	2,533,169
Ohio	25,870	601	3,756,510
Oregon	6,997	321	415,455
Pennsylvania	60,497	3,706	2,472,517
Rhode Island	7,921	168	640,232
Virginia	16,251	955	738,077
Washington	256	101	48,871
West Virginia	1,142	64	30,665
Wisconsin	3,497	112	NA
Total	1,466,626	52,173	169,994,265

(b) Beach and Windstorm Plans

State	Habitational Policies	Commercial Policies	Exposure ($1,000)[1]
Alabama	3,662	76	$336,759
Florida	467,3692	35,000[5]	91,118,965
Louisiana	8,803	322	453,239
Mississippi	9,896	1,453	968,387
N. Carolina[4]	33,791	2,452	6,074,696
S. Carolina	17,913	1,186	4,235,453
Texas	58,126	22,463	11,633,935
Total	599,560	62,942	$114,821,434

Notes:

[1] Exposure is the estimate of the aggregate value of all insurance in force in all lines (except liability, where applicable, and crime) for 12 months ending September through December 1998.

[2] Includes a wind and hail option for certain coastal communities.

[3] Includes a wind and hail option for any dwelling, including those in coastal communities.

[4] Not a PIPSO member but submits data to PIPSO.

Source: Property Insurance Plans Service Office (PIPSO).

[5] Estimated.

private-sector insurance covers many fire risks, the most concentrated and costly areas of exposure are increasingly being seen as uninsurable, and the use of FAIR plans has been brought into play to transfer the risk. Because of the high brush fire potential in certain areas of California, the Insurance Services Office (ISO)—with input from the California Department of Insurance (CDI) and the California FAIR Plan (CFP)—acts to "Designate Brush Areas". Potential brush areas are identified and inspected by ISO, and rates and surcharges are established by the CFP with the approval of the CDI. It is possible for a designated area to lose its "Designation" once the real property has been developed and the brush hazard reduced. Global warming is likely to increase the risk of wildfire (Torn *et al.* 1998).

The losses borne by the residual markets are allocated among the participating insurers on a pro-rated basis of written premiums. Participating insurers are permitted to recoup their share of deficits by including them as an expense item on rate filings. Thus, these deficits are distributed, in the form of increased insurance premiums, to all property insured.

Risk Management and Insurance Loss Prevention

Groups seeking to engage U.S. insurer interest in climate change have cited their long history with risk management and loss prevention.[25] Fire companies effectively encouraged loss prevention through inspections, restrictions on coverage, and premiums based on risk. The first U.S. fire company sponsored fire brigades and mandated restrictions on wood-frame houses, indoor smoking of meats, and trees in front of buildings (AMICA 1999; Libertynet 1999). In the late 1800s, Spinners Mutual offered insurance only to mills with sprinkler systems installed. One company, Boston Manufacturers, helped lantern manufacturers incorporate safety design features and recommended that policyholders only buy lanterns meeting those standards (Kunreuther and Roth 1998). Eventually, with the formation of the National Fire Prevention Association (NFPA) in 1896, insurers began to promote building, equipment, and land-use planning standards to foster fire-safe infrastructure. Insurance loss prevention, however, has generally focused on arming the individual against risk rather than reducing the risk itself (Kunnreuther and Roth 1998).

Automobile insurers are well known for their use of pricing and underwriting mechanisms to reward safer drivers, but also are also known for their collective efforts to influence safety standards. Collective insurer action to improve automobile safety began in earnest following the unanimous passage of the National Traffic and Motor Vehicle Safety Act of 1966, which enacted safety standards for motor vehicles (Holley 1982). Shortly thereafter, U.S. insurers founded the Insurance Institute for Highway Safety (IIHS) in 1968 and named as its head the first director of the National Highway and Traffic Safety Administration, William Haddon.

Unlike the example with the NFPA where insurers were the initiating force in creating safety efforts for fire prevention, insurers launched the IIHS *following* a government initiative on automobile safety. Insurers implicitly attribute their reactive stance on traffic safety to the prevailing automobile manufacturers' public relations that "vehicle characteristics were irrelevant because people caused accidents... people not vehicles needed to change" (IIHS 1999). Since the late 1960s, IIHS has conducted crash tests to support the initial introduction and (more recently) redeployment of 5 mph bumpers, rear impact tests to improve fuel tank safety (1970s) and most recently 40 mph head on tests for passenger compartment integrity (IIHS 1999). NHTSA and IIHS automobile safety rankings have motivated some manufacturers to make safety improvements.[26]

In general the emphasis has been on arming the individual against the danger but not necessarily eradicating the underlying risk. An exception to this orientation is the transition of health insurance from more of an accident and casualty model to a preventive, health-maintenance model. As of yet, only selected overseas insurers have opted to extend their definition of "risk management" to include climate change mitigation.

[25] The following discussion is based on Peara (1999).

[26] "In 1981, after the 35 mph NHTSA crash tests were publicized and the Honda Civic 'failed,' Honda worked to improve the design of its car so that it would pass the next year — even though no regulation was issued" (Claybrook and Bollier 1985). This source also cites data that crash tests prompted improvements in Volvo and Subaru automobiles.

The Legacies of Superfund & OSHA

Reflection on the insurance industry's experience with Superfund, and to a lesser extent OSHA, is essential in understanding insurers' history and their potential disposition towards future government initiatives on climate change.[27]

The editor of one insurance industry trade journal notes that:

> **"Fear of starting up an environmental morass like Superfund might also restrain insurers from action [on climate change]."**
>
> — *Bill Thorness, Editor, Claims Magazine (1998)*

U.S. insurers have not embraced the federal government's handling of occupational safety and environmental clean up. U.S. insurers' skepticism of federal government safety efforts is probably greatest with the Occupational Safety and Health Act of 1970 and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (*Superfund*). Whereas promotions of fire and automobile safety have generally benefited the public and the insurance industry, the EPA and OSHA have enforced their mandates through fines and assessments on employers. Employers hit with these fines and assessments have sought compensation or legal defense from their environmental liability insurers. Insurers' objections to OSHA and Superfund have generally aimed at changing the punitive mechanisms that create liabilities for their clients.

The aim of Superfund has been to recover costs of cleaning up old hazardous waste sites. Superfund assigns responsibility for clean-ups on strict, retrospective, and joint and several bases. The strict, retrospective basis essentially means that companies and landowners may be deemed liable for clean up costs due to dumping, handling, or receiving any amount of toxic waste in relation to a particular site. They are also liable regardless of whether their actions were in compliance with existing laws, for periods retrospective to the enactment of Superfund. Joint and several liability provisions have attached liability also to anyone who takes possession of affected property, well after the disposals of any toxic waste. Also, the liability does not need to be proportional to one's contribution to the hazard (Smith 1995). The last provision allows enforcement efforts to seek funding from those with the deepest pockets, regardless of their relative responsibility.

Many parties deemed liable for clean-up costs have filed insurance claims for policies that never anticipated the liability associated with toxic waste handling (Vagley 1996). Insurers have either incurred the costs of challenging their presumed liability, or, in other cases, defending their clients (Smith 1995; Vagley 1996). Moreover, insurers have collected no premiums for the pre-1980 "unforeseen" Superfund liability (Vagley 1996). In response to the perceived unfairness of Superfund's assignment of liability, a senior insurance executive testified:

> **"We believe... that the Superfund liability system generates more general distaste, distrust, and cynicism with respect to the Federal government than probably any other program."**
>
> — *Richard D. Smith, President of the Chubb Group of Insurers (1995)*

Insurance organizations have proposed eliminating retroactive liability prior to 1987, replacing joint and several liability in favor of establishing strict, proportional liability for waste disposed after 1987 and Superfund taxes to pay for any resulting "orphan" shares (Smith 1995). These alternatives would eliminate most insurers' liability, since no polluter would be held responsible for pre-1987 waste and since insurers' more recent pollution exclusion clauses would protect them from post-1987 clean-up liability. The National Association of Independent Insurers and the American Insurance Association recently have supported Republican moves to suspend corporate Superfund income taxes and excise taxes on crude oil, petroleum products, and hazardous chemicals until passage of Superfund reforms (NAII 1999). The unity of insurers' resolve on Superfund reform gives some sense of the obstacles to overcome in terms of regaining their confidence in government-sponsored environmental initiatives.

[27]The following discussion is based on Peara (1999).

In light of OSHA and Superfund standards, insurers have more carefully excluded coverage of liability due to pollution and toxic exposure, but this has not always protected them from liability. A recent OSHA rule requires building owners to report asbestos exposures to tenants and employees (McKeith 1995). Even though insurers may exclude asbestos from liability coverage, they still might have to defend or indemnify building owners who fail to report (McKeith 1995). Thus, insurers believe they have reason to be wary of government public safety efforts that rely upon fines or civil lawsuits for their enforcement. For these reasons, insurers have not rallied for enhanced OSHA or EPA funding but have formed coalitions to push for their reform and to support voluntary compliance strategies.

The resolve of U.S. insurance associations to reform Superfund is rare for its unanimity but indicative of their shared concerns about government solutions to environmental problems.

A New Era of Natural Disasters, Disaster Mitigation, and Regulatory Responses

Irrespective of whether human-induced climate change and/or natural forces are at play, there is little dispute that the cost of natural disasters has been on the rise. The insurance industry has had to repeatedly re-evaluate its conception of "worst-case" events (Davidson 1996).

> **"Before Hurricane Andrew struck the South Florida coast on August 24, 1992 many experts thought the worst possible windstorm would cause no more than about $8 billion in insured property damage. Prior to Hurricane Hugo in 1989, which cost insurers $4.2 billion, no hurricane had resulted in claims in excess of $1 billion. The ultimate price tag for Hurricane Andrew was $15.5 billion, twice as large as earlier estimates for hurricanes."**
>
> — *Insurance Information Institute (2000a).*

The 1970s saw an arson-for-profit epidemic sweep the Nation scorching many inner city areas. It also saw the emergence of the asbestos and toxic waste (Superfund) problems and a crisis in the availability of liability insurance. The 1980s and 1990s have witnessed the re-emergence of natural hazard catastrophe losses, such as those caused by: hurricanes (Hugo, Iniki, Andrew, Mitch, Floyd, etc.); earthquakes (Whittier, Loma Prieta and Northridge); floods (The Great Flood of '93 and '97 Grand Forks); tornadoes, wildfires, mudslides, coastal erosion, and an ice storm (see Box C on the Ice Storm and Table 5). Following Hurricane Hugo, changes in the Coastal Barriers Resources Act of 1982 and the Coastal Barriers Improvement Act of 1990 resulted in prohibiting the National Flood Insurance Program from providing insurance in certain locations and left the voluntary and residual market insurers as the sole providers. Although not providing flood, rising water or wave-wash insurance, the voluntary and residual mechanism insurers are forced to demonstrate, at the time of loss, that the cause resulted from uninsured perils as contrasted to wind.

Hurricane Andrew was a watershed for property/casualty insurers. Although the hurricane missed the vulnerable Miami area by a very small margin, the event resulted in insured losses of $20 billion[28] and total economic losses of $30 billion (Munich Re 1999). Insured losses could have been more than triple this level had Miami been hit (ISO 1994a; Davidson 1996). The event raised awareness of the scale of losses that a hurricane could create, and showed that insurance firms could be brought to financial insolvency by such events. Subsequent to Hurricane Andrew, insurers were stopped, in Florida, from leaving the state and from not issuing new policies, which resulted in limiting coverage or terminating policies.

While not weather-related, case studies of great earthquakes serve to illustrate the kinds of systemic stresses placed on society by large natural disasters (Box D).

Insurers have become sensitized to the uncertainties created by hazards, which are capable of causing catastrophic losses and are too variable and infrequent for sound actuarial pricing. Hazards are also the subject of social solutions by well-intentioned but not necessarily far-sighted politicians. Insurers know more about fire than weather. However, because weather related losses have escalated, insurers are now undertaking some research. Evidence is found in the

[28] Many estimates of Hurricane Andrew's cost can be found in the literature. They vary largely due to the inflation-corrected year to which the costs are normalized, but also because the full realization and accounting of costs ("loss development") took many years.

BOX C: THE NORTH AMERICAN ICE STORM OF 1998

For seven days in January 1998, freezing rain fell on the Canadian provinces of eastern Ontario, southwestern Quebec, southern New Brunswick, and Nova Scotia.[1] These areas were pelted with 80 millimeters or more of freezing rain, double the amount of precipitation experienced in any prior ice storm. The result was a catastrophe that produced the largest estimated insured loss in the history of Canada. The same storm ran across northern New York and parts of Vermont, New Hampshire, and Maine in the United States.

The storm produced over 835,000 insurance claims from policy holders in Canada and the U.S, 20% more claims than created by Hurricane Andrew, the largest natural disaster in the history of the United States.

The combined Canadian and U.S. insured losses stood in excess of $1.2 billion U.S. as of October 1, 1998. Total Canadian insured and uninsured economic losses were approximately $6.4 billion (Cdn).

The event served as a grim learning laboratory for the insurance and disaster recovery communities. It evidenced the wide spectrum of insured and non-insured losses that can materialize from a single natural catastrophe, including:

- Property losses (e.g. roof damages and destruction of perishable goods due to loss of electric power)
- Business interruption losses (19% of the employed Canadian workforce was unable to get to work)
- Health/life losses (including losses incurred during recovery operations)
- Additional living expense costs for people relocated to temporary housing
- A host of agricultural losses included livestock deaths and interrupted maple syrup and milk production
- Disruption and damage to recreation and tourism infrastructure
- Disaster recovery costs including personnel and overtime expenses, provision of backup electric generators and fuel, debris clearing, temporary shelter, and disaster assistance payments

Total losses exceed the insured losses by a substantial margin. The event also threw into sharp focus the vulnerability of the electric power grid to natural catastrophes, and raised questions about the connection between such events, the El Niño phenomenon, and global climate change.

Type of loss	Canada (Cdn $)	United States (U.S.$)	Total (U.S.$)
Insured losses	$1.44 billion	$0.2 billion	$1.2 billion
Insurance claims	696,590	139,650	835,240
Deaths	28	17	45
Customers without power	4,700,000	546,000	5,246,000
Electricity towers/poles toppled	130 / 30,000	unknown	unknown
Electric system damage	$1 billion	unknown	unknown
Business losses	$1.6 billion	unknown	unknown
Forests damaged	unknown	17.5 million acres	unknown
Loss of worker income	$1 billion	unknown	unknown
Disrupted dairy producers	5,500	unknown	unknown
Loss of milk	$7.3 million	$12.7 million	$20.6 million
Agricultural sector losses	$25 million	$10.5 million	$35.5 million
Quebec & Ontario Governments	$1.1 billion		

[1]This discussion is based on an analysis conducted by the Canadian Institute for Catastrophic Loss Reduction and the U.S.-based Institute for Business and Home Safety, both insurance industry organizations (Lecomte *et al.* 1998). Losses as of 10-1-98.

work of the Risk Prediction Initiative (RPI) of the Bermuda Biological Station for Research sponsored by a limited number of insurers and reinsurers. The RPI effort focuses on the "transfer of climate forecast information from the academic communities to business, a greater appreciation in the business community of the utility of climate science, and investigations of the implications of climate forecast for functioning of the insurance industry at all levels from individual client to catastrophe reinsurer".[29]

It is important to comprehend the facts outlined in this history, as these happenings have served to formulate and shape many of today's insurer philosophies and attitudes toward risk. To reiterate, these beliefs can be reinforced by the uncertainties accompanying the hazards and the perception that government is unnecessarily intruding into the business of insurance.

Continuing a tradition almost as old as the insurance industry itself, insurers have sought ways to better prepare for and recover from natural disasters. Among the strategies used are:

- promotion of pre- and post-event mitigation activities;
- development of loss-resistant building, fire and energy codes;
- development of loss-resistant building materials;
- use of restricted coverage covenants and deductibles;
- purchase of reinsurance;
- use of innovative initiatives, i.e., establishment of single line companies and the selling of books of business;
- supporting federal and state mitigation activities;

BOX D: The Northridge Earthquake: A Case Study in Natural Catastrophes

While not weather-related, recent experience with the earthquake risk brings into focus many issues of direct relevance to the question of insurer adaptation to climate change. Much as Hurricane Andrew was a humbling weather-related event for the insurance community, the Northridge Earthquake of 1994 shed new light on U.S. insurer vulnerability to seismic risks.

Although the quake took place at an "ideal time" (on a holiday morning), it resulted in a $12.5 billion insured loss ($44 billion total economic loss, University of Surrey and IIASA 2000)—an amount surpassing by four-fold to $3.3 billion in earthquake premiums collected in California during the previous 25 years (III 2000b). Again, as in the case of Andrew, had the quake been centered in more densely developed parts of Los Angeles just a few miles away the losses could have been two- or three-times as great. Also notable, a very significant fraction of the total losses resulted from business interruption and an associated 1,250 person-years of lost labor time (Collins 1998).

The event also showed the tremendous vulnerability of public infrastructure—water, power, transportation, healthcare, schools—and a correspondingly large fraction of the total cost that had to be paid by local, state, and federal government funds. Federal assistance alone was estimated at $12.5 billion (FEMA 1998).

The immediate reaction was for insurers to withdraw from the California marketplace almost completely. Regulators subsequently implemented measures requiring insurers to provide insurance and established the California Earthquake Authority (CEA) in 1996 to help secure funds for major losses and reduce the financial risk for insurers.

In the ensuing years, premiums and deductibles have been raised considerably and coverages have been restricted to establish limits on personal belongings claims (also known as "contents"), temporary living expenses, and to exclude coverage for ancillary property such as garages, swimming pools, and landscaping.

[29] Insurers sponsor the RPI at the rate of $100,000 per year. U.S. members as of mid-1999 included Ace U.S.A Inc., American International Group Inc., IPC. Reinsurance Co., American Reinsurance Co., Employers Reinsurance Co., General Reinsurance Co., State Farm, and USAA (Goch 1999). For additional information see the RPI Home Page http://www.bbsr.edu/rpi/.

- pricing; and
- use of capital market alternatives.

Some within the industry question whether these kinds of measures, taken alone or in combination, have been sufficient to address the problem:

> **"Existing risk management methods available to insurers, including geographic diversification of risk, traditional reinsurance, loss mitigation, derivative products, and pre- and post-event financing through the capital markets, have not, alone or in combination, been sufficient to solve the entire problem."**
>
> — *Ross J. Davidson, Vice President, Corporate Finance, USAA Insurance (1996)*

Aside from mitigation, insurers have many tools for reducing their financial vulnerability to losses (Doherty *et al.* 1992); Mooney 1998; AIA 1999; Bruce *et al.* 1999; III 2000a). These include: increasing their equity ("surplus"); raising prices; non-renewal of existing policies, and cessation of writing new policies. Other strategies include, limiting maximum losses claimable, paying for the depreciated value of damaged property (instead of its new-replacement value),[30] reducing dividends paid to shareholders, or tightening deductibles (by raising the floor or redefining them in percentage terms instead of fixed amounts). However, insurance regulators have shown limited willingness to grant such changes (III 2000a).

Structure of Today's Insurance Industry

In discussions of insurance and climate change, it is important to keep in mind that today's insurance "industry" in the United States is hardly a monolith. It is divided into two categories: property/casualty insurance companies[31] and life and health insurance companies. In 1997 there were 3,366 property/casualty companies and 1,796 life and health companies in operation (III 1999)). While there are many firms, the industry is relatively concentrated, with approximately 50% of premiums generated by the top 20 firms (Appendix A).

This report relates primarily to property/casualty companies even though there is the potential for catastrophic fallout for the life/health insurers from climate change, as discussed in Chapter 1. Nevertheless, those companies providing both kinds of insurance must consider the loss potential of their property and casualty operations when evaluating their financial strength.

Examining the property/casualty component of the insurance industry reveals it to be highly diverse (Table 2). It is comprised of large, medium and small size insurers; its companies insure commercial (office/apartment buildings, government structures, shopping malls, manufacturing plants and their contents as well as roadways, bridges, and interchanges) and residential properties and their contents. Also there are niche or specialty writers, i.e., companies that insure specific lines (types) of risks or classes of properties. Property-casualty companies may also insure the consequential loss, i.e., such as additional living expenses for insureds displaced from a residence or their loss of income and continuing expenses from the interruption of a business.

When the impact on an insurer's operation is evaluated, the types of insured assets and their values, protection to be afforded and hazards insured against, must be examined in relationship to the potential loss caused by climate change.

[30] This has been evidenced in hail-prone parts of Texas, Kansas, Kentucky, and other mid-western states where, in addition to tightening deductibles, some companies are providing coverage for roofs on a depreciated (actual cash value) basis, rather than on the full cost of replacing a damaged roof (Insurance Information Institute 2000).

[31] When a property insurance policy indemnifies the owner of the property it is referred to as "first party" insurance, and when payment is made on behalf of the property owner because of that party's legal liability it is referenced as "third party" or casualty insurance.

Types of Property/Casualty Companies

How a company relates to its owners, members, or policyholders is one determinant in shaping its attitude toward the climate change issue. The financial structure of insurance companies mostly falls into one of three categories, mutual, stock, or reciprocal. All forms of ownership receive ratings for their ability to pay claims and service their debts. The following brief definitions, although capturing the essence of the "type" of company, do not capture the myriad legal issues or operational nuances that shape the agenda and management attitude of these companies.

- *Mutual Companies*, as the original form of ownership for insurers in U.S., pay profits to policyholders (who are also owners) in the form of dividends. Mutual company premiums earned in 1999 were $94 billion, with $63 billion in losses incurred (A.M Best Co. 2000). Their limited access to capital (essentially bonds, investment earnings, and premiums) inspired many to convert to stock companies, and more recently to a novel form of mutual holding company, which ultimately allows access to capital from equity issues. Some of the largest companies including Nationwide, Liberty Group, Prudential, and the majority of companies within the State Farm Group are mutual companies owned by their policyholders. Mutual companies are vulnerable to catastrophic loss events insofar as they typically must raise premiums to pay for losses. However, the profitability expectations for mutuals are less demanding than for publicly traded companies. Mutuals tend to be more vulnerable to unanticipated losses that call upon companies to utilize their surplus (Doherty et al. 1992). Mutuals are seen as among the most vulnerable types of company (Doherty et al. 1992).
- *Stock Companies* raise capital through various stock and bond offerings, and pay profits in the form of dividends to shareholders. Stock company premiums earned in 1999 were $165 billion, with $105 billion in losses incurred (AM Best Co. 2000). Some of the larger stock companies are members of the Allstate Group, American International Group (AIG), Travelers, and The Hartford. Stock companies have the option of selling their stock to help pay losses from catastrophic loss events. Stock companies are particularly confronted with the tension between pursuing high-risk/high-return investments and the requirements for solvency in the event of natural disasters or other catastrophic losses.
- *Reciprocals* rely on premiums and assessments from policyholders (owners). Reciprocal company premiums earned in 1999 were $23 billion, with $16 billion in losses incurred (A.M. Best Co. 2000). Members of the association (policyholders) generally share common backgrounds, such as being schoolteachers or ex-teachers, farmers, or military or ex-military personnel. They band together to maximize the cost and efficiency benefits to be realized from their homogenous grouping. If claims exceed asset holdings, a reciprocal can assess policyholders to make up any shortfall. The Farmers Insurance Exchange and United Services Automobile Association (USAA) are among the larger reciprocal associations.

These structural differences, in a highly competitive environment, can be expected to impact a company's position on the climate change issue. It is dubious that a company would take any action in establishing its underwriting standards, investment policies, or stance on public policy issues that would adversely affect its stockholders or insureds. Similarly, the impact of natural disaster losses can have a particular impact on the share prices of publicly traded ("stock") insurance companies (Edgecliffe-Johnson 1997).

Reinsurance

It is common practice for primary insurers to assume a larger share of a risk than they can safely retain, and thus reinsurance is acquired as a means to transfer part of the risk to others, thereby increasing the pool of capital available to support the risk. In effect, the primary insurer carriers take a deductible equal to the difference between the customer's personal deductible and the level of loss beyond which the reinsurer(s) begin to pay. Additional reinsurance-type support can be obtained through *retrocession*, which is essentially reinsurance bought and sold among reinsurers. Reinsurance is typically bought in "layers", each of which covers a certain band of costs

above what the primary insurer can pay. The higher layers of cover are "invaded" only if the losses are sufficiently large. This practice helps distribute the risk among many reinsurers (i.e. the sellers of each layer of coverage). In short:

> **"Reinsurance does for the insurance company what primary insurance does for the policyholder or property owner: it provides a way to protect against unforeseen or extraordinary losses . . . For all but the largest insurance companies, reinsurance is almost a prerequisite for covering hazards where there is the potential for catastrophe damage."**
>
> — *Kunreuther and Roth (1998)*

For reinsurance to fulfill its role, the product(s) must be reasonably priced, and the reinsurer must be financially positioned to discharge the obligations assumed in a timely fashion, which could be difficult following severe natural disasters.

If for any reason reinsurance is not available or is not affordable, an availability problem results. Reinsurance suffered in this fashion in the wake of major insured disasters like Hurricane Andrew. Conceivably, if insurers could not obtain and/or afford reinsurance, they would lack the financial reserve strength (surplus) to maintain existing insurance or take on new risks.

Allied Industries

All strategic issues facing insurance providers necessarily involve a number of allied industries, including sales persons, agents, brokers, and risk managers, representing 746,000 workers in 1998 (III 1999). Self insurers are another extremely significant allied industry.

While *self-insurers*[32] are not insurance companies, they constitute an increasingly important and influential segment in the insurance marketplace and their positions on issues confronting or vexing primary insurers and reinsurers should be known, understood, considered, and included in any evaluation. According to Bowers (1999), the "Alternative Markets" (Risk Retention Groups, Self- Insureds, Captives, Pools and Trusts, and Private Retentions) provide coverage that would cost $128 billion or 84% of the current premiums of $158 billion. Self-insurance does not provide, generally, for the transfer of the risk although, in part, it may do so through the acquisition of reinsurance.

Professional risk managers[33] usually counsel self-insurers. The Risk and Insurance Management Association (RIMS) has given prominent attention to the climate change issue in their trade journal (Mills 1998b) and co-hosted a roundtable on the topic (Rimscope 2000).

Self-insurers can be expected to be more receptive to climate change discussions, because politics is less of an issue and increased premiums are particularly undesirable whereby losses go straight to the bottom line. Through their connections with reinsurers, they may receive information on climate change. On the other hand, many of the barriers faced by insurers are arguably present for self-insurers as well.

Insurers sell their products through salespersons, agents, or brokers all of whom can have an impact on how insurers confront and act on public policy issues. The salesperson is a direct employee of the insurance company, is licensed by the state, and works solely for the company who pays his/her commission. An agent is an independent contractor and in insurer, licensed by the state. The agent can be licensed to represent one or more insurers, and the insurer pays the agent's commission. A broker is an independent businessperson who is licensed by the state and is employed by a property owner to assist in the acquisition of insurance for the property to be insured. All these individuals can and do influence the insurer's decisions on issues of coverage, matters affecting the insurance marketplace and public policy, as the sales persons (agents and brokers) that pro-

[32]Self-financed insurance (e.g. via captive insurance companies) is the planned assumption of risk instead of purchasing insurance. A self-insuring organization develops a program for identifying, evaluating, and funding its losses. It is often used for workers' compensation, where losses are fairly predictable. Smaller losses that occur frequently are a better subject for self insurance than large infrequent losses. Self-insurance programs are frequently structured to retain losses up to a specific limit, and insurance is purchased above that level. Most states regulate self insurance as they do commercial insurance, requiring certificates of self-insurance for compulsory coverages such as auto liability and workers' compensation (Rupp 1998).

[33]An individual or firm that provides risk management and insurance consulting, e.g., risk management audits, policy analysis, feasibility studies, etc. on a fee basis or in-house to the property owner. As a rule, the risk management consultant does not sell insurance, and so maintains its independence and objectivity (Rupp 1998).

duce the business serve as a channel through which the thoughts and demands of the policyholder flow. Insurers are cognizant of the power of voters, (i.e., their policyholders), and through the sales representatives' attempt to acquire the pulse of the policyholders and influence their behavior on issues.

Insurance Trade Associations

Through their influence in public policy and legislation, insurance trade associations may play a role in galvanizing U.S. insurer opinion on issues like climate change.

The major national trade associations to which property-casualty companies can belong are the Alliance of American Insurers (AAI), the American Insurers Association (AIA), the National Association of Independent Insurers (NAII), and the National Association of Mutual Insurance Companies (NAMIC).

In addition to the national trade associations, there are a number of state insurance trade associations. Further, reinsurers have their own national trade association known as the Reinsurance Association of America (RAA). The professional risk managers are organized under the Risk and Insurance Management Association (RIMS).

On subjects and issues such as taxation, accounting standards and reserving, antitrust laws, and topics relating to the financial and economic effects of catastrophic losses, the national trade associations possess significant expertise. Moreover, they are viewed as being highly influential on matters involving government affairs.

Some of the largest insurers, e.g., State Farm and AIG, operate largely independently of trade associations and are referred to as "unaffiliated" insurers.

The Standards of Insurability

The sizable increase in weather-related disasters and their costs over the past decade have insurers scurrying to examine their exposures and policy coverage. Additionally, property insurance executives are toiling to ascertain whether these catastrophic losses meet the criteria of the time-tested *Standards of Insurability* (Denenberg 1964, Kuenreuther 1998, Hausmann 1998, Nuttall 1998, and Mittler 1992; White and Etkin 1997).

At the outset it should be recognized that not all "hazards" are insurable by non-governmental organizations. Yet, there is probably no hazard that would fully meet all of the Standards if they were rigorously applied. In making the judgement regarding insurability, statistical and administrative deliberation will be required. Each insurer, to arrive at its decisions, will impose controls that accommodate its underwriting philosophy, policy contracts and pricing (rating) programs. Based upon their findings, exceptions may be made provided that they are permitted by the regulations and meet the tests of being fair, reasonable, and non-discriminatory. The Standards of Insurability (paraphrased from Denenberg 1964) are:

1. There should be a large number of homogeneous exposures to permit the operation of the theory of probability and setting of actuarial rates (law of large numbers).
2. The occurrence should be fortuitous; the timing or the severity of the loss should be out of the control of the insured.
3. The peril must produce a loss definite in time and amount. The insurer must be able to verify the loss promptly and measure its magnitude.
4. The insured group of risks must not be exposed to an *incalculable* catastrophe hazard. There must not be a significant concentration of values in vulnerable areas.
5. The premium must be reasonable in relation to the potential financial loss, i.e., priced to attract purchasers, and, simultaneously develop the actuarially sound premiums necessary to cover the losses while providing for insurer solvency.

Doherty (1997) offers a conceptually similar framework, adding that excessive "politicization" can also impede insurance market efficiency and performance.

Through the utilization of these Standards uncertainty is reduced and the transfer of risk facilitated. Insurers may perceive certain government actions as having violated the 3rd Standards, especially with regard to asbestos and Superfund claims. At the time these hazards were created, insurers had no idea of the liabilities they might assume decades later. The lessons learned from that experience might also explain, in part, some of the insurer reluctance to engage in activities relating to climate change.

These Standards bring into consideration factors that go beyond those focused on the underwriting of the fire hazard. Further, it should be noted that subsequent to Hurricanes Hugo and Andrew, greater emphasis has been given to understanding and underwriting the wind hazard. The fourth of these Standards has taken on particular importance in the hurricane age. Following the major hurricanes of the 1990s, insurers—with the help of catastrophe loss simulation models—are much more careful to consider the concentration of their risk exposures in coastal regions. Underwriters are inquiring about the wind resistant design qualities of a structure and the materials used in construction. Likewise attention is given to building codes and their enforcement as evidenced by the introduction of the Building Code Effectiveness Grading Schedule (BCEGS) by the Insurance Services Office.

Contributing to the ambivalence on the part of U.S. insurers toward weather events and climate issues, is the fact that the insurers often lack the scientific (meteorological and climatological) expertise to address such matters (see Appendix B). With few exceptions, the belief persists with many insurers that the scientific explorations should be left to the scientists and that insurers should restrict their involvement to matters pertaining to the development of insurance coverage, loss control, and/or reduction.

Applying the "Standards" is part art and part science. The high degree of variability in flood insurance coverage in the world raises the question of how economists, insurers and insurance regulators interpret and apply the Standards. The differences, in good measure, arise from variances in national politics and political philosophies. They reflect the country's per capita wealth and exposure to the hazard, and the government's beliefs regarding its obligations to the citizens.

Flood Risks

Flood insurance merits special mention, given the magnitude of risks and losses seen in recent history, the difficulty of establishing fair and actuarially based rates and the relatively clear connections between flood and climate change (Karl and Knight 1998; Aldred 2000). Most studies find an increase in fresh-water flooding under climate change scenarios. Sea level rise will impact flood insurance through inundation and erosion due to level increase and storms. Recent analyses in the U.S. found that even without sea-level rise 25% of homes and other structures within 150 meters of the coastline will fall victim to the effects of erosion within 60 years, as exemplified in Figure 7 (Heinz Center 2000).

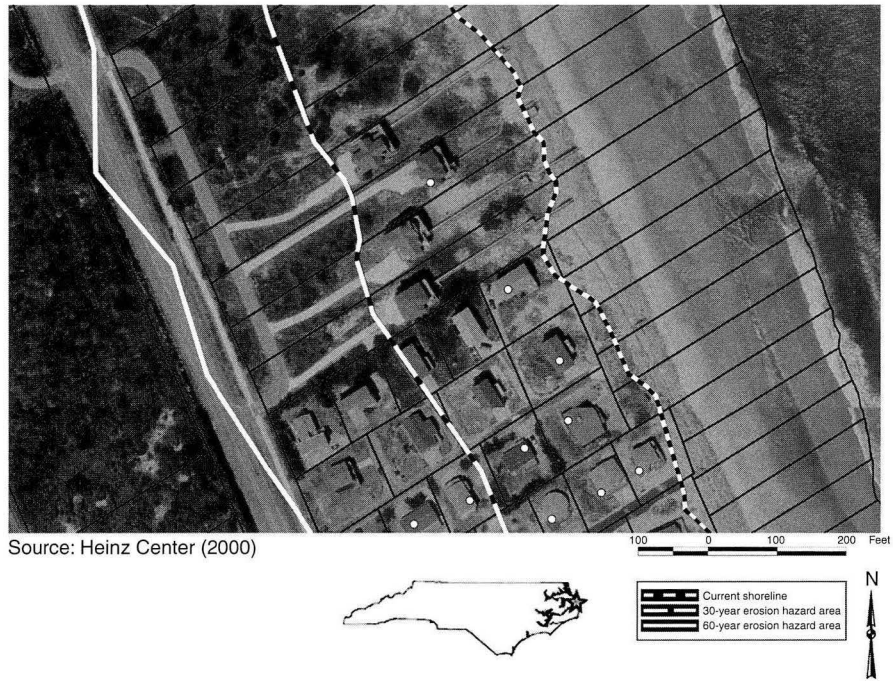
Countries differ widely on the approach to defining and financing flood risks via private-sector (re)insurance versus public mechanisms (Van Schoubroeck 1997; Hausmann 1998; Gaschen *et al.* 1998). Among the countries where flood insurance is supplied exclusively or predominantly by private insurers are: Argentina, Canada, Czech Republic, France, Germany, Israel, Italy, Japan, Philippines, Poland, Portugal, South Africa, Switzerland, Taiwan and the United Kingdom (Gaschen *et al.* 1998).[34] Hybrid public-private systems and government-only systems can also be found. In the U.S. flood insurance is available from private insurers for commercial risks in excess of the National Flood Insurance Program's limits of $500,000 per claim (each, for real property and contents) and for automobile losses.

The question of flood risk illustrates the importance of understanding the differences among various actors in the insurance and risk management community. For example, a risk and insurance trade association expressed concern about flooding and climate change, noting that:

> **"As the reality of global warming sets in, the factors that are causing this trend and its effects on extreme weather patterns—from floods to droughts to hurricanes—concerns all businesses and communities."**
>
> — *Risk and Insurance Management Society (Rimscope 2000)*

[34]These types of assessments are partially subjective and the conclusions vary within the insurance literature.

The March of Coastal Erosion Threatens Property Along U.S. Coastlines



Source: Heinz Center (2000)

Figure 7.

As shown on this aerial photo of Nags Head, North Carolina, the beach is expected to erode inland about 550 feet over the next 60 years. Five rows of houses are likely to be lost to erosion over this period.

It should be noted that customer-side risk managers must deal with flood risks whether or not they are commercially insured.

In a comment that reflects the importance of mitigation in determining the insurability of flood-related climate risks, a British insurer organization warned that:

> **"If insurers in the United Kingdom are to continue offering flood insurance . . . local authorities must wake up to the effects of climate change and the increasing risk of flooding."**
>
> — *Association of British Insurers (Aldred 2000)*

Insurance Regulation

U.S. Courts have deemed the business of insurance to be interstate commerce and therefore subject to federal jurisdiction. Going back to the 1880s when the insurance markets were centered in particular communities, regulation was viewed as a local matter. In 1944 the U.S. Supreme Court ruled in the case of the United States *v* Southeastern Underwriters Association (332 U.S. 533) that the commerce clause of the U.S. Constitution applied to insurance thus making it subject to the federal antitrust law. As a consequence, in 1945 the states and insurers joined forces behind the passage of the McCarran-Ferguson Act. That Act delegated the regulation of insurance to the states, except in those instances where federal law specifically superceded state laws—e.g., in the case of the National Flood Insurance Program, NFIP (Klein 1998).

The federal government—through the action of the Congress—has initiated certain federal controls over specific insurance markets or aspects of insurers' operations previously delegated to the states (e.g., the provision of liability insurance by risk retention

groups, employer-sponsored health, pension, and benefit programs, etc.). In other instances the federal government has established insurance programs, such as flood and crop insurance, which are exempt from state regulatory oversight (Klein 1998). Most recently, President Clinton signed into law legislation that will enable banks and mutual fund companies greater freedom to sell insurance.

State insurance regulation has two basic responsibilities: (1) to regulate and ensure the solvency of insurers and (2) to regulate the market, overseeing that price, products and trade practices are fair, reasonable, and nondiscriminatory (Klein and Barth 1995). Regulators monitor the financial disposition of insurers and can liquidate the firm if pre-emptive measures fail. In 1871 the insurance regulators of each state—to assist in giving the regulatory process a high degree of uniformity—formed an extra legal conference. Today that body continues to function under the name of the National Association of Insurance Commissioners (NAIC).

Regulatory issues may present obstacles to insurers regarding climate change for two reasons: (1) the fact that most states require that rate filings use historical loss data in the development of proposed premiums and (2) the current Internal Revenue Code. "Historical loss data" does not inform insurers, regulators, or the marketplace of the potentiality of future insured events. Moreover, by taxing the reserves at the corporate rate, some argue that the Code discourages the development of catastrophe reserve funds for events that have not yet occurred (Davidson 1996). Others argue that the establishment of such reserves, could have counterproductive effects (Eley 1996).

Some insurers have voiced a high level of confidence that rates can easily be increased if climate change proves to generate growth in losses (Mooney 1998). Experience has shown, however, that regulators are not always forthcoming with such increases (III 2000a). In some states, insurance regulators are elected, while in others they are political appointees. In either case, regulators can find themselves caught between the interests of industry and those of the voters.

Regulatory burdens that accompany the insuring of new lines of business or impact public policy (and are not clearly the responsibility of an insurer) will be approached conservatively before being addressed by insurance company leaders. In today's insurance environment insurers would seek to have regulatory acquiescence to their involvement on any issue, even some which might be argued as being outside regulatory purview.

Regulatory authorities have given insurers little if any guidance on the question of climate change, at least as evidenced in the public-domain literature. Over the past five years, the National Association of Insurance Commissioners (NAIC) journal contained only one article on the topic (Quirke 1994). With a heightened concern about solvency issues (including the increase in weather-related losses and the ability of existing solvency analyses tools to accurately characterize the financial stresses and vulnerabilities of insurers), regulators may have a new rationale for studying climate change.

Government's Role in Addressing Uninsurable Risks

Where insurers will not accept specific catastrophe risks (or are directly or indirectly regulated not to accept them), government may adopt the role of insurer or reinsurer, or of regulator in establishing risk-pooling mechanisms (Denenberg 1964; Kuenreuther 1998; Hausmann 1998; Nuttall 1998; Mittler 1992). Programs in France, Japan, and New Zealand explicitly define their role as paying for "uninsurable damages" (CCR 1999; 1999b). The primary weather-related risks that have shown insurability problems are flood and crop.

From a public-policy perspective, the dual questions of insurer insolvency and insurance availability for consumers are of central importance. The availability of government-provided insurance (or insurance equivalents) helps to fill—to some degree—the

gap left by insurers electing to exclude certain risks from coverage, e.g., due to a failure to pass the previously discussed Standards of Insurability. Government insurance can serve a critical function in making markets acceptable to insurers who would not otherwise accept the risk of entry (Pullen 1999a).

Comprehensive data on government spending for insurance and disaster preparedness/recovery is not readily available. One estimate pegs the value of U.S. include disaster-related payments at $119 billion ($1993) for the 1977-1993 period (Anderson 2000). Payments to localities following official presidental disaster declarations have been $30 billion since 1953 (Changnon and Easterling 2000). Nearly half of these occurred since 1990, and inflation-corrected payments rose 6-fold between the late 1960s and the early 1990s (Easterling *et al.* 2000a). In the case of Hurricane Andrew, only half of the total $30 billion loss was born by insurers. Public sector relief was also a major contributor (Pielke 1997; Pielke and Landsea 1998). A similar ratio applied in the case of the Northridge Earthquake in California (IBHS 1999).

It should be noted that tensions exist between federal and local governments concerning the allocation of risk and insurance costs. A federal effort is underway to shift more of the risks of natural disaster costs to local governments (Fletcher 2000).

Government Insurance Programs

U.S. Federal Insurance Programs have included the National Flood Insurance Program (NFIP), Federal Riot Reinsurance Program, Federal Crime Insurance Program, Crop Insurance, Social Security, Supplemental Security Income (SSI), Medicaid and Medicare and the Price Anderson act for insuring nuclear power (see Appendix C). The NFIP had 4.1 million policies in force in 1998, providing $484 billion in coverage (III 2000b) to 4.1 million policyholders (III 1999). Claims paid in 1995 totaled $1.3 billion and $800 million in 1997.

Governments are particularly sensitive to changes in flood- and crop-related losses, and climate changes are expected to exacerbate these losses (Rosenzweig *et al.* 2000). U.S. government-insured crop/hail losses grew 11-fold between the 1950s to the 1990s (Easterling *et al.*, 2000a). Solvency is a concern, as exemplified by the 810 million US$ deficit seen in the U.S. flood insurance program in the mid-1990s (Anderson 2000). The U.S. crop and flood insurance programs have never been profitable (GAO 2000a; Heinz Center 2000).

A major component of government insurance is that it aims to accommodate social goals, including some degree of stability for people with inadequate resources or excessive loss exposures (e.g. farmers, laid-off workers, retirees, disabled people, or those living in high-risk areas). Ideally these programs also promote loss mitigation (soil and water conservation, employee retraining, adequate income to maintain health and well-being and home relocation to safer areas). The government's "return on investment" (which an insurer couldn't really realize except in the sense that a better society would mean a better business environment) is a reduction in the often-expensive consequences of human suffering. If viewed from a financial perspective, social insurance (as long as it includes thoughtful and effective loss mitigation measures) costs something but is generally less expensive to society in the long-term than letting people fend for themselves. Social insurance also reduces the burden that otherwise would arise from the payments of government disaster assistance and relief.

The U.S. Federal Emergency Management Administration (FEMA) outlays for 396 declared weather-related disasters, between 1985-1999, totaled $10.9 billion (Kunkel *et al.* 1999). These efforts are often creatively coupled with government insurance activities, as in the case of the linking of eligibility for National Flood Insurance Program access to the local adoption of adequate flood plain management regulations.

As exemplified by the U.S. Federal Hazard Mitigation Grant Program, governments have also elected to purchase properties in flood-prone areas (III 2000a).

Lastly, the U.S. government—as owner of some 500,000 buildings and significant other civilian and military assets—must ponder the climate change question also from the perspective of a (typically self-insured) property owner.

The Federal Catastrophe Reinsurance Debate

The extended debate over federal catastrophe reinsurance in the House and Senate (with eleven hearings as of April 2000) evidences the difficulty in finding an acceptable balance for risk sharing between the public and private sectors. It also reveals worrisome limitations in lawmakers' grasp of how the insurance business works.

The common feature of all competing proposals would have the U.S. Treasury auction off excess-of-loss contracts, i.e., insurance for losses above a given threshold or "trigger" for a single event (Nutter 1998). Disagreements have centered on the size of the trigger and who should be eligible to bid for coverage.

Efforts to bring forward this legislation have stumbled over disagreements among insurers, reinsurers, and agents (Gettlin 1998). Consumer and taxpayer groups have also expressed concerns due to inadequate loss mitigation provisions, and problems with affordability, high deductibles, and availability for homeowners in high-risk areas (Hunter 1998). Several witnesses have argued that such insurance should be offered only temporarily, lest it stifle innovation within the private insurance sector. Government itself has expressed concern that insurers would pick the "safest" risks and transfer the worst ones to the State (GAO 1994).

In testimony before the House Banking Committee, these groups argued that the trigger should take effect at a level close to the capacity of the industry in any given state. Many industry groups, like AIA, AAI, NAII, and RAA, worry that provisions to offer reinsurance contracts to state catastrophe funds will broaden their appeal to other states, potentially encroaching upon the markets of their member companies (House Banking Committee 4/23/98). Concern has also been raised that the government will end up competing with, rather than protecting, the private insurance industry.

The Senate has also deliberated on the point (S:1361) (Federal News Service 2000). Testimony offered during Senate Hearings in April 2000 by an Administration official and two consumer representatives revealed a seeming lack of knowledge and understanding about technical matters relating to the standards of insurability, pricing of products, and regulation of property-casualty insurers. The comments of two insurance representatives were split with one focusing on the needs of homeowner (personal lines) insurers and the other on reinsurance.

Although the McCarran-Ferguson Act of 1945 delegates to the states the regulation of insurance. The role and responsibility, if any, of the state regulator under the proposed reinsurance legislation is unclear, despite the apparent recognition of the need for actuarially sound rates and for solvency oversight. In these hearings, at least, the record does not address the subject. Thus, the question is raised whether, if enacted; the legislation would result in dual regulation of homeowners insurance (federal regulation of the reinsurance program and state regulation of the primary homeowners insurance programs).

A misleading point is made by a non-insurer's testimony regarding the industry's "surplus." The record reveals that the "surplus" approximates $330 billion, despite catastrophe losses that cost insurers $70 billion during the decade of the 1990s. The conclusion of the witness was that insurer surplus "skyrocketed" despite these heavy catastrophe losses. In other words, insurers have ample monies to pay for catastrophe losses.

This statement seemingly reflects a lack of knowledge about what surplus is, how it functions and how it is depleted. Surplus is a term unique to insurance and represents the policyholder's equity capital in the case of a mutual company, reciprocal, or of the owner's equity in the case of a stock company. In short, it is a safety net from which losses that exceed the premium pool can be paid. As pointed out above, while the aggregate potential to form U.S. insurance reserves is often cited, this is a sum of non-poolable individual company reserves. These funds must be available to all lines of business written by the company, and the industry does not provide insurance. Individual insurers do.

In sum, the public commentary and debates regarding federal catastrophe reinsurance suffer from serious misunderstandings or mis-characterizations. Any federal reinsurance program would benefit from a more thorough understanding of the standards of insurability, the impact of recent catastrophic losses on insurers' surplus, and the importance of loss miti-

gation strategies. Without proper consideration of these issues, taxpayers may be subject to considerable financial burdens, and little public benefit in terms of loss prevention.

Some have expressed concern that governments—not unlike private-sector insurers—are facing real questions about the affordability of increased natural disaster losses:

> **"Even the [U.S.] government is starting to feel the financial pinch of disaster aid. … The enormous size of recent catastrophes and the potential for more of the same have caused the government to reevaluate its role as a provider of disaster relief."**
>
> — *Insurance Services Office (1994b)*

A major question facing policymakers and insurers alike, and one inseparable from the climate change discussion, is whether changes in the timing, intensity, frequency and/or spatial distribution of natural-disaster-related losses will generate a need for increased use of already overburdened government-provided insurance mechanisms. The political, market and public policy consequences of such changes are substantial.

Alternative Risk Transfer (ART)

As population expanded following World War II and home ownership became looked upon as a "right" regardless of a person's financial status, the importance of property insurance grew. Property insurance was deemed essential to protecting the colateral of both owner and mortgage provider. Concurrently, access to property insurance became viewed as a right in the eyes of many policy makers. Simultaneously, insurers were being stripped of their ability to underwrite the physical characteristics and location of the risk, loss experience and the moral turpitude of the ownership.

Actuarial rates (designed to recover all costs, plus a rate of return) were not always promulgated, because in the eyes of the regulator they can place a hardship on low-income property owners limiting their ability to acquire or maintain ownership. Premiums were depressed by being smoothed across classes of risks, thus distributing the costs among all insured in that class. Significantly, in this interval, regulators began to give recognition to the insurers' substantial return on investments in rate promulgation.

When the losses arose underwriters turned to writing more business in an effort to generate greater income. More income meant more investments and larger returns. When the losses occurred, as long as they were not catastrophic, and the interest rates remained high, the insured losses could be absorbed. Thus, utilizing cash flow underwriting and minimal rate increases, insurers realized marginal profits, avoided being chastised as socially insensitive and confronted this regulatory challenge. This phenomenon is dramatically evidenced in Figure 8a, which shows that although the U.S. property/casualty segment's "core business" had an underwriting loss, and numerous insolvencies (Figure 9b) for a 20-year period, the net performance was generally profitable given substantial revenues from their investments and capital gains (III 1998 and 2000b).

Floods, rains, severe windstorms, tornadoes, droughts, ice storms, and wildfires have wreaked havoc in unprecedented dosages. Catastrophe loss models have begun to foretell of staggering insured losses from hurricanes and earthquakes, that would consume much of the property-casualty insurers' surplus and erode the capacity of reinsurers. In turn, it was believed that the losses would result in significant insurance availability and affordability problems. The question became: "Not if, but when?"

The spate of catastrophic natural hazard losses has caused insurers and reinsurers to look for alternative means for financing the risk and loss (Elliott 1998).

Capital Market Alternatives

The buyers and sellers of corporate debt and equity make up the capital markets. Over the past several years, they have offered products that resemble rein-

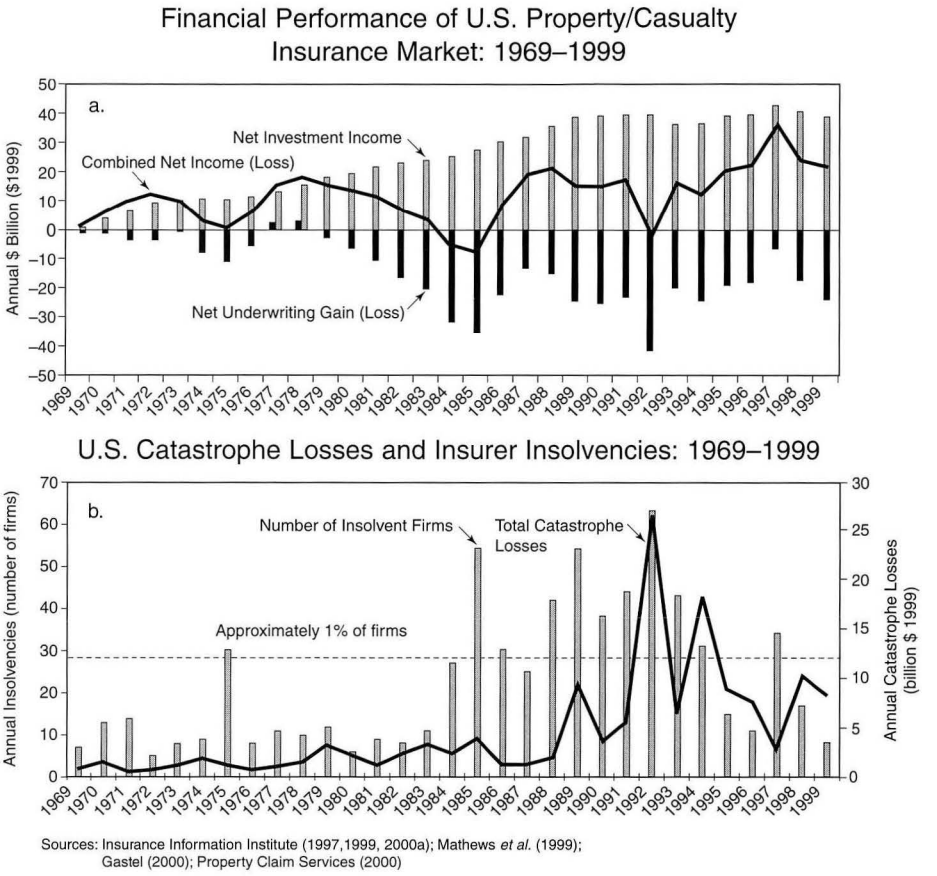


Figure 8a-b.

Profitability and solvency of U.S. property/casualty insurers during periods of natural disasters. (a) Sensitivity of U.S. property/casualty insurance sector net financial results to investment income and underwriting gain/loss. Curve is the net result. (b) Annual number of U.S. insolvencies (from all causes) and natural disaster losses: 1969-1999. Costs converted to $1999 using GDP deflators. Includes insured losses of >$5 million through 1996 and >25 million beginning in 1997. Note that due to various lag times insolvencies do not necessarily take place in the same year as the precipitating event.

surance and provide a means of risk financing for primary insurers (see Appendix D for more detail). As mentioned above, primary insurers in the United States cannot, under the current IRS Tax Codes, reserve for future events exceeding loss rates predicted by historic trends without paying the full approximately 40% corporate tax rate on the income used to feed such loss-reserve funds. Following are definitions of the main alternative risk-financing mechanisms in use today.

Contingent Capital Securities

The two types of Capital Contingency Securities available to investors are contingent surplus notes and catastrophe equity puts. Investors in these securities become, at the insurer's option, creditors of or equity investors in the insurer. The exercised "notes" and "puts" are shown as surplus on an insurer's balance sheet, and thus increase assets without an offsetting increase in the liability portion of the balance sheet. The insurer can draw from surplus to pay unreserved catastrophe losses and have the funds (surplus) necessary to take on new exposures.

- *Contingent Surplus Notes* (*CSN*): Insurers typically have difficulty borrowing money to cover excess claims in the event of a disaster. With a CSN, an insurer establishes a trust which issues notes paying a premium yield (y) to a limited group of

investors. To pay the interest, the CSN trust invests the proceeds in stable, fixed income securities earning a lower yield (x) while the insurer makes up the difference (y-x). If an agreed upon disaster strikes, the insurer can claim the trust assets and is then responsible for paying the entire interest (y) and principal, over an agreed upon period of time. The premium interest rate (y) is notably lower than what an insurer could get from borrowers following a disaster.

- *Catastrophe Equity Put Options:* Insurers sell these options on the financial markets which enable them to sell their stock at an agreed upon price in the event of a catastrophe. Proceeds reduce the need to liquidate assets at "fire-sale" prices to pay claims.

Catastrophe Risk Securities

Two forms of "Cat Risk Securities" are available which transfer underwriting risk to investors: catastrophe bonds and catastrophe insurance futures. Both primary insurers and reinsurers can make use of these securities. Both benefit the insurers by making monies available to offset catastrophe losses. In contrast to contingent capital securities, these instruments do not bolster an insurer's surplus but, rather, provide funds for the payment of losses. They are reflected as both an asset and as a liability on the insurer's financial statements.

- *Catastrophe Bonds:* Insurers issue bonds bearing a premium interest rate. In the event of an agreed upon catastrophe, interest rate reductions and/or partial or total principal forgiveness take effect.
- *Catastrophe Options:* Three options exchanges sell options which compensate insurers if aggregate industry losses for a given region fall within an agreed upon range (Boriaux 1998).

The Uncertain Future of Alternatives for Financing Risk

Capital market alternatives came into existence because the effective markets are so large in comparison to the insured catastrophe exposures that they offered a means, other than that provided by the somewhat limited capacity of reinsurers, to finance the risk and loss. This was accompanied by a shift within the industry from a traditional underwriting perspective to a "cashflow-underwriting" view. While some use has been made of these alternatives, they have not been fully tested, and some in the financial sphere are unsure of their attraction. One *Fortune* magazine writer commented in 1997:

> **"Just picture hurricanes as huge spinning pork bellies. On second thought, don't bother . . . securitized CAT risks are too dicey for most investors."** (Stipp 1997).

The president of an insurance trade organization noted that:

> **"The capital markets to date have not provided any large degree of new capacity. The capacity that has been provided has been more expensive than what's available in the private reinsurance markets...."**
>
> — *Frank Webber, president of the Home Insurance Federation of America (Federal News Service 2000)*

An Insurance Information Institute (III) survey in 1997 found that 86% of insurance executives believed ART to be a fad (GAO 2000). A recent International Securities Market Association (ISMA) members survey found that catastrophe bonds were "unexciting" and "unimportant" and "unlikely to find broad appeal among investors", because the risk is uniquely high making them "intrinsically unattractive" to certain segments (e.g. pension funds). Of eleven major trends in investing, catastrophe bonds were rated as least likely to have significant impacts on securities markets in the future (Freeman 2000).

There are also questions from the insurer or consumer's perspective about the performance and regulatory implications of ART mechanisms (GAO 2000; Swiss Re 1999c; Nutter 2000; Tol 1998; Bantwal and Kunreuther 2000; Jamison 2000), e.g.:

- The design and application of ART mechanisms is not guided or managed by the regulatory principles of solvency and consumer protection today applied to insurance.
- Most insurance regulators do not allow insurers to purchase these instruments.
- Some ART tools are constructed so that they are triggered by a physical event such as the intensity of a windstorm. The result can be an important mismatch between the loss and the underlying exposure of the investor, thus rendering these mechanisms very unlike traditional insurance or reinsurance. It is

thus possible that individual insurers could turn out to be "lucky" or "unlucky" in a particular event, i.e. if the degree of damage to properties which they insure did not parallel the way in which the proceeds of the financing mechanism were distributed to insurers following the event. This type of dynamic is referred to as "basis risk".

- Alternative financing systems replace relatively robust fixed capital (reserves and surplus) with much less predictable resources from the capital markets.
- ART mechanisms bypass the traditional checks and balances provided by insurance/reinsurance arrangements.
- A higher return is typically required than for other types of investments.

A number of particular questions arise about the significance of the alternative methods in relation to the issue of climate change:

- If successful, would derivatives shelter insurers and keep them from participating in actions to minimize the impact of catastrophic climate changes, in the same way that government sponsored programs (like flood and crop insurance) have mitigated insurers' exposures to the consequences of increased atmospheric moisture (due to warming temperatures)?
- Could the protection, provided by derivatives, potentially expose insurers to greater hazards if proper loss mitigation measures are less emphasized?
- Do derivatives signal a potential means by which self-insurers can expand their capacity, thereby providing greater competition for primary insurers and reinsurers?
- Might the expanded use of derivatives place insurers in the role of risk management consultants (today a largely independent industry)?
- What impact, if any, might derivatives have on intermediaries (i.e. brokers who operate between primary insurers and reinsurers to whom they cede part of their risk)?
- Will the occurrence(s) of catastrophic weather related events turn away investors?

3 Understanding Insurers' and Governments' Vulnerability and Capacity to Absorb Losses

"The industry does not provide insurance. Individual insurers do. To analyze the insurance industry's financial capacity to handle catastrophe risk, one must study each insurer."

— *Insurance Services Office*

"Potential events could cause a catastrophe of $50 billion or more for the industry. Based on current reinsurance levels, and assuming that all reinsurance is collectible, these events could result in insolvency for up to 36% of all insurers."

— *Insurance Services Office*

"[T]he closure of an insurance company has serious ramifications for the other insurance providers in the area. Companies are obligated to pay into insurance guaranty funds, which are used to settle the claims of insolvent insurers. Essentially, those left standing are responsible for the risks assumed by those driven out of the market. ... If insurers routinely close their doors because of the mounting costs of natural disasters, those remaining in the market will need to buffer themselves and their bottom lines by writing fewer policies, charging more in premiums, or setting higher deductibles. Or, they can go out of business themselves and this starts the spiral all over again."

— *Harvey Ryland, President, Institute for Business and Home Safety*

"Either a mega-catastrophe or a series of closely occurring disasters could greatly strain or overwhelm the capacity of the insurance industry and result in large federal payments for disaster relief."

— *U.S. General Accounting Office*

"[Insurance premiums are] no longer commensurate with risk because it is politically unpalatable to raise rates to actuarially justified levels."

— *The Insurance Information Institute*

"[T]he enormous size of recent catastrophes and the potential for more of the same have caused the government to re-evaluate its role as a provider of disaster relief."

— *Insurance Services Office*

"A.M Best Co. believes that the industry is still in its infancy stage of catastrophe management, and that there may be regions where true catastrophe exposures are still to be unveiled, leading to potential insolvencies . . . A.M. Best views the potential "mega-catastrophe" as the most serious financial threat to the industry."

— *Patrick Matthews et al., A.M Best Co.*

In managing vulnerability, insurers must properly judge the potential size and timing of losses, their capacity to pay for these losses, and their ability to recharge depleted reserves and surplus. Impacts on insurers can be moderated or intensified by the vitality of the financial markets, competitive pressures, consumer attitudes towards loss-prevention, and the dispositions of insurance regulators and politicians. The availability of risk-pooling mechanisms and of government-provided insurance and disaster aid is also a key factor, and one that cannot be taken for granted. Technical, political, and economic uncertainties compound financial and strategic challenges. Increased weather-related losses (small or large) can lead to upward pressure on insurance reserves and prices, the sensitivity of insurers' stock prices to major weather-related events, and increased insolvencies. Large and small insurers alike have been impacted by weather extremes and will be more so in the future if the frequency or intensity of weather-related events increases. Making insurers' job even harder, demographic, market, and climate trends all conspire to limit the value of historical experience as a predictor of what the future may hold.

Defining Vulnerability

For insurers, vulnerability can be broadly viewed in terms of the relationship between probable maximum losses (PMLs), the sector's capacity to pay for these losses, and its ability to recharge depleted reserves and surplus (assets), taken together with the predictability of such events. The exact definition of PML varies by type of event (Kunreuther & Roth 1998). Notably, we have identified no published quantitative analyses of potential changes in PMLs under global climate change.

In recent times, PLMs were revised upwards. A report commissioned by the All-Industry Research Advisory Council, AIRAC (now the Insurance Research Council) to estimate the effect of two $7-billion events on the insurance industry, was considered by some to be a frivolous exercise not based on reality (AIRAC 1986). Subsequently, the $20-billion Hurricane Andrew loss again raised the bar on what was considered a maximum probable event. Similarly, the European winter storms Lothar and Martin of 1999—with $8.4 billion in insured losses—caught European insurers and reinsurers off guard, presenting losses substantially exceeding conventional wisdom.

The cyclic nature of the insurance industry (prices and reserves) intrinsically leads to periods of higher-than-average vulnerability (GAO 2000). While the ultimate manifestation of impacts for an insurer is insolvency (bankruptcy), catastrophes can disrupt insurance markets and harm insurance companies and consumers even in cases where all claims are paid (GAO 2000; Ryland 2000).

The insurance sector is extremely diverse, with most branches vulnerable to climate/weather-related losses but to significantly varying degrees. Meaningful analyses must pinpoint the most vulnerable industry segments. Based on experience to-date, the property/casualty (P/C) segment is more vulnerable to weather-related events than the life/health segment. The single-most vulnerable segment appears to be property insurance for structures. Other segments, such as personal automobile insurance, have more limited exposure. Less obvious vulnerabilities include impacts such as those from increasing lightning strikes on machinery breakdown and business interruption insurance.[35] As an indication of the diversity of indirect effects, industry groups have cited social and economic instabilities caused by climate change as a potential trigger for "political risk" insurance claims, although the likelihood and magnitude of such losses is relatively low. Other types of insurance (e.g. medical malpractice) are largely unaffected by weather.

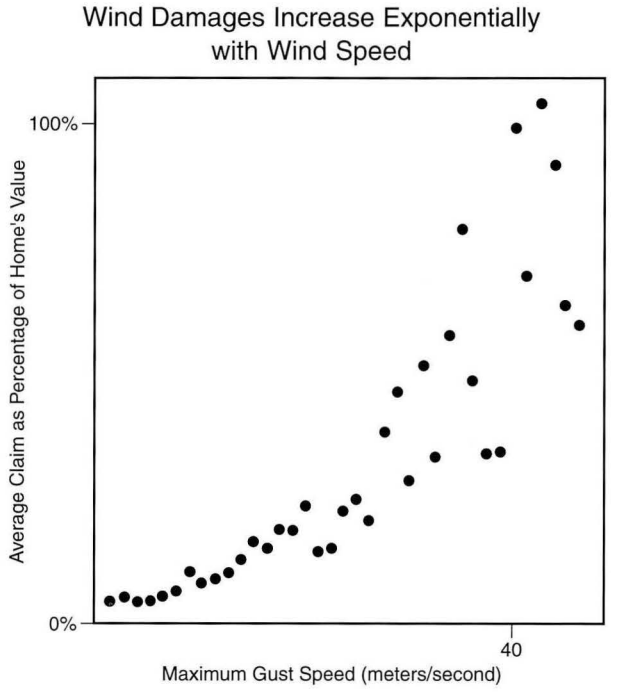
A central component of vulnerability for insurers is uncertainty in the size, location, or timing of extreme weather events.

> **"The [property/casualty] industry is at great risk if it does not understand global climate variability and the frequency of extreme events.**
>
> — *Franklin Nutter, President, Reinsurance Association of America (1999)*

Changes in average conditions can mask exposure to risks from associated changes in extreme events. This is particularly true in the case of insurance where the rate of damage rises faster than the driving weather phenomenon. Examples include the relationship between peak wind speeds to structural damages (Figure 9), average temperature changes and lightning strokes, extreme temperature events and electric power reductions or crop damages and heat stress mortality, and precipitation and flooding. Table 7 presents various examples of increases in extremes caused by relatively small changes in averages.

It can be is helpful to picture a "bell curve", representing that the most frequent events are "average" but that extremes above or below average also occur, although less often. If the probability distribution of events remains the same but the average changes, the likelihood of extremes at the high end of the scale

[35] Lightning has been cited as responsible five percent of (presumably property) insurance claims (Kithil 1995), but estimates vary widely. The review by Kithil (1995) placed the national cost (insured and uninsured) at $4-5 billion annually, noting that insured losses were estimated by the Insurance Information Institute at $1 billion in 1990. St. Paul Insurance Co. reported paying an average of $332 million in lightning-related claims between 1992 and 1996 (Kithil 2000). Reve and Toumi (1999) have shown that a 1-degree-C increase in average wet-bulb temperature can be accompanied in mid latitudes by a 40% increase in lightning. Price and Rind (1993) found that in a $2xCO_2$ climate with a 4-degrees-C warming, global cloud-to-ground lightning strikes would increase by 72% over continential regions.



Source: Dlugolecki *et al.* (1996)

Figure 9.

Insurance losses increase exponentially as a function of wind speed, with a four-fold increase in losses for each doubling of wind speed. Each point below represents losses following a windstorm, by postal code. Vertical axis is the claims cost as a ratio of total value of insured property for homes. The rapidly increasing "scatter" of the points as wind strength increases adds to the difficulty faced by insurers by lowering the predictability of loss.

will increase while those at the low end will decrease (Figure 10a). If the average remains the same but the variability on either side of the average increases, then extreme events at both high and low ends of the spectrum tend to increase (Figure 10b). Both processes can occur in tandem (Figure 10c), and this is the most undesirable eventuality.

Changes in the spatial distribution of natural disasters pose special risks and challenges for the insurance sector. For example, had Hurricane Andrew made landfall a mere 20 miles north (near the heavily populated greater Miami area) insured losses could have been three-fold higher, exceeding $50 billion (Davidson 1996).

Moreover, localities to which risks shift will tend to be relatively inexperienced and unprepared to handle such risks, potentially resulting in a net increase in losses. In some cases, adaptation can proceed rapidly while in others the rate of adaptation will be inherently constrained (e.g., by the rate of turnover of capital stock). An extreme example is the atypical inland path taken by Windstorms Lothar and Martin in 1999, given that such storms often stay largely at sea.

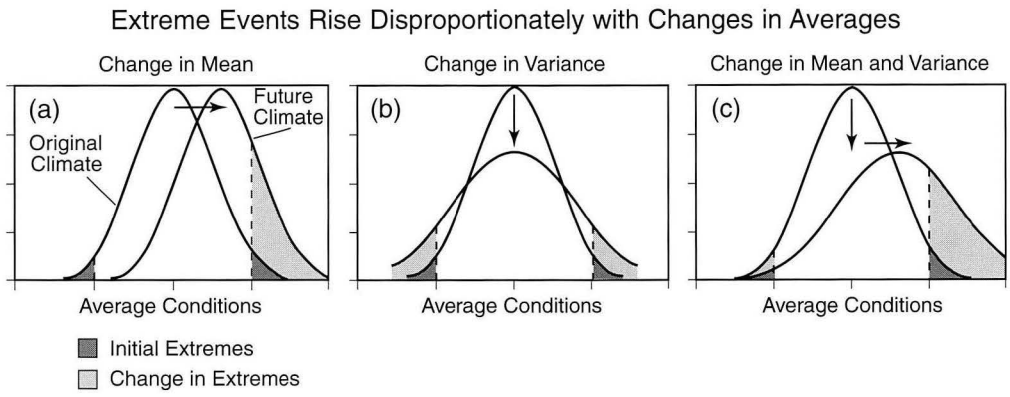
Ultimately, vulnerability manifests itself in economic form. Evaluation of insurers' capacity to pay claims and solvency analyses can help quantify the impacts of past and future natural disasters on insurers. Under normal circumstances, a given year's premium income is sufficient to pay for losses incurred by customers and help generate sufficient operating profit. Solvency becomes an issue when an insurers' equity or "surplus" must be used to pay claims for abnormal losses.

In order to maintain solvency, insurers must manage risks, ranging from the coverage of their "core business" to managing their investments. The risk factors include adverse securities market performance, interest rate increases, bond defaults, ordinary random variation in losses, underestimating maximum probable losses, insufficient reserves, failure of reinsurers, and catastrophe loss events.

Analyses of insolvency (bankruptcy) issues must cope with the differing, and often-competing financial perspectives of various stakeholders, insurance company owners, employees, policyholders, rating agencies, and regulators. Insofar as high-risk asset management can be rewarding to owners and shareholders, inherent in this dynamic is a tension between profitability and solvency.[36] As an example of these competing concerns regarding solvency and high-risk asset management (junk bonds) can be rewarding but may result in statutory business or investment restrictions, concerns from consumer groups, and eventual solvency issues in the event of default or adverse claims experience, etc.

Recent natural disasters cast a new focus on insurer solvency. As mentioned previously (Figure 6), over the past 30 years, the U.S. ratio of P/C premium income to natural catastrophe losses has decreased from 204:1 to 35:1, a nearly 6-fold increase in "exposure", with a minimum level of only 10:1 in

[36]The National Association of Insurance Commissioners maintains an extensive bibliography on the topic of insurance solvency. See http://www.naic.org/1library/subs/sub31.htm.



Source: Adapted from Meehl *et al.* (2000)

Figure 10.

Schematic diagram illustrating how changes in mean (a) and variance (b) can effect the level of extreme weather and climate-related events. Both types of shifts can occur simultaneously (c). If the shaded area after the shift is larger than the originally shaded area, then the overall exposure has increased. For example, for panel (a) the original risk for extreme events is about 5% but increases to about 25% after the shift in mean.

Table 7. Disproportionate changes in extremes in comparison with changes in averages.

Hazard	Cause of Change in Hazard	Resulting Change in Damage/Loss	Location	Source
Windstorm	Doubling of wind speed	Approx. four-fold increase in windstorm damages	UK	Dlugolecki *et al.* (1996)
	2.2°C mean temperature increase	Increase of 5-10% in hurricane wind speeds	Western Pacific	Francis and Hengeveld (1998)
Flooding	25% increase in 30-minute precipitation	Flooding return period reduced from 100 years to 17 years	Sydney (AU)	White and Etkin (1997)
	2°C mean temperature increase	Increase of 16-19% in average peak river discharges	India	Mirza *et al.* (1998)
Lightning Strikes	4.5°C mean temperature increase	Increase of 72% in air-to-ground strikes	Continental regions	Price and Rind (1993)
	1°C mean temperature increase	Increase of 40% in air-to-ground strikes	Mid-latitudes	Reve and Toumi (1999); Dinnes [Germany] (1999)
	1.5°C mean temperature increase	Increase of 50-100% in air-to ground strikes on days over 35°C	Victoria (AU)	Hennessy and Pittock (1995)
Extreme Temperature Episodes	1.7°C mean temperature increase	Increase of 300% in heat waves	De Moines (USA)	Mearns *et al.* (1984)
	1.6°C mean temperature increase	Increase of 25x in extremely warm summer (mean temp over 17.3°C)	Central England	Munich Re (1997)
	4°C mean temperature increase	Increase chances of summer days over 30.5°C from 1-in-10 to 1-in-2	Toronto (Canada)	Francis and Hengeveld (1998)
	3°C mean temperature increase	Increase of 7% in peak power demand; 22% in standard deviation	Toronto (Canada)	Colombo *et al.* (1999)
	0.5°C/1.5C mean temperature increase	Increase of 25%/50-100% in extremely hot days (over 35°C)	Victoria (AU)	Francis and Hengeveld (1998)
	1°C mean temperature increase	300-year return period events occur every 10 years	UK	Hulme (1997)
	1°C mean temperature increase	Reduction of 7000 wintertime deaths annually	England and Whales	Palutikof *et al.* (1997)
Wildfire	1°C mean summertime temperature increase	Increase of 17-28% in wildfires	England and Whales	Palutikof *et al.* (1997)
	Doubling of atmospheric carbon dioxide levels	Up to 143% increase in escaped (catastrophic) wildfires	California (USA)	Torn *et al.* (1998)

the year of Hurricane Andrew. As shown in Figures 8a-b the segment as a whole has exhibited considerable sensitivity to major natural disaster events in recent decades, as evidenced by the substantial reductions in U.S. insurer profitability during 1973-74 (flooding of the Mississippi, tornadoes across the country, and tropical cyclone Fifi); 1983-1984 (Hurricane Alicia, snowstorms, and cold weather extremes); 1992 (Hurricanes Andrew and Iniki); and 1998 (Hurricane George; drought, wildfire, heat waves, wind/ice storms, and other El Niño-related events). In three instances, industry-wide earnings were zero or negative as a result of large losses. A list of the most costly events over the past four decades is presented in Table 5.

Figure 11 presents an insurance financial performance indicator, the "combined ratio," which shows the strong role of natural catastrophes on overall industry profitability in the U.S. P/C sector. Industry-wide property/casualty insurer ratios shot from 108 in the U.S. to 117 in the year of Hurricane Andrew, while return on equity fell from over 10% to 4% (Sedgwick 1997).[37]

In addition to natural disasters themselves, the overarching insurance business and regulatory environment is also a key factor in determining insurer solvency. Coinciding past or potential broad-based stresses on the industry such as major tobacco litigation (Clow 2000), the crisis in environmental liability insurance (U.S. Superfund, asbestos, and lead paint claims), world events such as the Asian financial crisis, increased competition due to Internet sales, e-business risks,[38] and even energy prices (Hartwig 2000) can also influence industry vulnera-

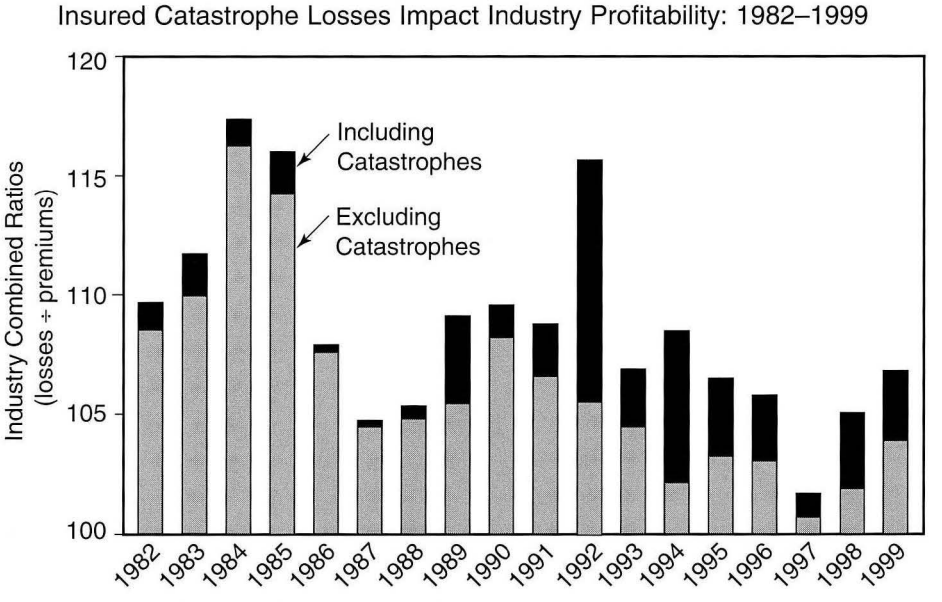


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Figure 11.

The role of catastrophe losses in U.S. property/casualty insurance sector profitability: 1989-2000. A measure of industry financial performance, the "combined ratio" is the ratio of net income to net expenditure (claims and expenses). Thus, an underwriting profit occurs when the ratio is less than 100. Peak catastrophe-related values reflect Hurricane Andrew which occurred in 1992 and the Northridge earthquake which occurred in 1994.

[37]In a European example, the profitability of "water and water pipe insurance" in Germany and Switzerland has shown strong correlation with temperatures (Klaus *et al.* 1992).

[38]In the insurance trade press, the specter of Internet privacy litigation has been likened to the pollution liability (Superfund) experiences (Ceniceros 2000).

bility. "Long-tail" losses manifesting as damages and claims over very long time periods add an additional dimension of uncertainty and risk for insurers. Insolvencies in the UK are also attributed to a string of natural disasters at the end of the eighties (Swiss Re 2000b). While the ultimate impact of such periods is insolvency, even lesser impacts on financial performance are of course unwelcome.

As a case-in-point, prior to Hurricane Andrew, reinsurance capacity from the largest reinsurer, Lloyds of London, was already weakened due to long-tail Superfund and asbestos litigation, junk bond losses, and lower stock markets. Lloyd's experienced a pronounced 13-year period of mostly negative profitability lasting from approximately 1980 to 1993 (Swiss Re 1998a). Subsequent losses from Hurricane Andrew put severe strains on reinsurance capacity, and prices skyrocketed (Figure 12). At the same time, a number of smaller U.S. reinsurers were stressed to the point that they went out of business or were absorbed by larger companies (Mooney 2000).

From a public policy standpoint, guarding against insolvency, reduced availability of insurance, or affordability crises are generally seen as a matter for regulators. Formal solvency regulation is relatively new to the U.S. insurance industry. If preventive measures are ineffective, regulators can preside over the liquidation of firms that have become insolvent. Techniques for evaluating solvency and providing early warning signals are constantly under development and have been criticized for their limitations, including the way that natural catastrophe risks are handled. Insurance rating organizations (such as A.M. Bests and Standard and Poors) have been cited as having more stringent criteria—for rewarding their top ratings—than those presented by insurance regulators (Swiss Re 2000b).

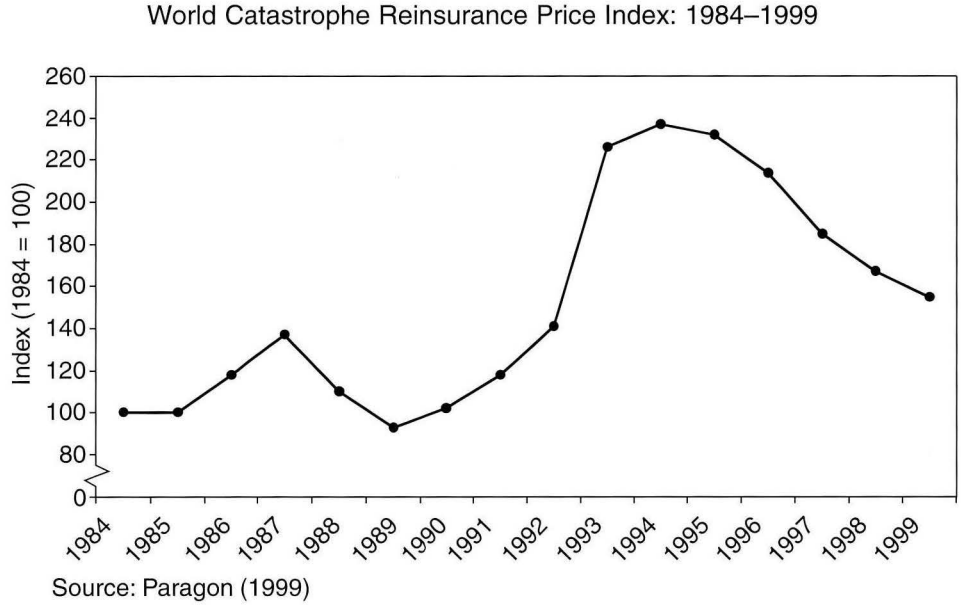


Figure 12.

The global catastrophe reinsurance price index reflects a price shock and gradual recovery following Hurricane Andrew.

Looking back at Catastrophe-Related Insolvencies

Historical events provide some opportunities to observe the industry's response to current-day climatic extremes and the kinds of catastrophic losses that could be expected under global climate change. Data for property/casualty firms show that "baseline" insolvencies (bankruptcies) rise in years with larger losses precipitated by natural disasters (Swiss Re 2000b).

Nearly 700 U.S. insurers became insolvent between 1969 and 1999 (Figure 8b), a number that excludes financially troubled companies and companies that enjoyed "11th-hour rescues" by being acquired by larger, healthier insurers. Matthews *et al.* (1999) were able to identify the primary causes for 426 of these insolvencies. Between 1969 and 1998, 36 (8%) of the companies became insolvent primarily as a result of catastrophe losses. Of these companies, 20 (56%) became insolvent between 1989 and 1993, the same time period as Hurricanes Hugo, Iniki, and Andrew occurred (Matthews *et al.* 1999). The Insurance Services Office (ISO 1999) estimates that 15 catastrophe-triggered insolvencies took place in 1992 alone. A number of smaller reinsurers in the U.S. also became insolvent or were absorbed by larger firms during this period (Mooney 2000). According to Matthews *et al.*, the rate of insolvencies during this period ranged from approximately 1.25% to 2.25% (27 to 63 firms) per year, compared to 0.5% (5 to 14 firms) per year in the preceding decades.[39] Other authors have associated insolvencies with natural disasters during this period (Doherty 1997; Davidson 1997; Swiss Re 2000b).

The somewhat reduced rate of insolvencies since the mid-1990s may be explained by the reduced incidence of natural catastrophes (Matthews *et al.* 1999). Some insolvencies are unambiguously linked to natural catastrophes, e.g. Hawaii's largest insurer became insolvent following Hurricane Iniki (ISO 1994a). However, it is important to note that multiple factors are usually involved. Factors that can be exacerbated by natural catastrophe events—e.g. deficient loss reserves, reinsurance failure, impaired affiliates, plus catastrophe losses—account for a full 53% of insolvencies during the 1969-1998 period.

The period of increased insolvencies that prevailed in the U.S. through the 1980s and 1990s was accompanied by the well-known "bull market" on Wall Street, which provided insurers with larger-than-normal surpluses from which to pay claims. The vulnerability of insurers to vagaries of the financial markets has been noted (GAO 2000) as have excessive investments in junk bonds or under-performing real estate.

While small and geographically specialized firms are most vulnerable, insolvencies of larger and regionally diversified companies have occurred in the European Union (Swiss Re 2000b) and in the U.S. the two largest homeowners insurance companies had to be rescued by their parent companies and others expended a significant fraction of their surplus to pay Hurricane Andrew claims (III 2000b). The nation's largest homeowner insurer, State Farm Fire & Casualty, was brought to the brink of insolvency by a $4 billion loss and its parent (State Farm Group), had to inject emergency capital to restore solvency (Stipp 1997). Allstate—the nation's second largest homeowner insurer—met the same fate. The company paid out $1.9 billion, $500 million more than it had made in profits from its Florida operations from all types of insurance, including investment income, over the 53 years it had been in business (III 2000b). Insurer insolvencies due to Hurricane Andrew resulted in $400 million in unpaid claims. Since then, some 44 companies have reduced their exposure in Florida by trimming coverage and raising premiums.

Historical insolvency data for self insurers are not available, but given their smaller size and lower level of diversification, their vulnerability is considered high.

[39] One anomalous year, 1975, saw 30 insolvencies (approximately 1.4% of the firms). This year followed the two largest natural disasters in recent U.S. history up to that time — 1974: $1.4 billion ($1998) in tornado losses in 14 states and 1973: $1.3 billion insurance losses from flooding in Mississippi (Swiss Re 1999b).

Insurers' Capacity to Withstand Losses

As discussed above, insurer solvency depends largely upon the adequacy of premium income, available surplus or equity, and diversification of risks. Of course an insurer's annual and cumulative operating surplus (held in the form of cash and investments) is designed to enable insurers to endure such events, but U.S. laws concerning insurance pricing dictate that the setting of premiums must be based strictly on the historical record. Projected future loss trends that depart from historical experience (e.g., due to climate change) can not be folded into rates. With limited ability to anticipate future climate changes in premiums or loss reserves, insurers must draw upon other methods to enhance their solvency.

Insurance losses are paid by reserves and from surplus (assets). The ability to form reserves and rebuild surplus cannot be increased quickly in response to changes in the incidence of losses. The industry's capacity to pay losses is not likely to be stable over time (GAO 2000; Mooney 1999), sometimes changing abruptly in response to market perturbations such as stock and bond market valuations or interest rates. For example, more than three-quarters of the growth in the U.S. insurance industry's surplus between 1995 and 1999 was due to capital gains (GAO 2000). Fueled in part by the bear market of 2000, insurers experienced net loss of surplus of $13 billion from mid-1999 to mid-2000 (ISO and NAII 2000).

Even during periods of stability, insurance pricing can be inadequate to cover future losses, as was seen in the case of the Northridge earthquake in California where the $3.4 billion in earthquake premiums collected during 25 years prior to the event fell far short of the $15.3 billion loss (Gastel 1999a).

Before liquidating assets (surplus) to pay losses, insurers can utilize "reserves". As of 1999, property/casualty insurer reserves totaled $346 billion, including reinsurance (A.M Best & Co. 2000). While this amount is large compared to catastrophe losses experienced in the past, not all of these funds are available to pay such losses. In fact, the majority of these reserves are associated with types of insurance that have relatively little if any weather-related exposure (e.g. workers compensation, medical malpractice, liability). Reserves for the most vulnerable lines: commercial multi-peril and homeowners multi-peril were less than $37 billion,[40] with an additional $6 billion provided by reinsurers (A.M. Best & Co. 2000). Total reserves fell by $14 billion between 1997 and 1999, and have fallen further with the stock market corrections experienced during 2000.

Individual insurers certainly study their exposure to weather-related PMLs, but comprehensive solvency analyses of global insurance sector vulnerability to past or future climate changes have not been performed.

A recent paper (see Appendix E) by the American Insurance Association—a trade organization representing mostly large U.S. property/casualty insurers (with approximately 20% of annual premium revenues for this segment)—estimated that in 1997 17% of U.S. insurance P/C premiums were associated with types of insurance with "significant" exposure to weather-related loss; 2% with "moderate" exposure; 66% with "minor" exposure; 10% with "minor to no" exposure, and 4% with "no" exposure (AIA 1999).

Studies such as AIA's are an important starting point, and highlight the need for segmenting and taking into account the financial complexity and diversity of the insurance sector, rather than regarding it as a monolith. Their study also points out the dominant role of hurricanes in the overall picture of weather-related losses in the U.S. and that a connection between hurricanes and climate has not been established. Moreover, the study notes the importance of proactive land-use planning and that certain measures normally thought of as climate change "mitigation" (e.g., emissions reduction achieved through public transportation or reduced highway speed limits) can also offer benefits to insurers by reducing everyday risks.

According to the AIA study, the most sensitive customer segments are residential and commercial

[40] This includes the "commercial multi-peril" insurance category, for which about 43% of the premiums are associated with commercial liability insurance that is also not weather-dependent. The associated level of reserves available for paying losses is not known.

property, ocean marine, crop and farm-owners, and flood. Crop insurance and residential flood insurance also face significant exposures, but are largely insured or reinsured by government. Within the risk category classified as "minor", 48% of premiums are for personal and commercial auto policies (see Box E).

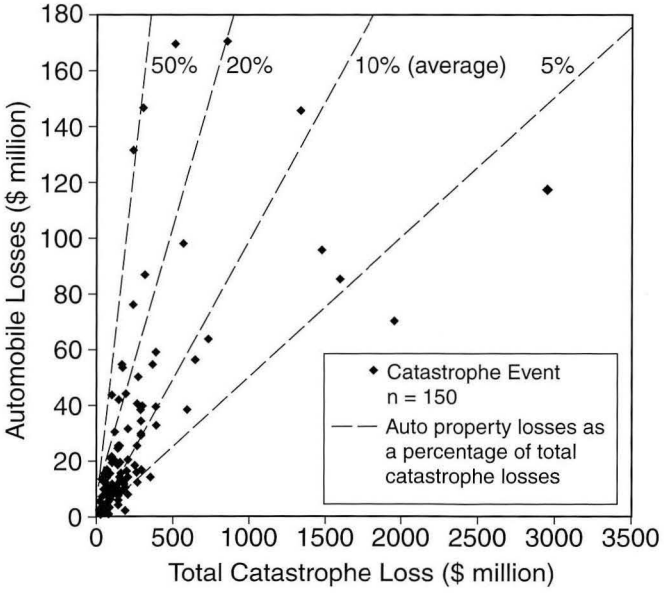
The paper did not explicitly evaluate other measures of vulnerability, such as profitability and solvency at the level of the firm or exposures in terms of total insured property values for which the at-risk insurers are responsible—e.g. $4 trillion in insured property in the Gulf and Atlantic coastal counties of the U.S. (Hooke 2000)—and the reserves available against which those losses can be charged.[41] The report did not analyze the potential impacts on offshore insurers doing business in the U.S. (significant according to AIRAC (1986)) or to insurance provided by U.S.-based companies to overseas customers (approaching 15% of P/C premium income in 1998 (III 1999)). A one-time snapshot of conditions is useful, but does not capture the considerable year-to-year variability in the ratio of premium income to losses or to the rapid narrowing of the gap between P/C premium income and payouts for catastrophe losses (Figure 6).

Analyses of vulnerability, impacts, and adaptation must take into account the complexity and fragmentation of the insurance sector, rather than regarding

BOX E: AUTOMOBILE LOSSES AND NATURAL CATASTROPHES

In the U.S., 16% of automobile accidents are attributed to adverse weather conditions (NHTSA 1999), as are one-third of the accidents in Canada (White and Etkin 1997), and 43% in the United Kingdom (Barker *et al.* 1998). Autos also sustain insurance losses during natural disasters, amounting to $3.4 billion and 1.7 million claims between 1/1996 and 9/2000 (PCS 2000) and averaging 10% of total disaster-related property losses, with much greater losses for some events, particularly hailstorm (Mannino 1999). These data systematically underestimate total losses because PCS records include only those events with total losses of $25 million or more. Individual events have seen as much as 55% of total losses attributed to autos.

U.S. Automobile Losses are A significant Part of Total Catastrophe Losses: 1/1996 to 9/2000



Source: Property Claim Services (2000)

[41] These reserves change over time. In 1997 the U.S. P/C aggregate reserves dropped for the first time in 50 years (Mooney 1999).

it as a single "mega-firm" (GAO 2000). For example, there were some 3,400 property/casualty insurance companies in the United States in 1998. Even though the *aggregate* potential to form U.S. insurance reserves of $200 to $350 billion are often cited (Doherty 1997; *National Underwriter* 1/19/99; GAO 2000), this is the sum of non-poolable individual company capacity that must also be available to weather- and non-weather-sensitive branches of the highly-diverse property and liability insurance sector. (This includes workers compensation, medical malpractice, general liability, burglary and theft, etc.) Reserves are also often limited in specific regions; thus they are not spatially (geographically) poolable over the entire country. Figure 13 captures both the spatial (state-level) capacity to absorb losses, as a function of both available surplus and expectation of the probable maximum loss (PML).

This is summed up concisely in the words of the well-known U.S.-based insurance organization, ISO:

> **"The industry does not provide insurance. Individual insurers do. To analyze the insurance industry's financial capacity to handle catastrophe risk, one must study each insurer."**
>
> — *Insurance Services Office (ISO 1996)*

Moreover, surplus must be available for payment of all kinds of losses. Interpretation of the AIA analysis (1999) may suggest to the casual reader that 17% or more of total surplus would be available for losses related to climate change. The actual values (for 1999) are 7.6% for commercial multi-peril and 2.8% for homeowners multi-peril (A.M. Best and Co. 2000).

Figure 14 summarizes a recent analysis by Cummins *et al.* (1999) of the ability of the industry, as a whole, to pay claims over a wide range of losses. The chart shows four views, encompassing changes in capacity between 1991 and 1997 and whether or not companies have access to the resources of Groups that own them. (Groups are not obligated to pay the

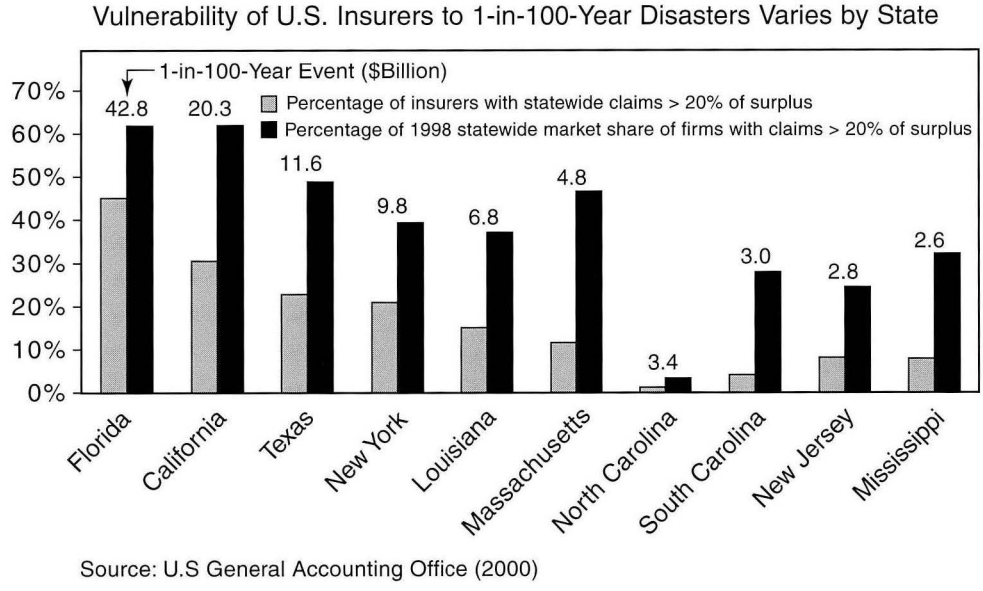
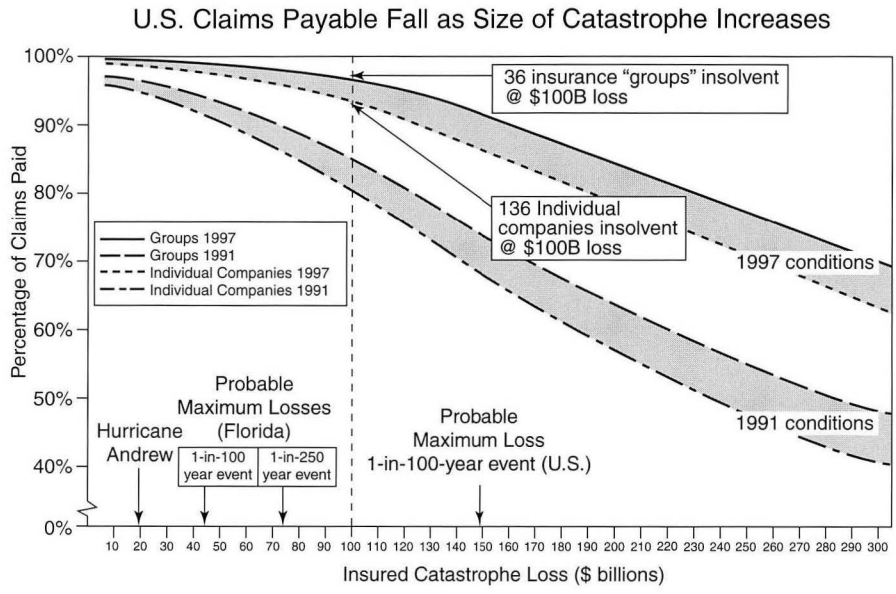


Figure 13.

Vulnerability of U.S. insurers to 100-year probably maximum loss events, represented as the combined effect of loss magnitude and insurance company capacity. It excludes reinsurance, and local government-supported insurance or reinsurance programs in California and Florida. It also excludes the effects of catastrophes striking more than one state (e.g. the estimated 1-in-100-year loss for the entire U.S. is $155 billion). The capacity implied may include some surplus amounts not available for paying natural catastrophe claims. Losses that result in claims of over 20% of surplus trigger the initial stage of formal solvency review by the National Association of Insurance Commissioners. Puerto Rico (not shown) has a 1-in-100 year loss of $27.1 billion.



Sources: Curves and $100B Impacts—Cummins *et al.* (1999); PMLs— U.S. General Accounting Office (2000)

Figure 14.

Ability of the property/casualty insurance sector, as a whole, to pay claims over a wide range of losses. The chart shows four views, encompassing changes in capacity between 1991 and 1997 and whether or not companies have access to the resources of Groups that own them. Groups are not obligated to pay the losses experienced by individual member firms, but retain the option to do so. Together, these four scenarios represent a range of ability to pay losses. For example, for a $155 billion loss year—a recent estimate of Probable Maximum Loss for all events combined—65% to 90% of claims would be paid. The improvement in vulnerability between 1991 and 1997 is attributed largely to the performance of insurers' investments in securities during that period (GAO 2000), however surplus fell by $13 billion between 1999 and 2000 as the favorable market conditions reversed (ISO and NAII 2000).

losses experienced by individual member firms, but retain the option to do so.) Together, these four scenarios represent a range of ability to pay losses. For example, for a $155 billion loss year[42] 65% to 90% of claims would be paid.

The distinction between the capacity of individual firms and "Groups", versus industry-wide capacity, is a critical one given a probable total economic loss in excess of $100 billion (approximately half of which would be insured) estimated by the Insurance Services Office, Arkwright Mutual Insurance Company (now FM Global) and by others for a loss caused by a hurricane striking a major U.S. urban center along the Eastern Seaboard (ISO 1999; Kelly and Zeng 1999; ISO 1999). While basing their analysis on a hurricane ranking seventh in intensity among those making landfall in the 20th century, the authors note that the most severe hurricane of the century had twice the inflation-corrected cost of Hurricane Andrew. According to Arkwright, however, even for a more probable case with losses of $45 billion, "significant insolvencies" in the U.S. insurance and reinsurance marketplace could be expected (Kelly and Zeng 1999).

The Cummins *et al.* study found that a $100-billion loss event would result in insolvency's of 30 major "corporate family" insurers (also known as Groups) or 136 individual companies nation-wide, and would disrupt the normal functioning of the property and non-property insurance market (Cummins *et al.* 1999). This idealised analysis likely overstates industry capacity because it assumes the reserves and equity of companies not writing weather-sensitive policies would be available to pay claims, that all insurers hold the same liability portfolio, that the losses for any given event would be spread among

[42]This is a nationwide annualized probable maximum loss—PML—according to GAO (1999a)—which would represent all events combined over the course of the year.

all insurers, and that all reinsurance would be collectable (GAO 2000). Additional insolvencies of reinsurers and overseas insurers were not estimated, but were comparable to those of U.S. firms in an earlier study (AIRAC 1986).

Industry-wide capacity is thus a crude measure of vulnerability. In the U.S., regulatory solvency scrutiny is typically triggered when claims exceed 20% of surplus. Potentially up to 45% of U.S. insurers could be placed in this position (representing 62% of market share) (GAO 2000).

Another indicator of the industry's capacity are statements that the industry would not require federal aid for disasters resulting in losses below $20 to 25 billion, i.e., about one-fifteenth of overall industry capacity (Pullen 1999b; III 2000a).

Individual firms may thus become insolvent long before losses approach the industry's aggregate capacity, even at a level of a $10-$20 billion-loss event in the case of the U.S. (Doherty 1997). According to Klein (1997), while reinsurers offer additional capacity, a general consensus at the time suggested that the capacity of insurers and reinsurers to absorb a single major catastrophe was probably $10-12 billion. This capacity has perhaps doubled in the ensuing years.

> **"Potential events could cause a catastrophe of $50 billion or more for the industry. Based on current reinsurance levels, and assuming that all reinsurance is collectible, these events could result in insolvency for up to 36% of all insurers."**
>
> — *Insurance Services Office (ISO 1996)*

Notably, this ISO report was based on a projection of historical trends, and did not anticipate the impacts of change in climate.

While past data and future scenarios of solvency are readily available, it is important to note that simply comparing maximum losses to aggregate capacity can understate the importance of maintaining functioning insurance markets in the aftermath of disasters (GAO 2000).

Vulnerability at the level of the primary insurance company is a function of its size, investment income, financial surplus, degree of diversification and ability to cross-subsidize losses across insurance lines within the firm. Vulnerability also reflects the level of reinsurance (including both provided to *and* purchased from other firms), and adequacy of prices.

Vulnerabilities are also expressed through movements in insurance prices. Attracted by higher prices, several reinsurance firms opened up in Bermuda, and within a year or two of Hurricane Andrew, reinsurance capacity returned, except in regions subject to hurricanes (Nutter 1998). The 1994 Northridge Earthquake sent similar tremors through the insurance markets. By the end of 1997, however, a downturn in natural disaster losses sparked a recovery and significant price competition (Nutter 1998). This competition and reduced risk-capital costs have translated into lower property insurance premiums (Katz 1999). Recent reports indicate that price reductions have even affected property coverage for catastrophe risks (Howard 1999). However, major insurers like State Farm and Allstate have sought several rounds of price increases for windstorm risks along the East and Gulf Coasts (*The Insurance Regulator* 1998). Reinsurers report that there is, again, downward pressure on reinsurance profitability and corresponding upward pressure on reinsurance prices (Mooney 2000).

The financial and regulatory interconnectedness of insurance firms is another important factor in vulnerability assessment. Through the state insurance Guaranty Funds—to which most insurers are required to contribute via a tax on premium income—solvent firms contribute monies to rescue those who become insolvent. Guaranty funds were originally for small, specialized, and geographically concentrated firms but there has been a trend towards insolvencies and demand for guaranty fund resources among larger and more diversified companies (Gastel 2000). Payments have grown substantially in recent decades, to as high as $400 million per company (Gastel 2000). Net assessments to guaranty funds amounted to $6.3 billion over the 1969-1998 period, and as much as $0.9 billion in a single year (1987) (III 1999; Gastel 2000). Of the 25 largest U.S. P/C insolvencies (amounting to $5 billion in unpaid claims), only 29% of the losses were recoverable through guaranty funds and national capacity was only $3.4 billion as of 1998 (NCIGF 1999).

In the words of one insurance trade organization:

> **"[T]he closure of an insurance company has serious ramifications for the other insurance providers in the area. Companies are obligated to pay into insurance guaranty funds, which are used to settle**

the claims of insolvent insurers. Essentially, those left standing are responsible for the risks assumed by those driven out of the market. ... If insurers routinely close their doors because of the mounting costs of natural disasters, those remaining in the market will need to buffer themselves and their bottom lines by writing fewer policies, charging more in premiums, or setting higher deductibles. Or, they can go out of business themselves and this starts the spiral all over again."

— Harvey Ryland, President, Institute for Business and Home Safety (Ryland 2000)

In many states, insurers also contribute to Residual Mechanisms (FAIR- and Wind/Beach Plans, and Joint Underwriting Authorities (JUAs) as a way to spread risks (see Table 6). The rapidly increasing use of these mechanisms is illustrated by the jump in numbers policies, 10-fold increase in payouts, and a growth in at-risk property to $285 billion since the 1970s. Insurance firms thus face two sources of risk: direct losses incurred by their insureds and indirect payments to the Guaranty Funds and/or RMMs.

Vulnerability of Reinsurers

Many of the aforementioned vulnerabilities experienced by primary insurers also apply to reinsurers.

Reinsurance provides a significant and essential form of risk-spreading capacity for primary insurers. Primary insurers retain the first tier of losses up to a "trigger point" above which reinsurance can be tapped. Prior to Hurricane Andrew and other multi-billion-dollar events of the past two decades, reinsurance effectively covered all losses above an agreed level, but in response to the limited capacity of the reinsurance sector, upper limits (termed "exit points") are now commonly specified.

By paying for losses up to a contractually agreed exit point, reinsurers share in the cost of catastrophic losses. Reinsurance adequacy is another indicator of vulnerability. An insolvency analysis conducted by Swiss Re concluded that the availability of non-proportional reinsurance coverage for probable natural disasters in 14 major markets (U.S. $53 billion) was insufficient.[43] As of 1997, exit points stood at 91% of the probable maximum loss in Germany, 87% in the UK, 76% in France, about 60% in the U.S.A, Netherlands, and Belgium, 38% in Japan, and 53% in Australia. This means, in effect, that the insurers need to step in and begin paying losses as their reinsurance expires. Even with reinsurance, the occurrence of a major loss event "would mean that the insured loss to be borne by primary insurers would be so great that their equity base would come under considerable strain" (Swiss Re 1997). For statistically based windstorm "reference loss"[44] events in Australia, Japan, and the U.S., the essentially instantaneous toll on primary insurer's equity capital would a reduction of be 24%, 41%, and 11%, respectively.

The worldwide reinsurance industry is clearly limited in its ability to fund catastrophic event risks. In the words of ISO:

"Reinsurance alone cannot be expected to solve the problems of a major catastrophe."

— Insurance Services Office (1994a)

As of 1997, the relatively small capital and surplus of the worldwide reinsurance industry was $57 billion ($26.7 billion for U.S. reinsurers, $6.5 billion for Bermudan reinsurers, $7.0 billion for German reinsurers and $16.8 billion for others) (Guy Carpenter & Co. 1997).

[43] This analysis represents 86 countries for which data were available and where volumes were at least $100 million. Non-proportional reinsurance is the most common type, providing coverage for losses in excess of pre-agreed target levels. Proportional reinsurance, far less common (i.e., far more risky for reinsurers), involves a percentage-based sharing of premium income and loss payouts.

[44] The "reference loss" corresponds to the major loss to which an insurer with average capitalization should gear itself when designing catastrophe cover.

All in all:

> **"[The world's] catastrophe reinsurance industry... lacks the capacity to insure mega-losses in the $50 billion and higher range."**
>
> — *Insurance Information Institute (2000b)*

Given rapidly changing marketplace conditions—e.g., fluctuations in stock market valuations—it is important to regard point estimates of industry reserves with care (GAO 2000). Since 1997, reinsurance capacity has been increasing. Swiss Re America estimates that in 1999 the U.S. "Cat XL" capacity was $22.1 billion (excluding the California Earthquake Authority) (Swiss Re America 1999). U.S. Re estimated the catastrophe reinsurance capacity on a regional basis, which ranged from 12.5 billion to $15 billion, with an additional 40% or so for proportional treaty reinsurance (Piccione 1999). Renaissance Re has presented similar estimates (Riker 1999) and this information appears to have been adopted by the General Accounting Office (GAO 2000). Nonetheless, as recently as 1999, as compared to 1998, European reinsurers have experienced considerable stress from natural catastrophe losses, with the ratio of losses to income increasing from 109% to 131% (Business Insurance 2000b).

As with primary insurance companies, reinsurers are also vulnerable to multiple consecutive losses that can deplete reserves more severely than isolated events.

There is an emerging trend in which reinsurers are transferring more of their risks back to primary insurers. This has been done by increasing the trigger point to above the $3 billion mark and by establishing exit points (Stipp 1997). Primary insurers have increased their "participation" (share of losses, also known as "retention") in the band between trigger and exit loss levels (III 2000b).

The phenomenon of "insurance spirals" merits special attention, as it can threaten the solvency of reinsurers (Bain 1999). Insurance spirals are created by imperfect information and unanticipated adverse interactions involving the contracts between reinsurers and other reinsurers to whom they intend to transfer risk. Spirals manifest where losses trigger reinsurance claims, and concentrate rather than disperse the risk. Spirals also occur, because players are unknowingly reselling the upper layers of risk back and forth between one another rather than diversifying the risk by selling to previously uninvolved reinsurers (as intended). The highly undesirable outcome can be that total claims exceed premiums collected by many, fold, while successive broker commissions dilute the available reserves. An extreme example concerned claims arising from the Piper Alpha disaster, which are said to have risen to ten-times the premium collected. An illustrative component of an insurance spiral scenario could involve European reinsurers retroceding part of their liability to a Japanese reinsurer, who in term could retrocede the upper portion of their exposure back to European reinsurers. Insurance spirals were a factor in the disruption experienced by the London Markets (e.g. Lloyds) in the 1980s.

While the question of solvency often focuses on primary insurers—as evidenced by the European storms of 1999—reinsurers can also become insolvent as a result of natural catastrophes. The resulting insolvency of the already weakened Reinsurance Australia Corp—with $766 million in claims from the European storms—also evidenced that insurers domiciled far from the geographic location of a loss event, can be severely impacted (Howard 2000a).

In recognition of the uncertainties facing reinsurers, solvency analyses for primary insurers typically give only "partial credit" for reinsurance (e.g., 50%) because of the uncertain viability of insurance contracts or the companies themselves following catastrophic losses (Doherty *et al.* 1992; Swiss Re 2000b).

Minor Events and Mega-Catastrophes: Both are of Concern

Various insurance groups and others have begun to use the term "Mega-catastrophes" (GAO 1994; ISO 1996; Klein 1997; Kunreuther and Roth 1998; ISO 1999; Guy Carpenter 1999; Matthews *et al.* 1999; III 2000a; Mooney 2000; Cummins *et al.* 2000; Ryland 2000) to refer to events that have been seen to test the financial fiber of the insurance system. Multiple mega-catastrophes in close spatial or temporal proximity would constitute particularly high-consequence, low-probability events for the industry. Localities to which risks shift will tend to be relatively inexperienced and unprepared to handle such risks, resulting in a net increase in losses. In some cases, adaptation can proceed rapidly while in others the rate of adaptation will be inherently constrained.

Although much attention is afforded to "mega-catastrophes," an examination of the trends in U.S. insurer insolvency suggests that closely spaced "small" natural disasters also correlate with an increased incidence of insolvencies (GAO 2000). This is evidenced during the period of relatively frequent events beginning with a major snowstorm ($1.4 billion insured loss) in 1983 and ending with Hurricane Opal in 1995. Insured losses between $2 and $12 billion occurred in each year from 1991 to 1996, followed by $6 billion in losses in 1998 from Hurricane George, flooding,[45] major hailstorms,[46] and the great North American ice storm that occurred during the El Niño of 1998.

As previously noted, a series of small "normal" events could be worse for reinsurers than a series of large events. This is because exit points (where coverage terminates) cap reinsurer losses per event. Thus, a series of relatively small events would result in more reinsurance payouts than a single large (but equally costly) event because of surpassing the exit points stipulated in policies held by primary insurers (Stipp 1997; Swiss Re 1997).

The U.S. government has also expressed concern:

> **"Either a mega-catastrophe or a series of closely occurring disasters could greatly strain or overwhelm the capacity of the insurance industry and result in large federal payments for disaster relief."**
>
> — *U.S. General Accounting Office (1994)*

As an illustration, the AIRAC report (noted above) evaluated the potential consequences of two consecutive $7 billion ($1986) hurricanes—with peak winds of 139 and 159 miles per hour-on the U.S. property/casualty insurers, and the Council found very substantial economic disruption would arise if the events were spaced closely in time (AIRAC 1986).[47] One hurricane struck in the Texas and Louisiana gulf area, while the other began in Florida and traveled northwards. The study illuminated the extent of risk spreading in the insurance sector—1112 primary insurers and 544 reinsurers would be involved in paying claims, representing 92% of the U.S. property/casualty business and significant overseas business as well. The international risk spreading showed that only 44% of the losses would be paid by U.S. primary insurers and 13% by U.S. reinsurers. The balance was paid by insurers in Europe, Japan, Hong Kong, Australia, New Zealand, Korea, China, India, Bermuda, and Brazil. The events would have consumed 13.3% of U.S. insurers' net worth, 34.4% of U.S. reinsurers' net worth, and 12% of the surplus of companies' involved worldwide. Insolvency would have struck 28 companies, the majority of which were non-U.S. insurers, and companies representing 65% of the U.S. market would have triggered some form of state regulatory solvency alert.[48] Clearly, the world insurance market

[45]Commercially-insured flood losses ranged from $139 to $582 million (i.e., outside the federal National Flood Insurance Program) in each year between 1989 and 1996.

[46]U.S. property insurers pay out an average of $1.5 billion each year for hail-related claims (III 2000a).

[47]Note that the date of this study precedes the establishment of the Bermuda reinsurers.

[48]There are a number of conservatisms in the study that resulted in impacts lower than would be likely in practice. These include assumptions that: (a) all reinsurance would be collectable; (b) each insurer's reinsurance coverage limits are reinstated following the first storm; (c) the effect of insurance spirals is not accounted for; (d) the analysis does not capture the impacts on (typically smaller) companies not responding to the research survey; (e) the trend towards limited reinsurance coverages; (f) no large losses prior to the two events are assumed; and (g) the first storm did not use up the primary insurers' reinsurance limits for the year in question. Assuming a "worst case" outcome, approximately 20% of the involved U.S. insurers could have become insolvent.

has evolved since this 1986 analysis. In some ways it is no doubt more resilient, although it is unfortunate that a re-analysis of this type has not been conducted so as to re-benchmark the industry's ability to respond to such consecutive events.

Insurance prices have exhibited sensitivity to disaster events. Global reinsurance prices rose by 40% following the autumn storm of 1987 and by 255% following Hurricane Andrew and other natural disaster events between 1984 and 1994, returning to 155% of their pre-event levels by 1998 (Figure 12). The trend is again towards upward pressure on prices (Mooney 2000).

Aside from issues of solvency, past extreme weather events clearly have measurable short- to medium-term impacts on the availability of insurance and reinsurance following the event (Pullen 1999a) and on insurance profitability (Figure 8a)—even at a national scale. Contending with major catastrophe losses during 1999, several large companies issued warnings of lower earnings due weather events, which led to marked short-term depressions in earnings and stock prices (Figure 15) and accentuated by reduced profit margins arising from extreme competition in the insurance market at the time (Edgecliffe-Johnson 1997). Allstate Corp—the second largest property insurance company in the U.S —saw regular earnings fall 27% due to an unusually high number of weather-related catastrophe losses due to hail, freezing temperatures, and storms in the first quarter of 2000 (Carpenter 2000) and an additional 40% in the second quarter (*National Underwriter* 2000). Following the major European storms of 1999, Bermuda reinsurers saw precipitous reductions in earnings and even severe negative earnings in some cases (Lonkevich 2000).

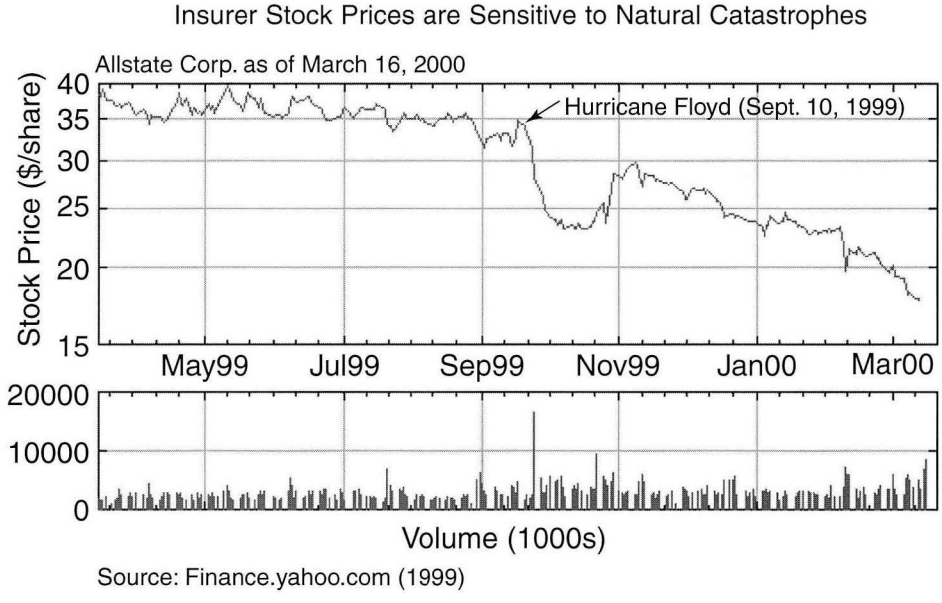


Figure 15.

Stock price trajectory for Allstate insurance company, showing performance following Hurricane Floyd on September 10, 1999 which resulted in a combined insured loss of $2.4 billion to U.S. insurers. (Source: http://finance.yahoo.com/q?s=ALL&d=1y).

Bulls and Bears: The Role of the Financial Markets

Aside from the question of loss reserves, an indirect form of vulnerability arises from the relative health of the insurance and broader financial sectors and markets prevailing at the time of a major catastrophic loss event (AIRAC 1986; Doherty *et al.* 1992; GAO 2000). As seen from the "net investment income" curve in Figure 8a, one measure of the importance of financial markets to the property/casualty insurance business is that, in the case of the U.S., insurer investment income has compensated for consistent losses in the core underwriting business over the past twenty-five years. In the event of major catastrophic losses, insurers may need to liquidate investments in order to generate loss reserves. As we have seen, insurer stock prices can be depressed following large loss events. Stagnant sales (premium income) can also increase insurer vulnerability by impeding the ability to form reserves following a major loss.

During a vibrant stock market, there are substantial resources in the markets. Unrealized stock gains grew from $5 billion in 1990 to $100 billion in 1998 (*Best's Review* 1999). While these periods increase the absolute value of an insurer's surplus, this kind of period is generally accompanied by increased investment risk (Swiss Re 2000b). A simulated 33% stock-market correction, resulted in reduced solvency indicators by 16% in the U.S., 26% in the U.K., and 31% in Germany (Swiss Re 2000b). Major security market fluctuations can thus have an adverse impact on insurer solvency (Swiss Re 2000c; Cummins 2000; GAO 2000).

Assessments of the insurers' ability to prepare for and respond to natural catastrophe losses must thus consider the relationships between the insurance industry and other branches of the financial services sector. Life insurers occupy particularly prominent positions in the world financial markets. Of the world's top 25 financial institutions in 1999, insurers occupied 7 positions and comprised 33% of the group's combined market capitalization of $524 billion (III 2000c). As of 1998, U.S. insurers had nearly $4 trillion in assets ($2.9 trillion among life/health companies and $0.9 trillion among property/casualty companies) (III 2000c). Among the institutional sources of funds in the U.S. money and capital markets, insurers ranked third (providing $204 billion, or 13% of new funds in 1998) after mutual funds and commercial banks (ACLI 1999). In 1998, U.S. life insurers had $216 billion in mortgage holdings, or about 10% of the total market (III 2000c). Real estate directly owned by U.S. life insurers in 1996 was valued at $59 billion. Insurance is also interwoven with the pension and retirement segment of the economy and the financial services sector. As of 1998 insurance accounted for $1.6 trillion (14%) of the total assets and reserves of the major pension and retirement programs in the U.S. equal in size to all government-administered plans (ACLI 1999).

Thus, adverse developments in the financial markets can influence the level and availability of insurance reserves. Conversely, disruptions to the insurance sector (from climatic or other events) may have second-order ripple effects within the financial sector.

The Convergence of Banking and Insurance

The degree of (in)dependence between the insurance and capital markets is a related and important determinant of vulnerability. On the one hand, the trend towards convergence between banking and insurance increases the potential for diversification and robustness. On the other hand, it increases interdependence by exposing one sector to risks faced in the other. Some see limited potential for convergence of property/casualty insurers with banks, due to: significantly lower profitability of insurers compared to banks; differences in regulatory environments; disinterest from banks in assuming property-related risks and liabilities; and due to the relatively large assets offered by life

insurers (Berry 2000; Greenwald 2000; Howard 2000b).

The banking sector has begun to understand its particular vulnerabilities to climate change (Burton and van Aalst 1999). Convergence also confounds the process of solvency analyses, as oversight and jurisdiction of the two sectors are typically non-overlapping and methods of determining insolvency risk differ. In some cases, geographical diversification of a company's insurance business has moved it into the path of increased disaster losses (Lonkevich 2000).

Regulatory and Political Uncertainties

An additional source of vulnerability arises from regulatory uncertainties (the relative flexibility afforded in withdrawing from markets and risks) and from raising insurance prices (III 2000a; *The Insurance Regulator* 1998; Ryland 2000). In some juri-sdictions, regulators have restricted policy cancellations and non-renewals following natural disaster losses (Davidson 1996; ISO 1994a; ISO 1994b). This is exemplified by the post-Hurricane-Andrew experience in Florida in which state government instituted moratoriums capping non-renewals aimed at reducing hurricane exposure to 5% of policies statewide and 10% in any given county (III 2000a). Following Hurricane Andrew, insurers attempted to either cancel or not renew nearly 850,000 policies (Lecomte and Gahagan 1998), but state government instituted moratoriums capping such non-renewals to 5% of policies. Recent requests from Florida insurers to double rates in order to protect insurers from hurricane risks have also been vigorously resisted by regulators (III 2000a). On the other hand, under some conditions regulators can force insurers to withdraw from markets so that they maintain minimum solvency requirements (GAO 2000).

Insurers question the wisdom of restraining rate increases, noting that subsidies exist where existing rates are politically influenced:

> **"[Insurance premiums are] no longer commensurate with risk because it is politically unpalatable to raise rates to actuarially justified levels."**
>
> — *The Insurance Information Institute (2000b)*

Another confounding factor is that favorable underwriting or investment experience may provide for surplus to create loss reserves, but the development of premiums in the U.S may not explicitly fund pre-event catastrophe reserves to account for anticipated changes in climate and weather. This represents a potential barrier to effective adaptation to climate changes.

Public policies focused on climate change itself also stand to impact insurers. Implementation of the Kyoto "Flexible Mechanisms" (Clean Development Mechanisms, Joint Implementation, and Emissions Trading) may represent an opportunity for insurers to create new products to insure either the capital projects themselves (property insurance) or contractual obligations to deliver emissions reductions (liability insurance) (AON 2000; Hugenschmidt and Janssen 1999; UNEP 1999). However, considerable business risk and liability may be associated with these projects if measurement and verification is poor or issues of buyers/sellers liability are not addressed by policymakers as part of the drafting of the policies.

Another uncertainty is the notion of liability claims against emitters of greenhouse gases (White and Etkin 1997). Proposals that insurers explicitly offer new forms of insurance against climate change do not appear to be viable given the uncertainties faced in diversifying and quantifying the costs (Tol 1998).

Competition, Consolidation, and Complacency

The trend towards consolidation within the insurance sector is often cited as a factor that reduces insurer vulnerability to catastrophic losses. While there are certainly numeous ways in which this applies, it is also important to consider potentially adverse aspects of these trends. Competitive pressures have caused insurers to assume greater risk in order to offer more attractive prices and products to consumers, contributing to a business environment increasingly conducive to more frequent insurer failures. Insurers may also feel pressed to reduce risk management efforts and incentives in the face of competition's downward pressure on prices. In the words of an analyst at A.M Best Co., "Intensifying competition [and] a continuing and significant softening of prices . . . raise serious questions going forward" (Matthews *et al.* 1999).

Mergers can be a mixed blessing: some are the union of two strong firms, but in others "troubled companies will be acquired as a vehicle to expand into a particular marketplace or to be stripped of value-added assets" (Matthews *et al.* 1999). The imperative to absorb another firm, weakened perhaps by recent catastrophe losses, may outweigh the financial liability that is being assumed. "Rapid growth" and "significant change in business" were cited as the primary cause of 27% of U.S. insurer solvencies in the aforementioned industry study (Matthews *et al.* 1999).

A related phenomenon has been observed wherein, shortly following the period of (upward) price adjustments in response to a major natural disaster, outside competitors with "short memories" enter or re-enter a battered market offering substantial (non-actuarial) discounts. Competition can subsequently operate such that inadequate prices result for all players in the market (Matthews *et al.* 1999). The same behavior has been observed among catastrophe reinsurers, according to William Riker of Renaissance Re (Stipp 1997).

A final class of vulnerability flows from what is known as "moral hazard" in insurance parlance. A pervasive issue in the industry, moral hazards result when by the very presence of adaptation efforts or insurance (or reinsurance or government aid) the insured or insurer feels less compelled to prevent losses (FEMA 2000; White and Etkin 1997; Ryland 2000). The resulting false sense of security is an inherent "Catch-22" in most insurance arrangements and can be managed but not eliminated. In the case of climate change, the moral hazard results in less-than-optimal investment in loss prevention, which in turn yields increased vulnerability. Government programs have been faulted for unintentionally encouraging such mal-adaptation and risky behavior (Anderson 2000; Changnon and Easterling 2000). For example, it is estimated that one-quarter of the development over the past 20 years in at-risk areas along the U.S. coastline is a result of the presence of the National Flood Insurance Program (Heinz Center 2000). Moral hazards have also been ascribed to primary insurers or reinsurers who rely excessively on state-maintained guaranty funds or Residual Market Mechanisms (Kunreuther and Roth 1998; Swiss Re 2000c).

Vulnerability of Local, State, and Federal Governments

By virtue of their involvement in public insurance, disaster preparedness and recovery, federal, state, and local governments share in many of the same risks and exposures faced by the private-sector insurance community.

Under climate change, the government sector would come under new stresses as: (a) a provider of insurance, (b) a provider of domestic and international disaster preparedness/recovery services, and

[49]Easterling et al. (2000) assign lower values to the 1988 event ($39 billion) and to the 1993 event ($19 billion), perhaps reflecting a difference in definitions.

(c) as an entity that itself manages property and undertakes weather-sensitive activities (ranging from mail delivery to operation of military facilities near coastlines or waterways). Concern is also evident, as private insurers seek to shift some of their risks to governments just as governments attempt to cap or reduce existing exposures. Governments in developing countries participate especially deeply in weather-related risks, given the low level of private insurance availability.

As previously noted, governments are particularly vulnerable to flood- and crop-related losses, as they are often the primary or sole providers of such insurance and climate changes are expected to exacerbate these losses (Rosenzweig *et al.* 2000). Total estimated losses from the 1988 U.S. drought were $56 billion, and those from the 1993 Mississippi River Valley floods were $23 billion ($1998) (Rosenzweig *et al.* 2000).[49] Total flood losses between 1987 and 1997 were approximately $65 billion (inflation-corrected to $1995, Pielke and Downton 2000). Solvency is a material issue for these government programs, as exemplified by the $810 million deficit seen in the U.S. flood insurance program in the mid-1990s (Anderson 2000). The U.S. crop and flood insurance programs have never been profitable (GAO 2000; Heinz Center 2000).

Government's ability to pay losses is limited.

> **"[W]hile the insurance industry has absorbed losses from recent natural disasters without systemic failure, there is concern about its ability to handle future losses from potentially larger catastrophes. The federal government has absorbed a substantial part of the losses from past disasters and is likely to pay out even larger amounts in the future."**
>
> — *The General Accounting Office (GAO 1994)*

The GAO went on to express concern that proposed federal catastrophe reinsurance would further increase their vulnerability, as commercial insurers selectively transferred more risk to the government. As an illustration, they note that due to high losses in the early 1900s, commercial insurers withdrew from providing multi-peril crop insurance. Government assumed much of the risk, which was later concluded to be excessive. Efforts to reduce the risk led to the Federal Crop Insurance Act of 1980. Among the revisions, government limited the coverage it will provide to 75% of their actual historical production and limited payments to 30% of the farmers' premiums. GAO notes that the program remains actuarially unsound.

From a European vantage point:

> **"We are fast approaching the situation where some parts of the world are becoming uninsurable."**
>
> — *UK's Loss Prevention Council (Nuttall 1998)*

However, the principles of solvency also apply to public-provided insurance and illustrate the interplay between public and private insurance providers. Non-actuarial rates further compound the problem of moral hazard. Concerning homeowners (a.k.a. "personal lines" insurance), one industry analyst says:

> **"Economic and political pressures have forced state officials to restrict the necessary adjustment of insurance markets to catastrophe risk, which has created a false sense of security . . . The scary reality is that state insurance mechanisms and many private insurers will be bankrupted by a mega-catastrophe and will not have enough money to cover the claims they have promised to pay. This will force federal and state governments, and ultimately taxpayers, to step in and cover the gap.**
>
> **Because of the way state insurance mechanisms, tax policy (e.g., deductibility of insurance losses), and insurance guaranty funds are structured, approximately three-quarters of an insolvent insurer's deficit would fall on taxpayers and policyholders of solvent insurers . . . The unfortunate fact is that government spending, tax and regulatory policies allow high-risk communities and property owners to externalize a substantial portion of their catastrophe losses to all Americans."**
>
> — *Robert Klein (1997)*

State and local governments also participate in reinsurance markets, as exemplified by the Florida Hurricane Catastrophe Fund (established to help keep residential insurers in the state following Hurricane Andrew) (III 2000a).

Governments thereby share in the risks and vulnerabilities faced by private insurers. Not surprising-

[50]Premiums paid by the insureds are designed to collect revenues sufficient to pay losses in "normal" years.

ly, they have also elected to cap their exposures (Insurance Information Institute 2000b; Pullen 1999b), e.g. by establishing an $11 billion exit point for losses payable by the Florida Hurricane Catastrophe Fund (III 2000a).

Currently under discussion at the federal level is FEMA's Advanced Notice of Proposed Rulemaking 44CFR Part 296, RIN 3067-AC90, "Disaster Assistance: Insurance Requirements for Public Assistance Program" (FEMA 2000). The intent is to reduce the financial burden of natural disasters on the federal government and, in turn, the taxpayers. This controversial discussion recognizes that the existence of federal aid can serve as a disincentive for public and certain non-profit entities from purchasing insurance. Proposed remedies range from eliminating federal-provided insurance to requiring minimum insurance (and capping or eliminating coverage, and increasing the size and/or percentage basis for deductibles) in order for properties to be eligible for federal post-disaster assistance. Embedded in the debate is a deeply-seated tension between the allocation of risk between state and federal government entities.

As discussed above, the extensive efforts being made to institute federal catastrophe reinsurance for homeowners (HR-21) in the U.S. evidence the perceived need for increased government involvement in the assumption of catastrophe risk. This kind of pressure even haunts existing government insurance programs, where taxpayers subsidize the losses of the National Flood Insurance Program in years with above-average losses.[50] Some within the insurance industry oppose federal catastrophe reinsurance (*Reinsurance* 2000).

Some may look at governments as the ultimate "deep pockets" for financing disaster losses. Others, however, note active local and federal government efforts to reduce rather than increase their exposures.

> **"[T]he enormous size of recent catastrophes and the potential for more of the same have caused the government to re-evaluate its role as a provider of disaster relief."**
>
> — *Insurance Services Office (ISO 1999)*

Moreover, there are tensions between government and private sector on the matter of insurance.

> **"Government's response to natural disasters ultimately exacerbates the problems it has sought to mitigate . . . Federal government policies also encourage excessive risk and do not support insurers' attempts to set aside reserves to cover future catastrophic losses."**
>
> — *Competitive Enterprise Institute (Pullen 1999b)*

Lastly, Governments also face exposures as self-insurers of their own buildings and facilities.

The preceding discussion is not intended to create a sense of alarm, but rather to illuminate and attempt to quantify some of the real-world factors at work in the insurer's business environment. Clearly, a relatively very small fraction (~2%) of U.S. insurers have become insolvent during years of significant natural disasters, and tremendous efforts are underway to deploy physical and economic means for enhancing solvency. But in this time of a changing climate—be it from natural and/or human-induced causes—the prudent path is one of vigilance and close study. The majority of historic U.S. insurer insolvencies (approximately 80%) are directly or indirectly related to vulnerabilities in which natural catastrophe losses can play a role. More than half of the historical insolvencies have been: primarily due to natural disasters (8%); and factors such as low reserves or reinsurer insolvency that is directly impacted by natural disasters (45%) and an additional share (27%) from trends associated with industry competition consolidation. In the words of the prestigious U.S. insurance industry organization, A.M. Best Co.:

> **"A.M Best Co. believes that the industry is still in its infancy stage of catastrophe management, and that there may be regions where true catastrophe exposures are still to be unveiled, leading to potential insolvencies . . . A.M. Best views the potential "mega-catastrophe" as the most serious financial threat to the industry."**
>
> — *Patrick Matthews et al., A.M Best Co. (1999)*

4 The U.S. Insurance Community Looks at Global Climate Change

"The insurance business is first in line to be affected by climate change. It is clear that global warming could bankrupt the industry."

— *Franklin Nutter, President, Reinsurance Association of America*

"Yes, climate change is real. ...To me, proving that earth's climate is changing from human actions, namely global warming is like statistically "proving" the pavement exists after you have jumped out a 30-story building."

— *Richard Jones, VP Engineering, Hartford Steam Boiler Insurance & Inspection Company*

"[The IPCC findings are] a milestone in terms of recognizing what is happening in the world today."

— *Kaj Ahlman, former CEO, Employers Reinsurance Company*

"The question of the magnitude of potential impacts of global climate change will be a continuing source of discussion. However, the Intergovernmental Panel on Climate change reported that there is a discernable human influence on climate change being observed."

— *Allstate Insurance Co.*

"U.S. insurers need to recognize the mounting costs in not acting to reduce fossil fuel emissions and become involved in promoting sound environmental policies."

— *Alexander Grannis, Chair of the New York Assembly's Insurance Committee*

"Insurers rely upon their ability to predict the economic consequences of future events. ...The fact that future events may not be a linear progression of the past, but in fact may have changed as a result of natural variability, or human activity or whatever, is an important thing to be taken into consideration."

— *Franklin Nutter, President, Reinsurance Association of America*

Insurers are not new to the question of climate change, with the first recorded activities in the United States dating to 1989. U.S. insurers also have a considerable track record in natural disaster loss prevention and modeling. While this history evidences considerably more activity in the U.S. than many outside the insurance community might expect, what does not emerge is a sense that these events have built upon one another towards some sort of consensus on the matter of climate change or towards a coordinated plan of action extending beyond preliminary discussion and fact-finding. Considerable steps in this direction were taken in the mid-1990s, but activity has moderated considerably since that time. Nonetheless, a small number of individual insurers have recently expressed a high degree of concern about climate change. To gain further insight, we conducted in-depth interviews with 17 insurer chief executive officers, presidents and/or senior executive officers.

History of U.S. Insurer Activities Related to Climate & Climate Change

The subject of "climate change" has been hovering over the United States since the 1970s when the Council on Environmental Quality advanced a warning to the effect that industrial activity might be changing the weather. In 1988 the United Nations and Canada sponsored the first World Conference on the Changing Atmosphere. At this Conference the Intergovernmental Panel on Climate Change (IPCC) was established under the auspices of the World Meteorological Organization and the United Nations and quickly recommended that carbon dioxide emissions be reduced by 20% from the 1988 levels by 2005. That recommendation propelled the greenhouse effect to center stage and into a full-fledged public debate. The IPCC *Second Assessment Report*—which incidentally included some insurer authors[51]—later concluded:

> **"The balance of evidence suggests that humans are having a discernable impact on global climate."**
>
> — *Intergovernmental Panel on Climate Change (1996)*

Sides were drawn with environmentalists on one side and much of the business community on the other. Reacting to the IPCC's findings, an uncharacteristic letter sent to the U.S. Vice President Al Gore by Employers Re, a major U.S. reinsurer and participant in the UNEP Insurance Industry Initiative, stated:

> **"[The IPCC findings are] a milestone in terms of recognizing what is happening in the world today."**
>
> — *Kaj Ahlman, former CEO, Employers Reinsurance Company (1996)*

In the United States many property/casualty insurers and re-insurers have claimed not to possess the scientific expertise to evaluate the greenhouse effect and have generally chosen to avoid becoming embroiled in the debate. On the other hand, insurers and re-insurers from other nations have been actively involved in the debate and have participated in the United Nations Environmental Program's Insurance Industry Initiative, among other activities.

In considering the following partial listing of activities, recall that since the late 1880s property-casualty insurers have covered losses caused by wind, and later for loss caused by the perils of hail, ice, snow, sleet and flood. Further, property insurers from pre-Revolutionary days have insured against loss by fire. It should be noted, however, that the insuring of the "weather related perils" did not gain significant acceptance until the late 1930s. Finally, it was not until the last days of 1989 that U.S. property insurers began to focus on and examine the scientific studies and causes of weather, climate, and climate change. Interestingly, the first known mention of climate change by an insurer was by a German reinsurance company 16 years earlier (Munich Re 1973).

A Chronology

To help provide a context, the following chronology describes U.S. insurer activities that have dealt with climate and climate change issues. Note that this chronology includes only those events initiated primarily or exclusively by U.S. insurers. A number of additional related events have taken place at the initiative of other groups outside of the insurance community.

Insurers contend that the action outlined in this history provides evidence of their acting responsibly on climate change. Further, insurers maintain that their current strategy allows them to remain sufficiently flexible and able to shift into higher gear, if scientists demonstrate that climate change will result in more frequent and severe weather related events.

December 13, 1989 National Committee on Property Insurance (NCPI), 1989 Forum. Theme: "America's Imperiled Coastlines: A New Concern for the Property Insurance Industry". Dr. Donald G. Friedman, Director,

[51] See Dlugolecki et al. (1996).

Natural Hazards Research Program, Travelers Insurance Company, spoke on "*The Greenhouse Effect.*"

December 12, 1990 NCPI 1990 Annual Forum—This meeting treated the question of climate change and featured an address by Dr. William M. Gray, Colorado State University, on *"Variations in U. S. Hurricane Spawned Destruction: As Related to Seasonal Variations in West African Rainfall."*

September 28, 1993 The College of Insurance, New York, NY, sponsored a Conference on *"Climate Change and the Insurance Industry: The Next Generation."*

December 9, 1993 NCPI 1993 Annual Forum—Dr. Robert F. Giegengack, University of Pennsylvania addressed the topic: *"The Global Warming Phenomena: Man-Made or Natural Process?"*

1994 The Risk Prediction Initiative (RPI) of the Bermuda Biological Station for Research was founded. This research is supported by international insurers, including a dozen or so U.S. reinsurers and insurers and is intended to contribute to the insurance community's understanding of climate related risks including global warming.

March 14, 1994 Widely cited quotation: **"The insurance business is first in line to be affected by climate change. It is clear that global warming could bankrupt the industry."** (in Linden 1994)

— *Franklin Nutter, President, Reinsurance Association of America, in* Time *magazine*

Summer 1994 The journal of the National Association for Insurance Commissioners (NAIC) publishes an article on global warming (Quirke 1994).

October 18, 1994 Insurance Institute for Property Loss Reduction (IIPLR), Boston, Massachusetts, sponsored a meeting entitled The IPCC Views Climate Change. The meeting focused on discussions of the findings of the IPCC Second Assessment Report by Andrew Dlugolecki of the General Accident insurance company (lead-author of the IPCC chapter on the impacts of climate change on the financial services sector).

January 1994 Insurance Services Office, Inc. publishes "The Impact of Catastrophes on Property Insurance" (ISO 1994a). The publication questions the value of global warming theory for predicting future hurricane risks.

1995 Founding of an ad hoc "Insurance Executives Group" working group on climate change. Members included the Alliance of American Insurers, American Insurance Association, Insurance Institute for Property Loss Reduction, National Association of Independent Insurers, National Association of Mutual Insurance Companies, Reinsurance Association of America and State Farm Insurance Companies.[52]

February 9, 1995 The "Insurance Industry Executives" group meets with Vice President Albert Gore (see Appendix F).

May 11, 1995 IIPLR and Reinsurance Association of America (RAA) co-sponsor an Energy Efficiency Conference in Washington, D.C.

May 31, 1995 IIPLR and RAA co-sponsor a Climate Change Conference in Washington, D.C. Speakers included, Andrew Dlugolecki (General Accident Insurance Company, Scotland), Gerhardt Berz (Munich Reinsurance Company, Germany), and Timothy E. Worth, Undersecretary of State for Global Affairs at the U. S. Department of State.

June 15, 1995 IIPLR Second Annual Congress. William H. Hooke, U.S. Weather Research Program Officer spoke to the subject *"Weather Proofing The Nation: A National Transition to "No Surprises" Weather Services and Optimal Use of Weather Information."* Dr. Peter J. Lamb, University of Oklahoma discussed, *"Freezing: The Silent Hazard".*

September 1995 "Insurance Executives Group" responds to Vice President Gore with four-page letter.

[52]State Farm is unaffiliated with any trade association, and hence represented itself in this group.

September 15, 1995 IIPLR Insurance Roundtable/Department of Commerce. The meeting touched upon climate and climate change and was held at the American Meteorological Society Headquarters in Boston and was chaired by Secretary of Commerce Ronald Brown.

June 9-10, 1996 IIPLR Third Annual Congress. Dr. Anthony Knap, Risk Prediction Initiative, addressed the subject, "Preparing for an Uncertain Future." Ms. K.A. McGinty, White House, spoke to the topic "A Changing Climate," and Dr. Dennis S. Mileti, Natural Hazards Center, University of Colorado, discussed "What is Sustainable Development?"

April 26, 1996 Global Climatic Change Conference sponsored by Employers' Reinsurance Corporation, Riverside, Missouri April 26, 1996. Attendees include EPA Assistant Administrator, David Gardiner.[53]

March 27, 1997 Arkwright Mutual Insurance Company meteorologists publish technical report on upward trends in U.S. river flooding. They cited global climate change as a factor.

April 21-22, 1997 The Employers Reinsurance Company hosts a conference entitled *"Beyond Businesses—Global Climatic Change."* Speakers include: Evan Mills, Tom Karl, Ross Gelbspan, Fred Palmer, Robert Balling Jr., Pat Michaels, Michael Oppenheimer and Jeremy Leggett. Considerable visibility on the agenda was given to the "climate skeptics."

May 15, 1997 Employers Reinsurance Co. sponsors "Hurricane Mania" speakers include: Nutter, Pielke, Bill Gray, Robert Sheets, Karen Clark, Tony Knap of RPI, issue of climate change discussed in several speeches (Nutter, Gray, Knap in particular).

May 23, 1997 Kellogg Graduate School of Management, Northwestern University hosted a conference on Global Climate Change for representatives from industry, environmental groups, the Clinton administration and academia. Eugene L. Lecomte, President, IIPLR presented a paper titled: *"Insurance Industry Perspectives on Climate Change."*

August 12-13, 1997 The Institute for Business and Home Safety (IBHS, formerly IIPLR) and the Federal Insurance Administration co-sponsor The Flood Insurance Summit in Grand Forks, North Dakota and presented: *"A Review of the Red River (Grand Forks) Flood of April 1997."*

January 17, 1998 The U.S. Employers Reinsurance Company becomes the first U.S. signatory to join the United Nations Insurance Industry Initiative and sign the Initiative's Statement of Environmental Commitment. (ERC's informal relationship with the UNEP group began significantly earlier.)

May 4, 1998 IBHS issues press release: "Insurance Industry joins PATH effort to strengthen homes against natural disasters." The Partnership for Advancing Technologies in Housing is part of President Clinton's Global Warming Proposal. IBHS press release is silent about the topic of climate change.

May 1998 In their 1998 10K report, Allstate Insurance Company stated:

> **"The question of the magnitude of potential impacts of global climate change will be a continuing source of discussion. However, the Intergovernmental Panel on Climate change reported that there is a discernable human influence on climate change being observed. In light of this, Allstate continues to explore and analyze credible scientific evidence, including, but not limited to, the impact of climate change, that may affect Allstate's potential exposure under its insurance policies."**
>
> — *Allstate Insurance Co. (1998)*

June 6, 1998 Sean Mooney (Guy Carpenter - Reinsurance Brokers) publishes an article entitled "Insurers should be the experts, not activists, in climate change debate" in *National Underwriter.*

June 22, 1998 The National Renewable Energy Laboratory and National Association of

[53]See http://www.epa.gov/oppeoee1/globalwarming/news/speeches/gardiner_042696.html.

Independent Insurers hold a workshop entitled "Solar Technology and the Insurance Industry," regarding applications for renewable energy sources in disaster recovery.

June 9, 1998 AON (world's largest insurance broker, based in U.S.) joins the United Nations Environment Program (UNEP) Insurance Industry Initiative for the Environment as affiliate member.

October 22-23, 1998 The 1998 IBHS Congress serves as a back drop for the U.S. release of the joint IBHS and Canadian-based Institute for Catastrophic Loss Reduction (ICLR, affiliated with the Insurance Council of Canada, Report entitled "Ice Storm '98." The report notes global climate change as one possible culprit in the event (Lecomte *et al.* 1998).

January 11, 1999 Arkwright Mutual Insurance Company publishes study at the 79th meeting of the American Meteorological Society estimating potential hurricane losses of $100 billion or more, "jeopardizing the solvency of numerous insurers and reinsurers" (Kelly and Zeng 1999).

February 25, 1999 State of NY holds hearing on future viability of insurance industry in view of projected climate changes, and sharp statements of concern emanated from state politicians (Levin 1999):

"It is of great concern that insurers are not doing all they can do."

— *New York State Assemblyman Richard Brodsky (Dow Jones 1999)*

"U.S. insurers need to recognize the mounting costs in not acting to reduce fossil fuel emissions and become involved in promoting sound environmental policies."

— *Alexander Grannis, Chair of the New York Assembly's Insurance Committee*

March 9, 1999 Weather and Climate Extremes Meeting, Asheville, North Carolina Papers presented *"Global Climate Change: Why U.S. Insurers Care"* by Franklin W. Nutter, President of the Reinsurance Association of America, and "Interactions between the Atmospheric Sciences and Insurers in the United States," by Changnon, Mahomet, Fosse and Lecomte.

April 19, 1999 The American Insurance Association issues a paper concluding that property-casualty insurance vulnerability to climate change is overstated. The insurance lines that face either moderate or significant exposure to weather-related losses reflect less than 20 percent of the industry's premium base (AIA1999). The document also endorses no-regrets energy-efficiency measures having to do with public transportation that would yield benefits to transportation insurers irrespective of climate change risks.

July 20, 1999 Hartford Steam Boiler Insurance & Inspection Company joins the UNEP Insurance Industry Initiative, the first U.S. primary insurer to do so.

March 28, 2000 The Risk and Insurance Management Society (RIMS) cosponsors a roundtable meeting on climate change (Rimscope 2000). The event was co-hosted by the U.S. Environmental Protection Agency (EPA), Public Risk and Insurance Management Association, Federal Emergency Management Agency, National Oceanic and Atmospheric Administration, and the National Renewable Energy Laboratory. The roundtable provided insurance and financial executives the latest federal government science and policy information on climate change and disaster mitigation, and included technical discussions on alternative risk transfer instruments such as weather derivatives.

Clearly, U.S. insurers have been involved in a large number of activities in which the question of climate change has been addressed. While this history evidences considerably more activity than many outside the insurance community might expect, what does not emerge from the preceding chronology, or the examples of loss-prevention initiatives that follow, is a sense that these events have built upon one another towards some sort of consensus on the matter or towards a coordinated plan of action extending beyond preliminary discussion and fact-finding.

Insurer Loss-Prevention Initiatives

In addition to the specific aforementioned activities, insurers, re-insurers, insurance organizations, and the national insurance trade associations have engaged in various ongoing activities related to weather and climate issues.

Catastrophe Modeling

To assist insurers in measuring their potential loss exposure and to provide support for rate filings, catastrophe computer models are being developed. These models embody scientific data regarding climate trends and the probability of future events. To be credible the models must have access to current exposure data, such as inventories of structures and their values, and be predicated on sound scientific facts: geologic, oceanographic, meteorological, climatological, and specifically stated assumptions. Once developed, credible computer model results will facilitate catastrophe planning and contribute to the promulgation of risk based premiums. Currently, the climate assumptions for developing rate filings can only be based on history or quasi-historic scenarios and don't reflect any projection of future climates based on greenhouse gas model studies (see Appendix B).

Basic Research

Through the lobbying efforts of insurance trade associations, support has been given for increased governmental funding for research and monitoring of climate and climate change through NASA's Mission to Planet Earth Project. Funding of the National Hurricane Center and the new World Institute for Disaster Risk Management has also been supported by insurers.

The aforementioned Risk Prediction Initiative is involved in insurance-focused climate research, with co-sponsorship from insurers. The newly founded World Institute for Disaster Risk Management is another insurance-sponsored entity that may engage in climate-related research. Some individual insurers employ climatologists and other specialists who study earth sciences of relevance to the question of natural disaster losses.

While insurers fund various types of research related to weather and climate, those efforts often do not look at the specific question of potential human-induced changes to climate in the future. Some within the industry think that scientific efforts should be increased:

> **"The insurance industry should be doing more to fund research to study the effect of global warming [on] severe weather events."**
>
> — *Franklin Nutter, President of the Reinsurance Association of America (in Goch 1999)*

Mitigation

It should be noted that insurers use the term "mitigation" to refer to fortifying human settlements against losses, while the climate change community tends to use the term to refer to the reduction of greenhouse gas emissions and other strategies to slow the rate of climate change.

The insurance industry is an important player in risk reduction efforts, in partnership with other public and private entities (Ryland 2000). Illustrative examples include use of geographic information systems to better understand and pinpoint risks, land-use planning, flood control programs, early warning systems, sustainable forest management, coastal defense, and wind-resistant construction techniques supported by building codes. The UN's International Decade for Natural Disaster Reduction (IDNDR) is a leading example of international cooperation in this area (Hooke 2000).

While much progress has been made in risk-reduction technology *per se*, attention is increasingly focused on the problems of implementation. Key issues identified by the International Decade for Natural Disaster Reduction (IDNDR) include public awareness of risks, training of practitioners, commitment of public officials, and the justification and financing of risk-reduction strategies (Hooke 2000; Hamilton 2000).

Insurers and others in the natural disaster community have rightfully been calling for a heightened priority for proactive loss-prevention ("mitigation") (Changnon and Easterling 2000), and in some respects only recently shifted their emphasis from post-disaster response and recovery to pre-disaster preparedness (Ryland 2000) while in other ways insurers have been doing this since the inception of the industry. Others have pointed out that increased adaptability is a good policy irrespective of the potential for climate changes (Sarewitz *et al.* 2000). Today, such efforts receive a small amount of resources compared to what is spent paying for losses

after the fact. Through the Institute for Business and Home Safety (IBHS) (with an operating budget of approximately $4 million per year, only 0.001% of the total property/casualty premiums in the U.S.), insurers and reinsurers are supporting on-going efforts to improve building codes and their enforcement: studies and activities aimed at enhancing the design and construction of buildings, evaluation of existing and introduction of new building materials, and promotion of structural retrofitting. In addition to industry-wide activities, a number of individual insurers conduct research on related issues.

According to the Insurance Information Institute (2000b), of the $675 million in insured damage caused by Hurricane Alicia, a startling 70% was attributed to poor code enforcement as was between 25 and 40 percent of Hurricane Andrew losses. It should be noted that many elements within the building industry resist changes to the codes, citing adverse effects on consumer affordability.

Following its creation in 1994, IIPLR initiated the Building Code Effectiveness Grading Schedule (BCEGS), a program that evaluates the code enforcement activities of cities and towns. The Institute has also developed a "Standard" (UL 2218) for grading the hail resistance of roofing shingles and introduced a method of firmly adhering roof boards to rafters using an adhesive. BCEGS was turned over to ISO for implementation. Additionally IIPLR prepared, published and distributed to insurers a manual titled: *Understanding the Wind Peril.* Also it prepared an made available a software program titled: *Wind-Rite*. This program provides a relative grade for a structure's wind resistance and in so doing assists the user in evaluating a property's loss potential from the wind peril and lead to loss control recommendations. Further, IBHS has undertaken the non-structural retrofitting of non-profit child day care centers and, through its Showcase Community Program, supported the concept of sustainability by making every aspect of a community safe from the impacts of natural hazards. Additionally, IBHS has entered into a number of partnership agreements, including those with the Association of Contingency Planners and Disaster Recovery Business Alliance (DRBA), to plan for the survivability of businesses.

Insurer Solvency Protection and Regulation

To assist in maintaining their solvency and to simultaneously allow insurers to provide protection that renders meaningful indemnification, at affordable rates, insurers are seeking ways by which losses can be controlled or reduced through the use of deductible programs and special limits of liability and coverage caps or restrictions. Embedded in these studies are questions of whether natural hazard events that do not meet the "Standards of Insurability" (discussed previously) and produce catastrophic losses size are insurable. Some within the industry have advocated for the creation of a Federal catastrophe reinsurance program.

Energy Efficiency and Renewable Energy

Although it is a relatively new concept, some insurers and insurance organizations have begun to grasp the notion that selected energy-efficient and renewable energy technologies and strategies yield risk-management benefits (Nutter 1996; Mills 1996, 1997; Mills and Knoepfel 1997; Mills *et al.* 1998; Mills 1999; Vine *et al.* 1998 and 1999; Deering and Thornton 2000; Stauffer, R.F. 1995; Changnon and Easterling 2000).[54] Examples include: efficient replacements for fire-causing halogen lamps; improved building insulation to reduce the risk of ice-dam formation; quality assurance procedures that enhance energy efficiency and prevent professional liability claims; public transportation (to alleviate roadway congestion) and reduced speed limits to improve highway safety; and the use of solar photovoltaic cells to provide emergency power supplies following natural disasters.

Among the U.S. entities participating in these are Hartford Steam Boiler Insurance & Inspection Company/Small Business Lifeline (HSB 1999), Arkwright Mutual –(now FM Global [Avery *et al.* 1998]), Developers Professional Insurance Company (Brady and Dasher 1998), USAA (USAA 1992; 1996), the American Insurance Association (1999), and the National Association of Independent Insurers (Deering and Thornton 2000).

Some insurer activities focused on the transportation sector have implications for energy use and efficiency. An active state and federal lobbyist for

[54]See also http://eetd.lbl.gov/insurance.

highway safety is the Advocates for Highway and Auto Safety. *Advocates* members include most major auto insurance, health insurers, and public health and safety organizations. *Advocates* supports federal controls on speed limits and increased funding for public transport to reduce air pollution and accidents due to road congestion (Advocates 1999).

In Congressional testimony, the Assistant General Counsel for the American Insurance Association (AIA) and spokesperson for *Advocates*, David Snyder, made a special point of the importance of reducing highway speed limits and improving public transport to combat perhaps the leading cause of accidents, aggressive driving (Snyder 1997). Snyder cited reports that over half of all accidents are due to aggressive driving such as speeding, tailgating, red light running, passing on the shoulder, unnecessary flashing of headlights, etc. Snyder attributed aggressive driving to higher speed limits and increased congestion. While conceding that insurance industry support of public transit may seem unlikely, he nonetheless reaffirmed support for federal control of speed limits and increased funding of public transport. AIA also advocated reduced speed limits as a means of reducing energy use and enhancing highway safety in a recent policy paper on climate change (AIA 1999).

Proactive involvement in energy management is also consistent with insurer concerns about the role of runaway energy prices (and their contribution to inflation and other problems in the financial markets) in adversely affecting insurer profitability. In a recent cover story in *National Underwriter*, Robert Hartwig (2000)—Chief Economist at the Insurance Information Institute—shows that the insurance industry's return on equity has been 6.8% during periods outside of high energy cost, versus a near-zero 0.7% during these periods, accompanied by negative real premium growth. The story notes that insurers have suffered worse than other industries during these periods. While energy efficiency and renewable energy are certainly not a panacea for avoiding energy shocks, they are well-recognized components of a sound strategy for doing so.

1995-1999: The Ebb and Flow of Insurer Involvement in the Climate Change Discussion

The activity begun in 1989 reached its peak in 1995 with the formation of the "Insurance Executives Group."[55] At the request of the Vice President, Ms. Katie McGinty (Chair, Council on Environmental Affairs), a special meeting of this group was organized on February 9, 1995. Thirty individuals attended the meeting from the insurance industry. Included were twenty-four reinsurance company executives and the Presidents of the American Insurance Association (AIA) Robert Vagley; National Association of Independent Insurers (NAII), Lowell Beck; National Association of Mutual Insurance Companies (NAMIC), Larry Forrester; Reinsurance Association of America (RAA), Frank Nutter; Insurance Institute for Property Loss Reduction (IIPLR), Eugene Lecomte; and Roger Joslin, Senior Vice President from State Farm insurance company (Brostoff 1995). In addition to Vice President Gore, representatives of the Administration included Dr. John H. Gibbons, Assistant to the President for Science and Technology, Dr. Robert Watson, White House Office of Science and Technology, and Ms. McGinty.

As a result of the meeting, the insurer organizations wrote the Vice President on September 6, 1995 (Appendix F) advising in essence that:

- they share the Administration's concern about the changing climate and impact it may have;
- they recognize that an assessment of financial consequences of natural disasters cannot replace sound scientific research on the nature of weather patterns and changing climatic conditions;
- climate changes, regardless of cause, could result in greater vulnerability to loss of life, economic distress, and the destruction of property;
- national and international efforts to address climate change are interwoven with economic and political considerations;

[55] "One of us (Lecomte) participated in convening this group, and helped organize the meeting with Vice President Gore and the writing of the letter of September 6th. 1995.

- the scientific evaluation of climate conditions and trends is beyond insurers expertise; and
- the historical paradigm used in the past to assess the catastrophic risk to be insured must be reexamined.

During the meeting with the Vice President it was declared that insurers had created the Insurance Institute for Property Loss Reduction, IIPLR, (now the Institute for Business and Home Safety, IBHS) and established as its goals the reducing of deaths, injuries, property damage, and economic loss caused by natural hazards. Additionally, the Trade Association Presidents indicated that IIPLR would assume a "leadership role" on matters related to climate and natural disasters.

In articulating the insurers' position it was stated that the insurers' perspective of financing recovery from the effects of natural disasters and encouraging improved safety and response to weather-related events should not stand apart from the interest of others in climate and climate change. The assembled insurance executives expressed the belief that the varying perspectives should be brought together in a "quilt of interests," addressing the effects of natural hazards on people and property to improve research and apply the results to the benefit of human health and safety.

Aside from IIPLR's (important) work on reducing vulnerability to natural disasters, following the meeting with the Vice President, the organization did not broaden its attention to encompass the question of reducing the likelihood of climate change itself. Despite the fact that up until now the AAI, AIA, and NAII had 12 member companies serving on the IIPLR Board, the organization's successor, the Institute for Business and Home Safety, IBHS, has not been authorized by its Board of Directors to directly address or assume a leadership role within the industry on the climate change issue. Absent authorization and financial resources[56] the issue of climate change continues to languish with IBHS and, by inference, among its member companies.

That said, it must be recognized that the IBHS mission is focused on protecting people and property from the effects of natural (or man-made) climate and weather events, as opposed to engagement in the public policy discussion of the causes of climate change or steps that may be taken to reduce it. In this regard, IBHS certainly should be credited for engaging in one aspect of the climate change puzzle. This particular illustration highlights a more general issue concerning differing uses of terminology between the climate change and insurance communities.

As discussed previously, part of the "disconnect" between the insurance community and the climate change policy of the Administration traces back to differences in conceptualization of the problem and its remedies and to the very meaning of the word "mitigation."

Insurer Perspectives at the Millenium: Executive Interviews

In order to develop an up-to-date assessment of insurer perspectives on the climate change issue, we conducted 17 in-depth interviews with ranking officials of personal and commercial line insurers, large, medium and small companies, trade associations, producer (agent and broker) associations, and reinsurers.

To assure the broadest possible discussion of the issues, we generally did not associate specific responses with individual firms and individuals. We characterized the summaries according to the insurer company size (large, medium or small), type of company (personal or commercial) and geographic spread of business (national, regional or single state). The comments of a limited number of international insurers, reinsurers, and other industry leaders have been separately identified.

It is noted that not all those interviewed responded to all of the questions. If an individual was reluctant to engage in the dialog, an effort was made to

[56]As noted above, the IBHS operating budget of approximately $4 million per year represents only 0.001% of the total property-casualty premiums in the U.S.

learn what gave rise to their unwillingness or apprehension.

We summarize the interviews as follows:

1. **Do you have an opinion relative to whether climate change, in particular "global warming" is occurring? If so, is it a cyclical or a permanent type occurrence? Does human behavior and/or an accident of nature induce it?**

A majority of the insurer executives interviewed acknowledge that, "something is taking place climate wise." Four ascribed the changes at least in part to human-induced global warming.

A national commercial line company executive confided that, "global warming appears to be happening although the reason(s) for its cause and possible duration have not been conclusively established."

A regional insurer officer stated " . . . the current climate change is an accident of nature. Throughout history, weather has shown cyclical patterns."

Another firm said:

> **"Yes, climate change is real. To think that all of the chemicals we release into the air doesn't influence the chemical balance of the atmosphere is beyond my comprehension. I believe that once science has enough data to show statistically significant changes, the momentum of the damage will require a long time to counteract the changes. To me, proving that earth's climate is changing from human actions, namely global warming is like statistically "proving" the pavement exists after you have jumped out a 30-story building. After each floor your analysis would say 'so far - so good' and then, at the pavement, all uncertainty is removed."**
>
> — *Richard Jones, VP Engineering, Hartford Steam Boiler Insurance & Inspection Company (2000)*

A large personal line insurer executive stated "there is no irrefutable evidence to support the concept of global warming." Another personal line officer proclaimed: "Something is happening; however, scientists have yet to determine whether global warming is actually taking place and have not pinpointed the cause of what is causing the phenomena."

Concerning possible alternatives to fossil fuels, one executive remarked: "What option do we really have? An alternative form of energy? Not in our lifetimes."

Inquiry regarding this question was made of the following Insurance Trade Associations: Alliance of American Insurers (AAI), American Insurance Association (AIA), National Association of Independent Insurers (NAII), and National Association of Mutual Insurance Companies (NAMIC).

The Alliance (AAI), an organization of 270 members, did not respond and whether they have an official position on this subject was not determinable.

NAMIC, with 1200 members, does not have a position on climate change, however, their Environmental Impairment Committee discussed the issue and chose not to take a position (Forrester 1999). This Association anchors its present lack of a position in the belief that conclusive evidence is not available to make a direct correlation between climate change and natural catastrophes.

The AIA (300 member companies) developed a position relative to this issue. Its central conclusion is that "advocates of aggressive climate change action have overestimated the vulnerability of the U.S. property-casualty insurance industry . . . " (AIA 1999).

According to the Association, about 20% of the property/casualty sector (measured as a percentage of premium collected, not insurance coverage) is vulnerable to climate change. They note that hurricanes remain the area of significant concern and they favor increased research into hurricane development, frequency, intensification and tracking. Although this position paper has been reported by some as the position of the entire U.S. insurance industry, it is important to keep in mind that AIA represents mostly large "stock company" insurers and is the only trade association thus far to issue an official position paper on climate change. Interestingly, AIA does endorse the use of certain no-regrets energy saving strategies (such as public transportation) which yield traditional insurance benefits (improved highway safety) irrespective of climate change dimensions of energy use and carbon reductions.

An Association of 650 members, the NAII, has not adopted a position on climate change. The NAII staff is developing an internal "White Paper" on the subject that currently is a work in progress. Purportedly, the author(s) will conclude that climate change is occurring and that only its causes and duration remain to be determined. The NAII currently sees East and West Coast hurricanes as the major weather events facing insurers.

The absence of leadership on the part of the national trade associations has contributed to the apathetic reception and treatment accorded the climate change issue by most individual firms.

The insurance regulatory authorities contacted expressed concern about the changing climate and an increase in the frequency and severity of weather related events, but they declined to state positively that global warming was in fact occurring.

U.S. professional reinsurers have, through the 25 members of the Reinsurance Association of America (RAA), expressed a level of concern about global warming and stated that:

> **"Insurers rely upon their ability to predict the economic consequences of future events. That's how premiums are set; that's the kind of assessment they do of their own exposures. In a period of changing climate, when the very basis of their decisions may be changing, then they need to have a better understanding of climate change . . . The fact that future events may not be a linear progression of the past, but in fact may have changed as a result of natural variability, or human activity or whatever, is an important thing to be taken into consideration."**
>
> — *Franklin Nutter, President, Reinsurance Association of America (Business Insurance 1998)*

In advancing this recommendation the wide differences in opinions between such recognized scientists as Dr. Jeremy Leggett and Dr. Robert F. Giegengack were noted. These divisions of opinion from scientific experts on both sides of the issue create confusion and add to the uncertainties in the minds of insurers about what is actually taking place.

The Canadian-based Institute for Catastrophic Loss Reduction (ICLR, affiliated with the Insurance Council of Canada, ICCO) demonstrates an attitude toward climate change that is largely identical (Kovacs 1999; Appendix G) to that of insurers in the United States. The ICLR indicates: "We need more research into the science of severe weather and more work to develop ideas for adapting to our increasing vulnerable world." The ICLR statement goes on to declare: "The insurance community is also pressing that these be treated as immediate needs, as severe weather is happening right now, and we must learn to better manage this risk before it causes even greater loss of life and property damage."

Foreign (non-U.S.) insurers and reinsurers contacted generally support the views on climate change expressed by the United Nations Environmental Program (UNEP) Insurance Industry Initiative. One U.S. primary insurer, one reinsurer, and one broker are currently affiliated with the Initiative (Appendix H).

2. Are catastrophic-type losses caused from floods, hurricanes, wildfires, ice storms, massive and prolonged power outages, insurable?

This question elicited varied responses but generally the thought expressed was that catastrophe losses that would impair an insurer's solvency are "uninsurable".

A national commercial line insurer declared: "Insurability problems exist because of the catastrophe loss potential and inability of insurers to secure an adequate spread of the risk." It was noted for instance, that "earthquakes and floods are hazards that produce such a situation." The same insurer alluded to the potential for hurricanes to fall into the "uninsurable" category. This is because values and concentrations of properties in high-risk areas are rapidly increasing and may soon exceed the capacity of insurers to provide indemnity. Other personal line insurers we interviewed shared these concerns.

A regional insurer noted: " . . . more and more state pools are coming into play to cover wind losses." The inference being that while these mandated pools provide a means of redistributing the losses, their proliferation are creating "time bombs" waiting to explode and consume or weaken some insurers, a result that would occur at a time when insurers were stressed with the settlement of their policy holders' losses.

Another national writer called attention to the fact that the answer to the question will vary, "depending upon an insurer's appetite, the existing regulatory climate, lines of business written (personal and/or commercial) and the companies' willingness to underwrite and assume the risk."

Others commenting on this question pointed to the new capital market alternative for financing the risk. Additionally, some expressed the hope that the promulgation of actuarial rates and meaningful and cost effective mitigation might enable greater capacity for assuming the risk.

3. Should government prevent development in areas of high risk?

Insurers generally support the goals and strategies of the IBHS concerning land use policy. Specifically, IBHS encourages land-use policy and that decision-makers understand the vulnerability of individual properties to natural hazards and to consider those potential hazards in their development and redevelopment decisions (Ryland 2000). Insurers also endorse IBHS's call for consumers (owners and developers) to be educated about natural hazards, including climate-related vulnerabilities associated with building sites. One insurer summed it up by stating:

> **"The people who choose to develop and live in those areas should understand that classical insurance protection may not be available and therefore they run the risk of losing some or all of their investment."**

Acknowledging the political sensitivities and problems associated with the interference of property rights, and actions that accompany the imposition of land use control measures, there was a general feeling that government (federal, state and municipal) must be the proactive force in these areas. Although one insurer stated:

> **"It should not be the responsibility of FEMA to pay out taxpayer funds if people knowingly build/live in a high hazard area and have no insurance protection."**

Many insurers do not believe that they should champion these issues. This conclusion is particularly revealing because land use planning (LUP) to avoid hazards is basic science compared to global warming. Even the Gospels allude to not building on sand. Yet, LUP can be controversial (like global warming) in that public policies aimed at protecting the broader community can infringe on the interests of property owners. Seemingly insurers would push LUP to prevent losses and mitigate the impact of hazards, especially since there isn't a lot of scientific controversy. Their often-soft position on LUP points to their aversion to controversy. It also suggests that United States insurers may be unlikely to be protagonists in the climate change issue, regardless of the scientific conclusiveness, until their policyholders support action. Nevertheless, they recognize that as stakeholders they should contribute to the dialog and in particular participate in public education and awareness-building efforts. A good example of this is the variety of LUP activities underway at the Institute for Business and Home Safety.[57] The American Insurance Association also highlighted the importance of land-use policy in its paper on climate change (AIA 1999).

4. Do the long established "Standards of Insurability"[58] apply to weather related catastrophe losses caused by climate change? Should the "Standards" be modified to meet the continually expanding exposure base and movement of people into harm's way?

In responding to these questions insurers raised additional questions relating to the growth and migration of populations, exposure expansion, reinsurance costs and availability, and the emerging alternatives for the capital market's financing of risk.

The answers indicate that not everyone had a solid comprehension of the "Standards." One insurance company executive pondered: "Have the standards of insurability changed? No. Should they? How?" Another stated: "The Standards are fine but, must be modernized." Yet another industry leader believed that, "Insurers should re-examine and redefine the Standards." Another stated with certainty: "There are already some situations we are experiencing today where the Standards of Insurability are out of date. For example, new diagnostic and condition-monitoring technologies can identify failure precursor conditions which challenges the fortuitous aspect of the insurability standards."

The discussion of the "Standard" that calls for the hazards to be "calculable" surfaced questions about "modeling," i.e., the accuracy and reliability of forecasting and loss estimation models. The discussions revealed concerns about the modeled results, about the accuracy of exposure inventories and structural values, the accuracy of ground/high altitude wind speeds, the assumptions used by the modelers and

[57]For the IBHS activities on land-use planning, see http://www.ibhs.org/html/info_center/landuse.htm.

[58]See Chapter 2 for definition.

the regulatory acceptance or rejection of the estimates. In short, this review reiterates many of the existing concerns and adds to the litany of issues causing uncertainties in the minds and attitudes of insurers.

5. How do you view the emerging alternatives for financing the risk as influencing an insurer's acceptance or rejection of risks prone to catastrophic loss?

The individuals interviewed displayed various levels of knowledge and understanding about the emerging capital market alternatives.

Some of the individuals who understood the "alternatives" saw them, "as the wave of the future for financing the catastrophe risk." The huge number of dollars available in the capital markets, estimated in the "trillions," was viewed as assuring the capital necessary for providing, on a worldwide basis, a viable alternative and supplement to existing reinsurance. Several voiced concern about the viability of these instruments, especially following major or consecutive losses. One primary insurer said: "I doubt if they are robust enough to protect the public (or direct insurers) from large scale CAT losses like Andrew or the Ice Storm in Canada." In some cases, a preference for traditional reinsurance was expressed.

Acknowledging that there hadn't been broad acceptance of the alternatives, it was observed that "time is required for their development and testing." It was noted that the alternatives would "facilitate the insuring of risks that otherwise might go uninsured." It was also stated that these arrangements would "permit a broad range of indemnity programs for dealing with varying customers in differing ways". The satisfactory experience of one company in using catastrophe bonds was cited as a means of allowing the insurer to continue to offer coverage to its customers situated in concentrated and highly vulnerable areas.

Due to the absence of a track record demonstrating the resilience and durability of these alternatives, one stated that "their usage might be slowed." Also seen as complicating the picture were the complexities of the arrangements and the large minimum investment increment, commencing at $50 million.

This and the preceding question raised issues regarding how underwriting profits should be realized, i.e., on underwriting results predicated upon a basis of risk evaluation, loss control and reduction, and actuarial pricing, or, alternatively, on a "cash-flow underwriting" basis. The latter would provide an emphasis on premium volume and the return on investments. No answers were offered; however, the complexities of the problems and issues were noted and the non-monolithic nature of insurers was cited as barriers to swift simplistic solutions.

6. For what reasons do overseas insurers and reinsurers support the active involvement of insurers in matters associated with global warming? How might you explain the response of U.S. insurers on this matter?

One U.S. insurer attributed the differences to a common-sense way of raising market awareness of the nature of risk and the role of insurance: "Making people aware of weather uncertainties is an element in a strategy to educate people about the value of insurance."

A possible explanation for some of the concern and aggressive approach to climate change by the Europeans may rest in the increasing incidence of floods, whose cause may be attributable to climate change, and in the differences in flood insurance in the U.S. and abroad. U.S. floods are in some cases viewed as uninsurable. Aside from the coverage provided commercial risks under Difference In Conditions (DIC) policies, the government offers residential and small-commercial flood coverage under the National Flood Insurance Program (NFIP). The Program provides very limited coverage for commercial risks. In Europe insurers have concerns about climate change affecting flood severity because of the flood insurance coverage afforded by commercial insurers. As shown in Figure 5, uninsured and (especially) insured flood insurance losses are more significant overseas than in North America (Appendix I).

Some executives believe that the differences in insurance regulation and taxation of insurers are partly responsible in the U.S. and elsewhere, i.e., Canada, Europe, and Asia. Others contend that "regulation and taxation are not the motivators." In the U.S. under the IRS Code, insurers cannot reserve tax free catastrophe losses (although this is currently under discussion). Thus, for non-U.S. insurers, climate change provides a rationale for sheltering spare

earnings from taxation, an incentive unavailable to U.S. insurers. In some European countries, catastrophe and equalization reserves are permitted.

In the mind of one American executive the fact that in addition to the differences in regulation and taxation and that European and Asian societies are "less litigious" are factors that influence attitudes toward climate change. The deep-pocket syndrome and uncertainties associated with climate change cause American insurers to be wary of involvement. Other insurance executives point to the adversarial relationship in the U.S. between insurer and regulator as a factor, and one noted that regulators "could provide more effective leadership" on the climate change issue. Additionally, some U.S. insurers view the issue of climate change as political and wish to stay above that fray.

Some in the U.S. contend that the support of European insurers for involvement with the climate change issue arises from their desire to expand their markets globally. This contention "boggles the mind" of some outside the U.S., who argue that the failure of insurers and reinsurers to become involved will prove to be a self-fulfilling prophecy as only foreign insurers and reinsurers will remain solvent.

Finally, insurers both in the U.S. and Europe are presently preoccupied with what many of them perceive as the more immediate and pressing issues: mergers, acquisitions and, in the U.S., the introduction of banks into the business of insurance.

7. What research or public assurances would you like to see before there is greater U.S. Government involvement in the issue of global warming?

Those interviewed provided few responses to this question. Although few specific suggestions were advanced, one reinsurer recommended that objective and rigorous scientific research be undertaken that would relate to the nature of weather patterns and changing climatic conditions. One respondent said that "the IPCC could be more effective," and suggested the value of a "National Academy of Sciences study that takes a stand based on current science and a little conservative common sense."

Concern was expressed about the proprietary (closed) nature of the industry's catastrophe ("CAT") models, implying the need for tools with transparent methodologies and underlying assumptions.

The critical point made by those interviewed was that the research and efforts undertaken to assess the risk must be focused and result in products that can be applied.

8. How important is the mitigation of loss?

Without exception, all respondents viewed loss control and reduction (mitigation) as extremely important. They saw this as the cornerstone of the foundation for the building of partnerships that address issues, or undertake projects and programs that flow from or pertain to natural hazard occurrences. One characterized it as "a genuine business opportunity."

Comments alluded to the fact that insurers brought into existence the country's first building codes, initiated boiler, machinery and elevator inspections, and created the Underwriter's Laboratory Insurers also initiated the National Fire Protection Association, Insurance Institute for Highway Safety, and Institute for Building and Home Safety.

9. Whose account of global warming have you found most convincing and why?

Many of those interviewed revealed a high degree of skepticism of all accounts and reaffirmed their lack of the scientific knowledge. Additionally, they expressed concern about being thrust into the middle of a debate with their customers on one side and government/regulatory authorities on the other—a situation they view as a "no-win" proposition. Two explicitly named the Intergovernmental Panel on Climate Change findings as something they trust.

5 Differences between the Viewpoints of U.S. and Non-U.S. Insurers

"European reinsurers and insurers look at the causes of severe weather, and their U.S. counterparts look at the consequences."
— *Franklin Nutter, President, Reinsurance Association of America*

"The situation we are in resembles that of a driver who approaches a wall of fog and, having only a vague impression of the stretch in front of him, looks into the rear mirror in an attempt to see in the clear view of the road behind some indication of what lies ahead . . . There are some drivers on this earth that, instead of stepping on the brake, are putting their foot down firmly on the accelerator…"
— *Munich Re*

"Green is socially acceptable, since companies with an eye on economic, environmental and social sustainability do outperform their peers."
— *Head of Risk Underwriting, Swiss Re New Markets Division*

"Risk management views the public discussion on climate change as a rabbit sitting paralyzed in front of a snake — unaware that behind it a fox is poised to strike. There is not one problem but two: natural climate variability and the influence of human activity on the climate system."
— *Swiss Re*

"One of the most troubling areas will be in that of human health where we will continue to see an increase in respiratory disorders …, there will be more water contamination…. We are also likely to see more environmental health refugees seeking asylum in Canada…. We must also consider the Northward migration of tropical diseases…."
— *Angus Ross, Chief Agent, Sorema North America Reinsurance Company*

"[The increased risk and costs of windstorms] are closely associated with global warming."
— *Shiro, Horichi, Vice President, Tokio Marine and Fire Insurance Company*

"As we are beginning to appreciate within the reinsurance industry the effects of climate change can be devastating…"
— *Kaj Ahlman, former CEO, Employers Reinsurance Company*

"The basis for an emerging global [insurance] market was created in late 1997 when more than 150 governments adopted the market-based mechanisms of the Kyoto Protocol."
— *Heinrich Hugenschmidt, Director, Union Bank of Switzerland*

"The U.S. delegation to the UNFCC has in fact committed to…a goal that now appears unreachable, without a dramatic restructuring of the economy and American lifestyles."
— *American Insurance Association*

"What option do we really have? An alternative form of energy? Not in our lifetimes!"
— *Anonymous U.S. insurance executive*

In this section we touch on the sometimes remarkable differences between the activities and statements concerning climate change among U.S. and non-U.S. insurers. It is important to appreciate the contextual differences in which these two groups of insurers operate. These include the relative weight of green marketing and green politics, the role of governments in natural disasters, conceptual approaches to loss prevention and mitigation, and the perception (or lack thereof) of new business opportunities presented by climate change risks. Likewise the tax-law environment, the tone and tenor of federal government relations with insurers, differences in corporate culture, and the timeframes with which insurers measure their futures can differ dramatically among countries. It was in 1973 that European insurers first articulated concern about climate change (16 years before their U.S. colleagues first publicly addressed the issue). Yet, it is also fair to say that, in a few select ways, U.S. insurers are ahead of their European counterparts.

Perspectives: North, South, East, and West

One need not look far to find statements that highlight the remarkable difference between U.S. and non-U.S. insurers on the question of climate change, as indicated by the following quotations.

> **"The situation we are in resembles that of a driver who approaches a wall of fog and, having only a vague impression of the stretch in front of him, looks into the rear mirror in an attempt to see in the clear view of the road behind some indication of what lies ahead . . . There are some drivers on this earth that, instead of stepping on the brake, are putting their foot down firmly on the accelerator . . . A further option entails active climate and environmental protection. This can lead to real win-win situations in the foreseeable future . . . Mankind is in the process of performing a gigantic experiment on the earth's climate. However possible it may still be to argue about the development of climate change and particularly about its effects, there are definite indications that the risk situation will deteriorate in the future. Every effort must be made to mitigate climate change and to restrict the impact as much as possible."**
>
> — *Munich Re (1999)*

> **"What option do we really have? An alternative form of energy? Not in our lifetimes!"**
>
> — *Anonymous U.S. insurance executive (1999)*

It is much more common for non-U.S. insurers to observe that corporate business objectives needn't be in conflict with environmental ones.

> **"Green is socially acceptable, since companies with an eye on economic, environmental and social sustainability do outperform their peers."**
>
> — *Head of Risk Underwriting, Swiss Re New Markets Division (Swiss Re 2000d)*

One recurring difference is the seeming acceptance of many overseas insurers that both natural and human-induced climate changes are occurring, whereas in the U.S. is often cast as a discussion of one versus the other almost as though they were mutually exclusive. In the words of one of the world's largest reinsurers:

> **"Risk management views the public discussion on climate change as a rabbit sitting paralyzed in front of a snake — unaware that behind it a fox is poised to strike. There is not one problem but two: natural climate variability and the influence of human activity on the climate system."**
>
> — *Swiss Re (1998b)*

Efforts of overseas insurers have begun to be documented by corporate "Environmental Annual Reports". Swiss Re's is particularly notable in the extensive integration with operating units within the company, including: services and products, investments, facilities and operations, information technology, and human resources (Swiss Re 2000d). Swiss Re's reports include quantification of environmental indicators such as carbon dioxide emissions associated with corporate operations, and goals such as an emissions reduction of 10% per employee for business travel (Swiss Re 2000d). Norway's Storebrand also has an impressive report, which also evidences widespread penetration of environmentally-oriented management practices throughout the company (Storebrand 1999).

Environmental groups and others, eager to see insurers engage in the climate change discussion, are quick to point to the proactive words and deeds of non-U.S. insurers as evidence that U.S. insurers are lagging behind their peers. However, the comments of these non-insurance groups often evidence little appreciation for the different conditions they face (Table 4).

By the same token, members of the U.S. insurance community (and others) often equate "overseas" activity with the United Nations Insurance Industry Initiative (see Appendix H), and imprecisely characterize it as a "European" initiative. In practice, insurers and insurance organizations overseas have been active on the issue for many years before the founding of the UNEP activity (e.g. Munich Re only became a member within the past year). One of the more active groups, in fact, has been from Canada:

> **"Some are of the opinion that no major actions should be taken until the evidence of climate change is more certain and the link to increased**

frequency and severity of climate-related natural disasters is verified. However, to delay taking action until the scientific conclusions are confirmed may be extremely risky as irreversible changes may have already occurred and additional enormous economic and human losses may have been suffered through natural disasters which could have been prevented or mitigated against. It would appear that sufficient economic and social benefits may flow from actions that improve disaster prevention and mitigation to justify these activities on their own merits."

— *Institute for Catastrophic Loss Reduction (Bruce et al. 1999)*

"While some members of the fossil fuel and other energy-related industries are pushing the [Canadian] federal government from one side, other industrial sectors such as the insurance industry, which is suffering huge losses due to extreme weather events, is pushing back."

— *Institute for Catastrophic Loss Reduction (1999)*

The Canadian reinsurer Sorema has noted the health concerns.

"One of the most troubling areas will be in that of human health where we will continue to see an increase in respiratory disorders ..., there will be more water contamination.... We are also likely to see more environmental health refugees seeking asylum in Canada.... We must also consider the Northward migration of tropical diseases...."

— *Angus Ross, Chief Agent, Sorema North America Reinsurance Company (2000)*

Japanese companies have also been outspoken:

"The recent large-scale disasters in Japan and abroad do not seem to be coincidental. It seems that behind these events are global-scale changes in climate patterns."

— *Toshifumi Kitizawa, Tokio Marine and Fire Insurance Company (Quirke 1994)*

"[The increased risk and costs of windstorms] are closely associated with global warming."

— *Shiro, Horichi, Vice President, Tokio Marine and Fire Insurance Company (Quirke 1994)*

While it is clear that the vast majority of U.S. insurers have expressed little or no interest in participating in the UNEP initiative, the presence of a few insurers goes largely un-noted. These companies include, the HSB Group, Employers Re, and AON (as an affiliated member). There are several non-U.S. members owned by U.S. insurance companies or in significant partnerships with them. These include CGU (has U.S. subsidiaries), Copenhagen Re, Ace Insurance, plus Frankonia & Aachener and Münchener (both owned by Employers Re).

Employers Re initially took a very firm stand on the question of climate change, but following management changes has subsequently retreated considerably:

"As we are beginning to appreciate within the reinsurance industry the effects of climate change can be devastating . . . Together with other members of the insurance industry who adhere to the UNEP Statement, we can make a positive contribution to the development of sustainable solutions to the pressing environmental issues which face our global society."

— *Kaj Ahlman, former CEO, Employers Reinsurance Company (UNEP 1998)*

In addition, among the 27 countries represented, the UNEP initiative is heavily populated by non-European insurers.[59] Among these, it is notable that a number of developing nations are active in the initiative (Argentina, Indonesia, South Africa, South Korea, Tanzania, and Thailand). This may reflect the particular vulnerability of developing countries to weather-related disasters. In emerging markets, climate change impacts could weaken economies and diminish demand for life insurance products (Peara 1999). Catastrophic losses during 1995, expressed as a percentage of GNP, were 5.5-times that experienced in high-income countries (Bruce *et al.* 1999). As an indicator of this vulnerability, economic damage from Hurricane Mitch amounted to 80% of GDP in Honduras and 49% of GDP in Nicaragua (FAO 1999). The costs of Hurricane Andrew, in contrast, amounted to less than 0.5% of GDP in the U.S.

[59]The list includes 87 signatories (insurance companies) from 27 countries: **Africa** (South Africa, Tanzania); **Asia** (China, Indonesia, Japan, Singapore, South Korea, Thailand); **Australasia** (Australia, New Zealand); **Europe** (Austria, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, United Kingdom); **North America** (Canada, United States); and **South America** (Argentina). For a complete list, see http://www.unep.ch/etu/finserv/insura/Signatories-by-Countries.htm.

Following is a partial list of reasons why overseas insurers have been more active:

- Overseas insurers have been studying the question of climate change much longer than have their U.S. counterparts (Munich Re 1973). There is a greater tradition of science in insurance in Europe and more staff climatologists providing analyses and corporate strategic counsel (although this work is concentrated in a few major companies). Munich Re has the largest climatology research activity, with a staff of thirty-five people.
- The U.S. industry is very fragmented into over 3,000 property/casualty companies, and is regulated by 50 state-level entities.
- Some of the largest carriers do not trade overseas, whereas European companies typically have multi-country markets and thus experience a broader range of risks and risk-management challenges.
- European reinsurers are heavily impacted by U.S. natural-disaster insurance losses. This was illustrated by the aforementioned study of two $7-billion hurricanes in the U.S. The surprising result showed that 5% of participating European insurers became insolvent, versus 1.5% of participating U.S. insurers (AIRAC 1986).
- The debate about the scientific validity of climate change is particularly polarized in the United States, and most of the highly visible "climate skeptics" are based there.
- "Green" marketing and product branding is ascribed a lower value in the U.S. than in many other countries, especially Europe.
- There is less government insurance for flood losses in many other countries.
- There is a "cultural" and corporate tendency among U.S. insurers to focus somewhat exclusively on the effects of natural disasters, whereas in some other countries there is an additional interest in focusing on and addressing causes. This is at times reflected in the very definition of terms, e.g. the Canadians include the reduction of greenhouse gases in their definition of "mitigation" whereas U.S. insurers would tend to use this word to refer to disaster preparedness.

> **"European reinsurers and insurers look at the causes of severe weather, and their U.S. counterparts look at the consequences."**
>
> — *Franklin Nutter, President, Reinsurance Association of America (quoted in Goch 1999)*

- Tax laws pertaining to reserving for disaster reserves vary among countries. Some believe that the non-taxability of reserves in some non-U.S. countries provides an extra incentive for insurers there to accept the global warming thesis. Some postulate that if U.S. insurers voice agreement with the global warming theory that they will then be forced to establish such (highly taxed) reserves.
- Unique to the U.S. are considerable negative lingering associations between Superfund and environmental concerns. Any "environmental" proposition automatically invokes the specter of Superfund.
- There is less of an adversarial relationship with government and insurance regulation in many countries, as compared to the situation in the U.S. Engagement in the climate change issue would likely invoke increased need for regulator-insurer interaction.
- "Green" politics and ideals are far more established and influential in some European political systems (e.g. Germany and The Netherlands), although much less so in others (e.g. France and the United Kingdom).
- The UNEP Insurance Industry Initiative did not obtain participation of U.S. insurers during its formation and has not made a concerted or well-conceived effort to reach out to U.S. firms since that time. Nor have they attempted to recast their message in terms that clarify its relevance and value in the U.S. insurance market and regulatory context.

An overarching difference is evidenced in perceptions of what is a "prudent" path. While many U.S. insurers prefer to remain inactive until more definitive scientific evidence is presented, non-U.S. insurers often take the following position:

> **"It would be prudent for the property/casualty industry to act as if that theory [global warming] is correct. Failure to act would leave the industry and its policyholders vulnerable to truly disastrous consequences."**
>
> — *H.R. Kaufmann, Swiss Re's General Manager in 1990 (Quirke 1994)*

One frequent manifestation of the various differences between U.S. and non-U.S. insurer perspectives is the virtual absence of U.S. insurer perception that climate change mitigation could offer business

opportunities and other financial co-benefits for insurers (Zwirner 2000) (see Box F). Overseas insurers, primarily in Europe, have, in contrast, been rather active in identifying opportunities and turning them into business realities, e.g., in thoughtfully identifying emerging markets based on the "Flexible Mechanisms" proposed in the Kyoto Protocol (AON 2000; Hugenschmidt and Janssen; Swiss Re 2000d; UNEP 1999).

> **"The insurance industry is prepared to contribute to making efficient use of energy and resources in internal operations and physical assets and by supporting programmes directed at introducing energy efficient technologies and practices... Based on its experience, the insurance industry in collaboration with financial institutions can provide a large array of services to other sectors of the economy including assistance in assessing 'carbon' liabilities of companies, project finance and insurance for infrastructure projects, verification and certification services...."**
>
> **"The envisaged market-based mechanisms Emissions Trading (ET), Clean Development Mechanism (CDM) and Joint Implementation (JI) may present opportunities for involvement of commercial insurance in the future. .... New roles for the insurance industry may emerge as it actively engages in a dialogue on the implementation of the Kyoto Protocol ..... The insurance industry is in a good position to play a catalyzing and facilitating role in this dialogue, based on a fairly neutral position in the matter, their international approach and their expertise in risk and claims management."**
>
> — *Heinrich Hugenschmidt, Director, Union Bank of Switzerland and Josef Janssen, University of St. Gallen (UNEP 1999)*

In one example, a member of the Lloyds of London syndicate offers a "Naturesave" commercial property policy, emphasizing that sustainable development and responsible risk management can go hand in hand. Insureds receive specialized surveys ("Environmental Performance Reviews"). The company offers a household property policy, and directs 10% of premiums to environmental projects.

In a rare example from the United States, the editor of one U.S. insurance trade journal, invoked this perspective in saying:

> **"While insurers might shy away from pushing industrial customers to clean up their acts, they may be missing a good marketing and public relations opportunity, too."**
>
> — *Bill Thorness, Editor, Claims Magazine (Thorness 1998)*

Few U.S. insurers have recognized business opportunities in climate-change avoidance.

> **"Developing 'green technologies' are providing very promising returns for the investors, technology developers, and of course, all of us." (2000).**
>
> — *Richard Jones, VP Engineering, Hartford Steam Boiler Insurance & Inspection Company (2000)*

> **"Climate change is already affecting our lives... The Precautionary Principle of recognizing that the risks of doing nothing are greater than the risks of doing something is now embedded in international legislation, graphically so in the case of the Kyoto Protocol... The insurance industry has a pivotal role to play in this process...."**
>
> — *AON (World's largest insurance broker; AON 2000)*

In some cases, overseas insurers are developing green investment funds. Swiss Re has a "sustainability-based investment portfolio" approaching 100 million Swiss Francs (approximately $60 million) in the form of venture capital and other investments (Swiss Re 2000d). As exemplified by the UK's Gerling Group, Swiss Re, Munich Re, CGU, Storebrand, and others, European insurers are more likely to adopt this perspective. Gerling has set up a $100-million Sustainable Investment Fund (in which several other insurers have invested to date.

> **"Sustainable strategies and value creation are not contradictory: Sustainable strategies lead to an increase of reputation, innovative capacity and better awareness of stakeholders' and customers' perceptions and needs. They also contribute to gain in efficiency and reduce risks."**
>
> — *Dirk Kohler, Gerling Sustainable Development Project (1999)*

BOX F: Insurance Synergisms and "No-Regrets" Co-Benefits of Environmental Protection

A number of adaptation mechanisms particularly applicable to the insurance sector possess important co-benefits or synergisms (sometimes also referred to as no-regrets opportunities). These benefits are rarely accounted for or otherwise incorporated into cost-effectiveness analyses. Many are normally associated with climate change avoidance (e.g., emissions reductions or enhanced carbon sinks) but in fact also stand to enhance adaptive capacity or otherwise benefit insurers. No-regrets strategies can be attractive irrespective of their potential effect on climate change (Sarewitz *et al.* 2000).

- **Energy End-Use Efficiency**. Various co-benefits have been documented (Mills and Rosenfeld 1996; Vine *et al.* 1999 and 2000; Avery *et al.* 1998; AIA 1999). For example, improved insulation and equipment efficiency can reduce the vulnerability of structures to extreme temperature episodes (adaptation) while contributing to reduced greenhouse gas emissions (mitigation). Other examples include: increased use of public transit and reduced speed limits and improved highway safety (AIA 1999) and ultraviolet water disinfection to conserve fuelwood (Gadgil *et al.* 1997). Emission reductions achieved through improved efficiency can translate into improved urban air quality, and reduced respiratory disease. Certain energy management strategies also stand to offer insurance benefits in terms of indoor air quality risks (Chen and Vine 1998; 1999).
- **Renewable Energy and Distributed Energy Systems**. Certain renewable and distributed energy supply technologies have attributes relevant to vulnerability and adaptation. There are a number of ways in which this class of technologies support disaster preparedness and recovery (Mills 1996; Mills and Knoepfel 1997; Mills 1999). For example, low-power/energy-efficient technologies can reduce business-interruption risks by extending the reliability and operating range of backup power systems (Lecomte *et al.* 1998b; Kats 1998; Deering and Thornton 2000; Stauffer, R.F. 1995; Gordes 2000). Substitution of biofuels for fossil fuels can yield safety benefits through improved air quality and reduced soil degradation/runoff/siltation (benefits health and property insurance) (IPCC 2000).
- **Sustainable Forestry, Agriculture, and Wetlands Management**. Enhancing the organic carbon content of agricultural soils or grazing lands reduces erosion and increases drought resistance (benefit to crop insurance) as well as contributing to reduced water pollution, improved water quality, nutritive value of foods, and food security (benefit to health insurance), while for forest soils benefits of enhanced carbon content arise in terms of watershed management and flood/mudflow control (benefit to property insurance) (Scott 1995; IPCC 2000; Hamilton 2000; IFRC 1999). Wetlands restoration helps protect against flooding and coastal erosion (benefit to property insurance) (IPCC 2000). A variety of sustainable agricultural practices also contribute to reduced energy use, reduced methane emissions, and increased biodiversity (IPCC 2000).
- **"Green" Financial Products.** Examples include innovative financing of energy efficiency improvements, "green insurance," or liability insurance for adaptation/mitigation projects defined under the Kyoto Flexible Mechanisms, etc. can simultaneously support adaptation and mitigation objectives (UNEP 1999).
- **Environmental Security.** Enhancing natural resource and food security disruptions arising from climate changes could avoid social and economic disruptions that could otherwise trigger "political risk" insurance claims (UNEP 1999).

"The goal of adopting sustainable development as a business principle should not only complement but also promote our economic and social goals. I am convinced that Swiss Re Group can create an economic advantage for itself if it becomes and remains a leader in realising that goal."

— *Bruno Porro, Chief Reinsurance & Risk Officer, Chairman Environment Steering Committee, Swiss Re (1998c)*

"The basis for an emerging global [insurance] market was created in late 1997 when more than 150 governments adopted the market-based mechanisms of the Kyoto Protocol."

— *Heinrich Hugenschmidt, Director, Union Bank of Switzerland (1999)*

Another even more fundamental and pivotal issue is the perception of whether climate change mitigation will be healthy or unhealthy for national economies overall. The following quotations, the first from the American Insurance Association (AIA 1999) and the second from representatives of the Reinsurance Association of America and the Harvard Center for Health and the Global Environment, illustrate the wide differing perspectives on the economic impacts of climate change mitigation that can exist.

"The U.S. delegation to the UNFCC has in fact committed to a reduction in emissions of 8% below 1990 levels, a goal that now appears unreachable, without a dramatic restructuring of the economy and American lifestyles. It will be a significant challenge to achieve these dramatic reductions in emissions while still preserving a healthy economy and economic growth in the U.S."

— *American Insurance Association (Unnewehr 1999)*

"To avoid the costs of climate disruption, a shift in priorities, credits, subsidies and incentives will be needed to help develop technologies that steer us into a renewable and energy-efficient future. The biggest surprise may be the better distributed economic opportunities produced by this transition."

— *Harvard Center for Health and the Global Environment & Reinsurance Association of America (Epstein and Nutter 1997)*

Weyant (2000) presents a thoughtful view inside of the various methods of analyzing the impact of climate change on the economy.

In summary, with notable exceptions, there are clearly differences in the tone and nature of positions taken on climate change by U.S. and non-U.S. insurers. However, many of those differences need to be understood in terms of prevailing conditions in the respective business and regulatory environments.

6 U.S. Insurer Perspectives on Climate Science and Catastrophe Modeling

"It seems clear that the best role for insurers in the debate on global warming is that of expert witness. We can bring our knowledge and expertise in calculating potential loss to assist policymakers and the general public in understanding the complex issues involved."

— *Sean Mooney, Research Director and Economist at Guy Carpenter & Company*

"[T]he insurance industry does not have the expertise to evaluate conflicting interpretations of scientific evidence or positions on climate change."

— *American Insurance Association*

"My perception is that insurers and reinsurers are both very well informed on the topic."

— *Paul Devlin, Vice President, Institute for Business and Home Safety*

Insurers have shown interest in climate science, and in isolated cases have participated in climate research and modeling. Insurers are divided, however, on the role they should play in this arena. Irrespective of the causes of past losses, one problem looking forward is that academic climate science is rarely designed to address the exact questions of importance to insurers. The growing popularity of catastrophe ("CAT") models is a positive development, although these models are predicated largely on historical data rather than scenarios incorporating future climate change, and there is regulatory resistance to the use of these models for setting insurance premiums. Interestingly, CAT modelers and climate modelers face similar barriers to the acceptance of their work.

Insurer Involvement in the Climate Sciences

When U.S. insurers have turned their attention to the science of climate and climate change, several circumstances have reinforced their reluctance to take a position (see also Appendix B). While U.S. insurers and their trade associations have followed some of the debates on global climate change, few if any U.S. insurers can claim expertise in the climate sciences (Nutter 1999). The relative lack of expertise in climate- or earth sciences among U.S. insurers stands in contrast to that of European-based companies like Munich Re, Swiss Re, and CGU. Without the advice of internal scientific staff, U.S. insurers have had to weigh numerous issues when investigating the merits and applicability of the science of climate change.[60]

Among these considerations are the views of hurricane experts unimpressed by the IPCC consensus, state regulators and consumers concerned about rising insurance costs, and clients adversely affected by environmental regulation. Other issues include the long-term nature of climate change projections as compared to the short-term needs of insurers.

Within the United States, the insurance industry does not speak with unanimity on the issue. The following quotations illustrate the mixed messages relayed on the question of insurer's depth of knowledge about and potential role in the technical discussion of climate change:

> **"It seems clear that the best role for insurers in the debate on global warming is that of expert witness. We can bring our knowledge and expertise in calculating potential loss to assist policymakers and the general public in understanding the complex issues involved."**
>
> — *Sean Mooney, Research Director and Economist at Guy Carpenter & Company (Reinsurance Brokers) (1998)*

> **"[T]he insurance industry does not have the expertise to evaluate conflicting interpretations of scientific evidence or positions on climate change."**
>
> — *American Insurance Association (1999)*

> **"My perception is that insurers and reinsurers are both very well informed on the topic."**
>
> — *Paul Devlin, Vice President, Institute for Business and Home Safety (quoted in Thorness 1998)*

However, there does seem to be a relatively wide consensus that among U.S. insurers that research is needed that is not perceived as engineered or predetermined.

U.S. insurers and reinsurers have followed the scientific debates on climate change and, on occasion, have lobbied Congress to support climate change research. Non-governmental research into long-term climate conditions has gained support from U.S. insurers, but not so much for investigations into forward-looking global warming scenarios. Insurers through the Bermuda-based Risk Prediction Initiative have funded some *retrospective* climate studies, primarily aimed at hurricane research, to help build more complete actuarial records of extreme weather incidence and severity (Malmquist 1998). While useful for understanding recent climate changes, better historical data on climate extremes, programmed into catastrophe loss models (a.k.a. "CAT Models"), can also assist insurers in forecasting the likelihood of potential weather-related losses.

It should be noted that U.S. insurer attention to climate science has focused almost exclusively on wind hazards (particularly hurricanes), which have been the main cause of weather-related losses in the past. Relatively little effort has been spent within the insurance industry on studying climate change and hazards such as crop damage, flooding, land subsidence (Association of British Insurers 1999), lightning, or life/health loss. The relationship between climate change and coastal erosion is also less studied, but a looming issue, e.g., for Cape Cod, Long Island, North Carolina, and Florida (Heinz Center 2000). This relatively narrow focus is justified to a degree given the dominance of windstorms in historical insurance claims, but also predictably leads to less-than-comprehensive strategic awareness of potential climate-change phenomenon.

[60]This is one reason that Reinsurance Association of American president, Frank Nutter has urged more dialogue between the natural and actuarial sciences (Nutter 1996).

Catastrophe Modeling *v* Climate Modeling

CAT Models estimate potential losses by simulating historical storm conditions and the relative durability of insured properties. Insurers can use the modeled results to justify their premiums to regulators. *Historical* climate information adapted for CAT Models may assist in more immediate chores like rate filings, solvency testing, portfolio risk assessment, short term marketing plans, and the evaluation of underwriting criteria. A key caveat to the usefulness of these models is whether the historical data used to predict future storms is a fair representation of future weather conditions, especially if climate conditions are changing. The National Association of Insurance Commissioners (NAIC 1999) also recognizes this.

These weather related CAT models and climate predictions focus primarily on analysis of the *historical* record and mostly concern tropical storms. Climate change modeling performed at government and university laboratories also incorporates processes inferred from historical records and significant parameterization of climate cycles, but it differs from CAT modeling in that it takes the additional step of simulating the impacts of changes in atmospheric chemistry. In contrast, CAT models make no attempt to project the impacts that global warming may have on future natural disasters.

Both climate change and CAT models have generated vocal opposition from parties potentially affected by their implications. Whereas fossil-fuel-intensive industries have attacked the validity of global warming projections, property owners, and insurance regulators have resisted the use of CAT models that support higher windstorm premiums. If insurers have run into resistance using models based only on historical parameters, one can imagine the outcry if insurers, lacking climate expertise, attempted to project future climate parameters, like global warming.

CAT models, if correct, suggest that in several coastal and seismically vulnerable regions, insurance pricing is inadequate. Before considering the potential effects of global warming, insurers have much to gain from achieving rate adequacy based on charges generated from CAT models.

Appendix B describes some of the major differences between climate change modeling and CAT modeling and their relative attractions to U.S. insurers and the potential impact of a prominent group of tropical storm forecasters on insurer perceptions of climate change.

Before considering the implications of climate change models, U.S. insurers face several challenges in implementing the results of CAT models. For rate filing purposes, insurers must justify to regulators the rate increases implied by CAT models, and the actuarial validity of the models themselves. The methodology is new, but it still relies upon analysis of documented experience, at least in terms of climate events, if not actual losses. Catastrophes during the 1990s demonstrated the inadequacy of then prevailing windstorm premiums. CAT models generally suggest that substantially higher rates are needed in some critical coastal regions. While this suggests that insurers have plenty of catching up to do before considering climate change, climate change projections may still provide some utility for long-term planning.

External Resistance to Catastrophe Models and Climate Change Models

Insurers arguing for the use of CAT models face credibility problems not unlike those of environmental interests promoting the acceptance of climate change models. One ostensible problem applicable to both types of models, cited by Georgia's Insurance Commissioner, John Oxendine, is that they cannot predict exactly when a storm or climatic event is going to happen (*Insurance Network News* 1997). This view is curious, given that both CAT and climate models are not meant to predict actual events, but to estimate the probabilistic potential for losses based on historical records of catastrophe recurrence. The very premise of insurance is that losses are not predictable with any precision.

The policy implications of both kinds of models, whether higher windstorm premiums or restrictions on energy use, have drawn fire from consumers and industries, respectively. As discussed in Appendix B, several different CAT models exist and critics have noted the disparity in their respective results (projected losses), especially when simulating single storm events (GAO 2000; Matthews *et al.* 1999; Snyder *et al.* 1999). Alternatively, results from different models converge more as the number of simulated storms increases. For climate change models, the academic circumstances for their development have allowed for the sharing and review of assumptions and methodology, which ultimately might lead to a convergence of predicted outcomes and thus greater credibility. Proprietary CAT models, however, have evolved within company confines, reducing the potential for widespread review, but competition among firms might spur innovation in technique.

U.S. insurers and CAT modeling firms have shown interest in climate research into historical records of extreme weather through the Risk Prediction Initiative. This kind of data is useful for CAT model development and for verifying trends relevant to climate change research. This data may or may not support any connection between global warming and changes in hurricane intensity. As discussed in Appendix B, increased attention to the impacts of El Niño and La Niña (ENSO) on hurricane intensity, however, may acquaint insurers with more solid evidence of global warming. Several climate change models have predicted a future with more intense ENSO events. Insurers may welcome a climate with more El Niños if this brings fewer intense hurricanes (Gray 1997); but, it may enhance risk in less predictable ways such as wildfires, tornadoes, floods, ice storms, power disruption, and other climatic extremes. Furthermore, whereas hurricane risks are more concentrated along the East and Gulf Coasts, El Niño risks are dispersed about the continent and manifest in the form of smaller events, potentially affecting larger books of business.

Alternatively, a climate with more prolonged and intense events from La Niñas could considerably enhance hurricane risks along the East Coast. Thus, greater focus on El Niño/La Niña events might engender more of a common interest and common concern for insurers and those seeking to tame global warming.

The preceding assessment, however, in no way captures the entire universe of opinion of U.S. insurers towards the science of climate change. Companies like Arkwright Mutual (now FM Global), Employers Reinsurance, AON, American Re, Allstate, and various others have expressed concerns about global warming in one form or another. However, comments gleaned from our executive interviews suggest greater influence by proponents of the view that changes in extreme weather events are mostly attributable to natural variation rather than global warming.

7 Surmountable Barriers

Given the potential for disruption caused by climate change, it is notable how limited U.S. insurer efforts to analyze the problem have been (at least as is evidenced in the public record). At the highest level, we discern three basic types of "perceptual barriers" to more in-depth insurer involvement and collaboration with non-insurer groups. These include: (1) uncertainties regarding the science of climate change, (2) distrust, emanating from parochialism and provincialism among stakeholders; and (3) lack of knowledge and the failure to fully understand stemming from insufficient dialog among stakeholder groups. Underlying these, we identify an extensive series of barriers that fall into the categories of "legal and regulatory", "technical and informational", "economic and market", and "political".

Thinking about Barriers

Based on the 17 in-depth interviews and our literature review, we offer a way of cataloging and analyzing the barriers to more proactive involvement of insurers in the climate change issue and to interaction between the insurance community and other communities concerned with similar issues.

Perceptual Barriers

1. The **scientific uncertainties** (both climate and catastrophe models) regarding climate change and predicting and forecasting significant occurrences, their frequency, severity, location and/or landfall points must be dealt with in a convincing manner.
2. The **distrust, parochialism, and provincialism** among the stakeholders (government, regulators, private sector participants and public).
3. The **failure to fully understand** an issue, problem, program, procedure, or process due to lack of knowledge, misunderstanding, or insufficient dialogue among stakeholders.

Contributing to the these perceptual barriers are a host of more specific contextual barriers and influences that exist in the environment surrounding insurers. We group these into four categories: legal and regulatory, technical and informational, economic and market, and political.

Legal and Regulatory Barriers

- U.S. Insurers have had few signals from their regulators that climate change is an issue that merits their attention.
- Reserves are taxed at the corporate rate in the U.S. and insurers are not allowed to reserve tax-free for un-incurred events. Thus, to reserve, an insurer must decrease their profits. Talk of climate change may be perceived as raising expectations on the part of consumers and the government that insurers should increase reserves (at any cost).
- Research and development costs incurred by U.S. insurers can not be recovered via the insurance premium, and therefore must be paid for from "surplus".
- Introducing new modeling techniques (e.g., global climate models) into the formal process of loss-estimation and rate making would invoke formidable regulatory approval hurdles, as well as technical questions about the ability of historically-based models to capture the impacts of potential changes in climate forces driving disaster losses.
- While some have suggested that insurers might be a good source of capital for the development of new climate-mitigation technologies, investment regulations on insurers might limit the amount of funds, whether equity or debt, available for investment in smaller, riskier, start-up firms. Also, such capital would serve to drain surplus.
- Given the government's track record with major environmental hazards, insurers are worried that government might yoke them into another round of what they perceive to be unreasonable coverage or unfair obligations. The vagaries and uncertainties associated with climate change, coupled with the fear of deeper government involvement create in the minds of insurers the potential that they might be:

- liable for past contributions to climate change similar to Superfund retroactive liability stipulations.
- required to monitor their policyholders for emissions reduction, similar to OSHA regulations concerning workplace safety.
- liable for policyholder misrepresentations concerning carbon emissions reductions, similar to proposed OSHA asbestos regulations.
- mandated to remain and insure in areas affected by climate change—even if the risks and exposures are viewed by carriers as uninsurable.
- legislated to adhere to the edicts and guidelines of state/federal certified climatologists as advocated recently by a New York Assemblyman during a special hearing (Levin 1999; Dow Jones 1999).
- forced to accommodate the sale of auto liability insurance at the pump.
- subject to climate change priorities that would prohibit or limit investments in oil, coal, and gas industries.
- subject to information requirements that might be construed as calling on insurers to reveal privileged client or insurer information.
- the object of civil actions that challenge the thoroughness and effectiveness of risk assessment procedures and "best practices".

Technical and Informational Barriers

- Scientific uncertainties, often exacerbated by the media, serve to create a sort of "analysis paralysis" among insurers. One insurance organization noted that in the 1970s the Council on Environmental Quality warned of "global cooling", citing the later switch to "global warming" as a source of skepticism and caution when regarding climate science.
- Unsubstantiated or exaggerated claims associating climate change with given extreme weather events—often confusing correlation with causation—erode the credibility of responsible science and scientists.
- Global climate models often do not provide analyses of the kind (scale, timeframe, etc.) required to be of use by insurers.
- Absence of in-house climatology experts who can weigh the arguments and advise upper management. To complete the evaluation and analysis process the services of other experts, i.e. meteorologists, seismologists, hydrologists, and/or oceanographers could be viewed as essential and the costs of which would have to come from surplus.
- Insurers lack extensive historical data on weather-related losses, which confounds efforts to detect departures from "normal" trends.
- Catastrophe models used in the insurance sector are based on past weather as opposed to future weather, and thus cannot be used to illuminate questions of the future climate and its impacts on insurers.
- Unknown or unfamiliar risk-management characteristics of climate change mitigation technologies (e.g., efficient or renewable energy technologies). While many of these strategies have been shown to be benign or beneficial—in risk-management terms—others are untested or (e.g., pay-at-the-pump insurance) believed to be counterproductive from an insurance business standpoint (AIA 1999). In some cases there is debate, e.g., in the case of fuel-efficient automobile safety (Mooney 1998, Nemtzow 1999).

Economic and Market Barriers

Supply-Side Barriers

- Insurers' attention is dominated at present by what are generally perceived as more pressing market dynamics, including competition, mergers and acquisitions, alternative markets for risk, financial services convergence, and intense debates about regulatory reform.
- Assumption that rates and/or deductibles can be easily raised, premium credits dispensed, and markets exited in order to compensate for potential growth in losses.[61]
- Soft market conditions: competition, price pressure detracts from potential investments in research and consumer incentives or other strategies for mitigation of climate risks.
- Resistance to adopting positions that could put insurers at odds with significant customers (fossil fuel producers, utilities, automotive sector) who are emitters of greenhouse gases and/or jeopardize insurers' investments in these industries.
- Potential global warming mandates to reduce the number of cars on the road could negatively impact automobile coverage revenues (50% of the P/C industry total).
- Perception by primary insurers that reinsurers are exaggerating the problem so as to sell more of their product to primary insurers.
- Availability of government insurance and insurance-type mechanisms that relieve commercial insurers from the most uncertain kinds of risks (e.g., flood).
- A reactive versus proactive business culture among many U.S. insurers.

Demand-Side Barriers

- Insurers fear being seen by some as having infinitely deep pockets and be expected to single-handedly fund major climate change initiatives.
- Shareholders or consumer groups have generally not called upon insurers to act on the climate change issue.
- The "Green Consumer" movement has not struck the insurance sector, and thus this type of market and product-branding incentive does not as yet operate within the industry.
- Availability of alternative loss-financing mechanisms via the capital markets.
- Availability of government-financed disaster preparedness/recovery helps to reduce losses faced by insurers, particularly those losses bearing high levels of insurance business risk.
- Lack of information or underestimation of the exposure or benefits of mitigation, lack of premium incentives for mitigation, tax deductible insured losses, poor building code enforcement, lack of financing for mitigation, mortgage default, and expectations of government financial assistance in the event of a disaster (or the failure of an insurer) (Klein 1997).

[61] In many cases, insurance loss deductibles are being changed from fixed amounts (e.g. $500 per event) to percentage values, e.g. 2% to 10% of the loss—a substantially higher number in cases of significant property damage. Insurers in coastal states including Florida, Mississippi, Georgia, Alabama, and Texas have implemented such deductibles and have begun doing so in northern states including New York (Lohse 1999).

Political Barriers

- Insurers may perceive that if they speak more definitively on the question of climate change that their regulators will tighten financial solvency requirements, further restricting their ability to pursue high-risk, high-return investment opportunities, etc.
- Insurers may perceive that they will be pressured to insure risks (e.g., flood) that would be unprofitable, especially if climate change caused increased the intensity of events or uncertainty of losses (Goch 1999).
- Insurers can feel singled out and expected to take the full load of climate mitigation efforts, whereas the fact is that insurers would be joined by many entities and have an inherent ability to serve as catalysts in public-private partnerships (Kunreuther 2000; Ryland 2000).
- Insurance is not a "polluting industry," and does not perceive itself as having a direct role in or responsibility for reducing environmental pollution.
- A general desire to avoid direct involvement with government programs and initiatives (even if designed to be voluntary).
- Insofar as the United Nations Insurance Industry Initiative is taken as a symbol, U.S. insurer disinterest can be a proxy of more general tensions between the U.S. and the UN. This view may operate in tandem with a "not-invented-here" perspective. Making matters worse, the UNEP/III was formed by five insurers and the United Nations, without input from the broader insurance community. There is some resemblance to the U.N.'s effort to form a multilateral agreement on investment through the OECD and subsequent disfavor among American firms.
- Overbearing and ill-conceived environmental initiatives focused on insurers. One recent example was discussion among New York insurance regulators about requiring insurers to employ climate scientists (Dow Jones 1999). This is perhaps perceived as a well-intentioned, but clumsy, inefficient, and impractical way of constructively engaging insurers more fully in the science of climate change.
- Insurers are wary of being caught in political tug-of-wars. On the one hand, they may be concerned that environmental, shareholder, or consumer groups will publicly criticize insurers who are judged not to be making enough progress. On the other hand, groups like the Competitive Enterprise Institute have accused insurers of fanning concerns about climate change as a means to encourage a government bailout (Brostoff 1997).
- Insurers are involved in many charitable and social causes that may be perceived as a higher priority—and closer to their core business—than that of climate change (Mooney 1998).
- Insurers receive mixed signals from their regulators. At times there is tension between consumer versus industry orientation of regulators, partially as a function of whether they are appointed or elected.
- The so-called "climate-skeptics," most notably the Global Climate Coalition, have vociferously maintained that climate-change is a non-issue. While no insurers are members of this group, an indirect influence, no doubt, remains. This is probably evidenced in the fact that Employers Reinsurance Company—which is owned by General Electric, an active member of the GCC—drastically reduced its involvement in the UNEP Insurance Industry Initiative following concerns raised by its parent company and GCC member, General Electric (Raupp 1998). Interestingly, Shell Oil and British Petroleum left the Coalition over the past two years, as did the large U.S. utilities American Electric Power and the Southern Company. Auto manufacturers Daimler-Chrysler, and, after ten years of involvement with the group, Ford Motor Company, dropped out, saying that their "Membership is an impediment to our ability to move forward credibly on environmental issues" (Holly 1999). Texaco left the group shortly thereafter (Kelly 2000), followed by General Motors.

8 Summary and Analysis

"[The insurance industry] must recognize that it must do more than be a pass-through mechanism for the costs associated with natural disasters."
— *Franklin Nutter, President, Reinsurance Association of America*

"Good science is on the side of global warming. The ones throwing the spitballs are the skeptics, and their motives are clear. ... But until we separate the junk from the science, an intelligent debate can't even begin.
— *Aaron Newhoff, Chief Actuary, Becher & Carlson, Insurance Brokers*

"We recognize that on matters of weather and climate change, our interest is one among many spheres of interest. We agree that our perspective—that of financing recovery from the effects of natural disaster and encouraging improved safety and hazard mitigation– should not stand apart from the interests of others in climate and climate change. We believe that these varying perspectives should be patched together into a quilt of interests addressing the effects of natural hazards on people and property to improve and apply the results to the benefit of human health and safety."
— *Insurance Executives Committee*

"Despite advances in research, climate development is and will remain uncertain. Immediate action must be taken nevertheless, ...man's influence on the climate system will aggravate [natural] risks still further. ... As a company whose daily work involves dealing with risks, [Swiss Re] sees realistic possibilities of at least effectively reducing the risks of climate change."
— *Swiss Reinsurance Company (1998b)*

"We believe that continuing along the same hazards research and practice will bring increased frustration (and losses) for everyone....We need a paradigm that ensures true long-term mitigation and loss reduction that is as permanent as we can imagine, avoiding burdening future generations with risk. We need to be able to increase the long-term equilibrium between humans and the environment.
We propose a new framework for hazard research and management... It will be underlain by a global system perspective; it will embrace the concept of sustainability; and it will derive its moral authority from local consensus. We call this new approach "sustainable hazard mitigation."
— *Dennis S. Mileti*

When it comes to the question of climate change, U.S. insurers can be found on all points of the public policy compass. While a number of insurers and their trade organizations have given some attention to the issue, the vast majority have not publicly indicated an opinion. A few have taken definitive positions believing that there is a material threat, while others have taken equally strong views to the contrary. Some have elected to pursue the fortification of society against natural perils, and others to adopt a more strictly "wait-and-see" stance. Relevant insurer activities fall in the (important) areas of pre- and post-disaster loss mitigation, rather than improving climate science or engaging in the public policy discussion about mitigating the potential effects of climate change itself. Assimilating climate science and coping with differing views remains an importing sticking point, although there is an emerging trend towards integrating what might be called "sustainability" considerations in a no-regrets fashion with the basic business of insurance. We close by offering some suggestions for how non-insurers interested in engaging insurers in the climate change discussion can better address their needs and interests.

Most U.S. Insurers Are Uninterested or Ambivalent about Climate Change, While Some Are Actively Concerned

Weather-related insurance losses are unquestionably on the rise. But the relative upward and downward influences of natural climate variation, demographic trends, mitigation efforts, and degree of possible human-induced climate change remain difficult to quantify.

The responses of 17 insurance executives we interviewed paint a picture of insurers who exhibit a desire to make a meaningful contribution toward safeguarding the public and their policyholders. However, most claim to lack the scientific knowledge needed to participate in the climate-change debate. Some stridently declare a lack of expertise and in the same breath paradoxically state with authority that climate change is not taking place. Some claim the happenings to be "an accident of nature," others subscribe to the theory that climate change is a cyclical event, and a few support the proposition that the earth's inhabitants, through the burning of fossil fuels and destruction of the rain forests, are in fact contributing to the phenomenon.

When queried about their role or responsibility to help determine the cause(s) of climate change, many wash their hands of the subject by declaring: "This is the responsibility of government." In this manner insurers cast aside potential conflicts with stockholders, automobile manufacturers, petroleum producers, contractors, builders, material manufacturers, developers, etc.

The climate change issue is perceived by many as "political," designed to maintain a large climate research budget and contribute to the size of the federal bureaucracy. It is also an issue that divides insurer organizations, notably companies who are headquartered in Europe or Asia and have branches in the U.S. For the most part, the foreign operations will be supportive of initiatives that would assist in controlling the impact of climate change, whereas the U.S. branches of those very companies (e.g. CGU, [formerly General Accident], Zurich American, and Gerling-Konzern) are ambivalent or indifferent to the discussions or involvement.

The answers by a number of respondents to our interview questions regarding the insurability of certain catastrophe type losses, the Standards of Insurability and emerging alternatives for financing the risk reveal a need for a refocusing on the principles of property insurance and indemnification. In other words, examining the physical characteristics of property risks and exposures, and not merely considering the involved financial exposure. An understanding and application of the Standards of Insurability are essential to maintaining the solvency of an insurer and the development of actuarial rates. Otherwise insurers drift into a mode of operation focused on cash-flow-management (sometimes referred to as "cash-flow underwriting"), that tends to disregard insured values, location of the risk, effects of the hazards and impacts of mitigation. Some contend that if there is an abundance of inexpensive money available through one or more of the disaster financing alternatives, a disincentive to support mitigation arises.

If additional evidence of the insurers' indifference to climate change is needed, consider the lack of action following the meeting in 1995 with Vice President Gore when insurer organizations stated (Appendix F):

> **"We recognize that on matters of weather and climate change, our interest is one among many spheres of interest. We agree that our perspective – that of financing recovery from the effects of natural disaster and encouraging improved safety and hazard mitigation – should not stand apart from the interests of others in climate and climate change. We believe that these varying perspectives should be patched together into a quilt of interests addressing the effects of natural hazards on people and property to improve and apply the results to the benefit of human health and safety."**
>
> — *Insurance Executives Committee (1995)*

Without exception, each of those we interviewed saw loss control and reduction (mitigation) as extremely important. Yet the seriousness of their commitment to mitigation is unclear in light of the relationship between insured values of property in harm's way, estimated in the trillions of dollars, the premiums written (approximately $279 billion), and the sums spent on mitigation.

Some respondents claim that the need also exists for insurers to be proactive on matters relating to "land use." These individuals perceive the necessity to clearly explain how the improper use of lands, i.e., land that does not, because of its location and/or soil composition, support development and yet is built upon, is exacerbating the damage to be caused by natural hazards. Additionally, they see the need to describe why and how properties that stand in harm's way are, in many instances, insured by government programs or in mandated insurance pooling mechanisms. The public must understand that through these insuring mechanisms that costs and losses are redistributed to *all* property owners, insurance consumers, governments (taxpayers), who each bear a share of the burden.

Although the notion of risk management and loss prevention is embedded in the very historical fiber of the insurance industry, U.S. insurers have yet to extend this thinking to the matter of climate change. Insurers have treated loss control as a relatively "local" enterprise, whereas it would entail a rather dramatic shift in self-perception for insurers to engage in the activity at a (literally) global scale. Presently, insurers' definition of "mitigation" implicitly excludes the *prevention* of climate change. While the European insurers are often cited as favoring action on climate change, less acknowledged are similar statements by neighboring Canadian insurance groups in which they explicitly include greenhouse gas reductions in the definition of "mitigation" (e.g., Bruce *et al.* 1999).

It is acknowledged by some of those interviewed that the lack of a 100-percent scientific consensus on climate change creates a huge gap in the development of an effective loss prevention strategy. To the extent that the stakeholders can reach an understanding of the scientific cause(s) of climate change they will be able at least to identify and justify the costs of mitigation strategies, programs, and activities that will have a meaningful impact.

One notable observation is that not a single insurer we interviewed noted any possible *benefits* from insurer initiatives on climate change. Overseas insurers, on the other hand, have spotted potential market opportunities in insuring emission-reduction technology projects as well as contractual commitments for emissions reductions (Willums 1999).

Insurers Remain Uncomfortable with Climate Science

On the one hand many insurers adopt a "hands-off" stance towards the science, and yet are conclusively skeptical given the prevailing "scientific uncertainties." It is not clear why insurers have historically grasped the materials and engineering sciences with considerable vigor (e.g., Underwriters Laboratories, Factory Mutual Research Corporation, The Institute for Business and Home Safety, and the Insurance Institute for Highway Safety (IIHS)), but are largely reluctant to do so in the area of climate science.

Insurers are among those within the business community who must reckon with the positions of "climate skeptics". At least some within the industry, however, do not seem persuaded by the skeptics' arguments. Noting that the climate skeptics are funded by fossil fuel industry representatives such as Shell, Unocal, Arco, and Western Fuels (a consortium of coal interests), one actuary questions the skeptics' motivations:

> **"Good science is on the side of global warming. The ones throwing the spitballs are the skeptics, and their motives are clear... But until we separate the junk from the science, an intelligent debate can't even begin... Financial ties to those with a vested interest in seeing that greenhouse gas emissions go unrestricted don't make these men liars. When Tiger Woods tells me that Buick makes a fine automobile, it's quite possible he's telling the truth. But I would certainly want to consider the fact that Buick paid him $30 million to reach that conclusion before I ran out and bought one."**
>
> — *Aaron Newhoff, Chief Actuary, Becher & Carlson, Insurance Brokers (Newhoff 2000)*

It should be noted that U.S. insurer attention to climate science has focused primarily on wind hazards (particularly hurricanes). Relatively little effort has been spent on climate change and hazards such as weather-related vehicle losses, electrical disruptions, crop damage, flooding, subsidence, life/health loss, or coastal erosion. This narrow focus is justified to a degree given the dominance of windstorms in historical insurance claims, but also predictably leads to less-than-comprehensive conclusions regarding the climate change phenomenon, and potentially complacency if hurricanes were to decline. Thus, in addition to concerns about the long-term nature of climate change predictions, insurers will need more confidence in localized predictions before voluntarily incorporating them into their pricing and underwriting.

A recurring distinction between U.S. and non-U.S. insurers is an acceptance of scientific uncertainty as a "necessary evil", rather than an obstacle to proactive steps to mitigate the potential causes and effects of climate change:

> **"Despite advances in research, climate development is and will remain uncertain. Immediate action must be taken nevertheless, ...man's influence on the climate system will aggravate [natural] risks still further. ... As a company whose daily work involves dealing with risks, [Swiss Re] sees realistic possibilities of at least effectively reducing the risks of climate change."**
>
> — *Swiss Reinsurance Company (1998b)*

Discussion of the means by which insurers have promoted the validity of catastrophe models is beyond the scope of this report, but it remains an interesting question for the prospects of evaluating the validity of climate change modeling. What arguments and information have insurers offered in making their case for CAT models before regulatory commissions, legislators, and consumer groups? Information offered in the insurance trade press might suggest that much credence was given to the test run for the Applied Insurance Research CAT model, which simulated insurance losses with an aggregate error of 4%. Climate change model predictions for the future may be unverifiable today, but much work has gone into having "transient" climate models simulate recent climate history and work is underway to improve the spatial resolution of these models. Perhaps greater investigation into this area might assist climate change and CAT modeling groups in their efforts at gaining public acceptance. Enhanced dialogue between insurers, CAT modelers and climate change modelers, as in the case of ENSO investigations, might reveal ground for collaboration and mutual benefit. At a minimum, merely pointing out the similar issues in promoting the acceptance of computer models might ease some insurer's concerns about the uncertainties associated with climate change models.

Is the Time Ripe for a Paradigm Shift?

Some are calling for insurers to take a larger role in the business of catastrophe preparedness, including more emphasis on public/private partnerships (Kunreuther 2000). Among the findings of the International Decade for Natural Disaster Reduction, successful natural hazard reduction does not occur in a vacuum, but rather is integrated with broader societal interests and planning (Hamilton 2000). According to the Reinsurance Association of America:

> **"[The insurance industry] must recognize that it must do more than be a pass-through mechanism for the costs associated with natural disasters."**
>
> — *Franklin Nutter, President, Reinsurance Association of America (Dow Jones 1999)*

Because of the controversy and uncertainties that swirl about the causation of climate change, and in an effort to provide society with the greatest possible protection, the question surfaces regarding whether the moment has arrived to consider an alternative

approach, perhaps a "holistic approach to mitigation"? If so, does the "approach" offered by Dr. Dennis S. Mileti (1997) of the University of Colorado provide a paradigm for the future?

> **"We believe that continuing along the same hazards research and practice will bring increased frustration (and losses) for everyone. We need an approach with much broader perspective so that far more complexity in both natural and human systems can be taken into account. We need a paradigm that ensures true long-term mitigation and loss reduction that is as permanent as we can imagine, avoiding burdening future generations with risk. We need to be able to increase the long-term equilibrium between humans and the environment.**
>
> **We propose a new framework for hazard research and management. Although the new paradigm will embrace the idea of adjusting to the environment, it will go far beyond that. It will be underlain by a global system perspective; it will embrace the concept of sustainability; and it will derive its moral authority from local consensus. We call this new approach "sustainable hazard mitigation. Its goal is not simply reducing losses, but building sustainable local communities throughout the nation. Under the new approach, actions to reduce losses would only be taken when they are consistent with the five other principles of sustainability: environmental quality, quality of life, disaster resiliency, economic vitality, and inter- and intra-generational equity."**
>
> — *Dennis S. Mileti (1997)*

The notion of sustainability is a compelling one, and it has been grasped by many fields and disciplines as a framework for planning towards long-term health and viability of the industry. It is appealing for business-sector applications insofar as in its fullest form it calls for both business sustainability and environmental sustainability, as opposed to a strictly ecological construct separated from economic dimensions. The relevance of sustainable development has been advanced in insurance circles as early as 1992 (Kunnreuther and Roth 1998). Insurers should not be looked to champion this goal unilaterally, but rather as an important partner in a broader mosaic of public and private interests.

Some Guidelines for Successful Insurer/Non-Insurer Interactions

We conclude with some general constructive steps for non-insurance communities wishing to engage with insurers in discussions concerning climate change and climate change mitigation:

- Become a student of the insurance sector. Understand the realities and constraints of its business and regulatory environment. State-level ratemaking, taxation, and investment regulations may limit the degree and/or form of potential insurer involvement. Understand how the Standards of Insurability define when private-sector insurance is viable and when it is not.
- Appreciate that insurer's primary historical and contemporary orientation to natural disasters focuses largely on pre-event preparedness and post-event recovery (a.k.a. "mitigation"). The notion of intervening in the events themselves (e.g., via the reduction of greenhouse gases) may be viewed by insurers as outside of the traditional conception of insurance and risk management, and not a part of their core business.
- Recognize that jargon-filled scientific explanations of climate change can be difficult for the average insurer (and others!) to grasp, although within the industry can be found individuals and organizations that devote considerable time and effort to following the issue.
- Support expansion and extension of current climate science research such that it yields results that are more useful for the insurance sector.
- Design climate change mitigation and "sustainable development" proposals such that they benefit

insurers by: reducing the likelihood of claims, providing new profit centers, helping to retain customers, increasing market share, avoiding unintended liabilities or uncertainties, and avoiding alienating policyholders.

- Seek input from insurers on future propositions regarding climate policy, especially if they involve new types of financial and contractual arrangements that may create new forms of liabilities for insureds.
- Consider the risk-management characteristics (beneficial or adverse) of carbon reduction technologies, be they to do with energy management, energy supply, or forest management and agriculture.
- Understand the relative roles of insurer- and government-provided disaster preparedness and recovery, as well as insurance products.
- Review and understand past governmental interactions with insurers on matters concerning the environment (particularly Superfund). New propositions perceived or intended to follow that model are likely to encourage the antipathy of insurers.

To their credit, insurers have exerted some effort in grappling with the question of climate change—with a focus on the effects of weather-related events—yet most currently find themselves with more questions than answers. Differences in worldview and analytical orientation have served to separate many insurers and non-insurers on the question. Some of these differences may be immutable, but others certainly can be bridged through increased mutual understanding and cooperative research and inquiry. Both communities and their constituencies no doubt stand to benefit from engaging with the other more than has been the case until now.

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APPENDIX A: SIZE AND CONCENTRATION OF THE U.S. INSURANCE SECTOR

The U.S. insurance industry falls generally into two major divisions, Property & Casualty and Life & Health. In 1997 there were 3,366 property-casualty companies and 1,796 life and health companies in operation (III 1999).

Table A-1 provides detail on major market contenders among property/casualty (panel a), life, and health lines (panel b). The table illustrates that for 1999 several companies ranked in the top-20 for net premiums in both the life and property/casualty markets such as Nationwide, Allstate, AIG, and The Hartford. Major contenders in the health markets include CIGNA, Principal Mutual, and Prudential also have major stakes in life insurance.

The market for health insurance is held by a shrinking number of managed care organizations (MCOs), owned by life insurers, and non-profits like Kaiser Permanente & Blue Cross/Blue Shield, and for-profit organizations such as Aetna, United Health Services, and CIGNA (Hoovers 1998; Coventry 1998).

Table A-1. Top 20 U.S. Insurers Ranked by Category and 1999 Net Premiums. (Excludes self-insurance and government-provided insurance.)

[a] Property/Casualty Companies	Premiums Written in 1999 ($ billion)	Market Share (%)
State Farm Group	34.2	11.9%
Allstate Insurance Group	20.8	7.2%
Farmers Insurance Group	10.9	3.8%
American International Group	10.8	3.8%
Nationwide Group	9.2	3.2%
Berkshire Hathaway Insurance Group	8.8	3.1%
Travelers PC Group	8.3	2.9%
CNA Insurance Companies	8.3	2.9%
Liberty Mutual Insurance Companies	8.2	2.9%
Hartford Insurance Group	6.3	2.2%
Progressive Insurance Group	6.1	2.1%
USAA Group	5.2	1.8%
Chubb Group of Insurance Companies	5.0	1.7%
St. Paul Companies	4.8	1.7%
Safeco Insurance Companies	4.5	1.6%
CGU Group	4.2	1.5%
Allianz of America Inc	3.7	1.3%
Employers Re US Group	3.6	1.3%
American Family Insurance Group	3.6	1.3%
Zurich US	3.1	1.1%
Subtotal	169.6	59.1%
All Property/Casualty Insurers	286.9	100%

Source: *Best's Review*, July 2000, p 52

[b] Life/Health Groups	Premiums Written in 1999 ($ billion)	Market Share (%)
Metropolitan Life & Affiliated	27.1	5.5%
Aegon USA Inc	22.8	4.6%
Prudential of America Group	17.8	3.6%
Cigna Group	16.2	3.3%
Principal Life Insurance Co	15.7	3.2%
Aetna Inc Group	15.3	3.1%
Nationwide Group	14.9	3.0%
American International Group	14.2	2.9%
New York Life Group	13.6	2.8%
American General Group	12.7	2.6%
Hartford Life Inc	12.5	2.5%
Equitable Group	11.1	2.3%
Joh Hancock Financial Services Group	10.6	2.1%
GE Financial Assurance Group	9.3	1.9%
Pacific Life Group	9.0	1.8%
Massachusetts Mutual Group	8.9	1.8%
Allstate Group	8.9	1.8%
Citigroup	8.7	1.8%
Manulife Financial	8.4	1.7%
Northwestern Mutual Group	8.3	1.7%
Subtotal	266.0	53.9%
All Life/Health Insurers	493.2	100%

Source: *Best's Review*, July 2000, p 86

APPENDIX B: CLIMATE CHANGE RESEARCH AND THE INSURANCE SECTOR

Climate change modelers analyze historical climate records to understand cyclical climate patterns, establish ranges and distributions of natural variation, and conduct validation studies by performing model simulations of prior periods. They employ geophysical, chemical, fluid dynamic, and thermodynamic principles to simulate changes in climate. The primary means of testing these models is to see how well they simulate climate changes from prior to contemporary periods, taking into account that much natural variability exists within the entire climate system. The major task of these models is to project changes in atmospheric chemistry (such as increases in greenhouse gases, ozone losses, and sulfur emissions which deflect incoming solar radiation), and simulate the resulting impacts on temperature, precipitation, humidity, wind speed, and barometric pressure, vegetation, and sea level. The discussion below considers the applicability of these models to the interests of U.S. insurers.

Long-Term Time Frame of Climate Projections

These models typically simulate future climate conditions where greenhouse gases are twice the level of pre-industrial-revolution conditions, or, as frequently noted "2xCO_2". Depending on the assumed rate of growth of greenhouse gases, these models generally look into the future as far as 2050 or 2100. The long-term time scale of these projections limits their utility for most U.S. insurance companies, for whom property, casualty, and health policies are renewed on a much shorter, annual basis.

Uncertainty Associated with Local-Scale Projections

Climate models operate on global, regional, and local scales. General circulation models (GCMs) have a global focus. GCMs incorporate feedback from land and ocean regions. Some laboratories have sought to reflect climate interactions with forests and vegetation, suggesting areas of ecosystem resilience (CO_2 absorption) and weakness (forest die back due to heat, dryness, and pests) (Hadley Centre 1998). GCMs offer generalized predictions of changes in temperature, precipitation and barometric pressure over areas of 3 degrees latitude x 3 degrees longitude (an area roughly equivalent in size to the state of Oregon). Computing constraints require that modelers represent the earth and its atmosphere as a system consisting of a limited number of distinct geographic areas, also known as "data points". GCM modelers average a huge array of climatic parameters for an area several hundred kilometers by several hundred kilometers into one single data point. For example, an area including high desert, temperate rain forest, irrigated agriculture, mountains, and sprawling urban expanses might be represented as a single spot of land with the one representative set of vegetation, slope, elevation, wind, sunlight reflectance and evaporation characteristics. Work is underway to reduce the size of these measurement areas so as to improve the representation of land, ocean, and climate properties. Regional and local scale models have advantages of reproducing climate variability and storm events with greater spatial resolution.

Recent work on wildfire modeling provides one example of "downscaling" GCM analyses in ways with increased relevance to insurers. Torn *et al.* (1998) scaled GCM results to local (county-scale) levels for parts of Northern California, and integrated this information with wildfire models that could account for the propagation of fire in different vegetation types and for the limits of existing fire-suppression infrastructure in the state. The results showed up to a four-fold increase in wildfire severity, given full deployment of existing fire-suppression resources.

While insurers might draw the most utility from localized projections for hurricanes and other rapid onset events, local climate model forecasts contain a

high degree of uncertainty. The Intergovernmental Panel on Climate Change has projected changes in extreme weather as global warming advances, with some areas seeing increases and others seeing decreases in storms and floods, but has cautioned that the greatest uncertainties in climate modeling extend to the most local scales (IPCC, Sect 6.5 1996). Similarly, the Insurance Services Office (ISO), a prominent property/casualty insurance information and consulting firm, questioned the value of global warming theory for predicting future hurricane risks. The report advised against rate filings for hurricane coverage based on global warming predictions, contending that:

> **"[Such projections are] the subject of disagreement among experts, [which] have not established a definitive record for reliability and accuracy..., and have large variability, making them unacceptable for projecting relatively small year-to-year changes in catastrophe activity."**
>
> — *Insurance Services Office (1994)*

Thus, in addition to concerns about the long-term nature of climate change predictions, insurers will need more confidence in localized predictions before voluntarily incorporating them into their pricing and underwriting.

Climate Impacts as Signals of Climate Change

Despite the limited applicability of long-term and somewhat uncertain climate change forecasts, various groups, including several of the foreign insurers participating in UNEP Insurance Industry Initiative, have spotlighted the rise in weather-related insurance claims as a possible sign of climate change. Much research has attempted to identify potential signals of a changing climate (Easterling *et al.* 2000). For those skeptical about climate change, however, the alleged linkage between climate change and the sudden rise in insurance claims is subject to scrutiny. The examples below review some of the uncertainties behind the assertion that the recent increase in disaster claims is related to climate change.

Enhanced Atmospheric Moisture and Flooding

Perhaps one of the more certain insurance-related predictions offered by GCMs and empirical research is an increase in atmospheric moisture as warmer conditions increase rates of evaporation and transpiration. Researchers at NOAA have documented a 10% increase in precipitation over the contiguous 48 states since the beginning of the century, with half of this increase attributable to 1-day events producing 2 inches or more of rain (Karl and Knight 1998). Such evidence for a more intense hydrological cycle may account for observed changes in flood frequency and severity, and ultimately may enhance tropical storm intensity.[62]

While the 1990s brought major floods to areas like the Midwest (1993), the Willamette Valley (1996), Grand Forks (1997), and the Ohio River (1997), scientists have not concurred that these events represent a trend to increased flood severity due to changes in precipitation intensity. A team of U.S. Geological Survey researchers have found a rise in average stream flows based on 1944-1993 daily mean discharges from 395 stations, but no clear change in extreme events on a national basis (Lins and Slack 1999). A prior study of 206 climatically sensitive streams (not biased by human disruption) found increased intensity in extreme events in the Midwest, but decreases in extreme events in the Pacific Northwest (Lins and Slack 1997). While results like these are consistent with IPCC predictions of regional increases and decreases in extreme events, several researchers are more inclined to implicate riparian disruption like flood controls, channelization of waterways, land uses, and de-vegetation than global warming for any change in flood severity (Pielke 1998a and 1998b; Pielke and Landsea 1998). As mentioned previously, governments have attributed much of the flood damage in China and Central America during 1998 to land-use problems.

At least one U.S. insurer, Arkwright Mutual, has conducted research into flood severity based on U.S. Geological Survey data from 2,432 stations from 1940-1993. Prompted by an increase in commercial flood claims not covered by the federal flood insur-

[62]One study has called for more varied indices of rainfall intensity than Karl *et al.*'s measure of 2-inches-in-one-day. Pielke et al. (1998) found that extreme flood events for any particular region depend on a variety of rainfall intensity indices, including rainfall in 2, 3, 4, or 5-day stretches.

ance program, Arkwright's climatologists documented a national trend to increased mean stream flow (Zeng and Kelly 1997) similar to Lins and Slack (1997). Similar concerns have been raised by the Association of British Insurers (Aldred 2000; Business Insurance 2000a). Their research attributes these changes to aforementioned land uses and hydrological controls, but also to climate changes and increased precipitation intensity. It is interesting to note that whereas Lins and Slack (1997; 1999) downplayed a change in flood severity based on one measure—extreme flood events—an insurer with similar findings but exposed to a surge in commercial property flood claims did not shy away from implicating a change in climate. The resonance of Arkwright's findings might be limited by the divergence of opinions concerning flooding and global warming and by the fact that commercially-available flood insurance coverage is limited to the non-residential insurance market.

Climate Change and Tropical Storms

Like the major floods of the 1990s, the losses generated by recent major hurricanes, especially Andrew (1992) and Mitch (1998), have captured much public attention as potential harbingers of global warming (Balling 1997a). Wracked by huge hurricane losses, insurers have identified hurricanes as a top priority for climate research at the Risk Prediction Initiative (Knapp 1997). From a standpoint of statistical significance, however, changes in hurricane frequency and intensity have not been the clearest signal of a changing climate (Landsea 1993; Lighthill *et al.* 1994, Henderson-Sellers *et al.* 1998) in a period where other potential signs of climate change have emerged, like record high temperatures, increases in atmospheric moisture, increases in rainfall severity, glacial retreat, coral bleaching and changes in species migrations (IPCC, Sect 3.25 1996).

NOAA researchers have identified an upward global trend in the number of severe tropical storms since 1970, but any increase may be attributable to improved data collection in previously underreported regions (Henderson-Sellers *et al.* 1998). While forecasters predict that we are entering a period of more frequent, intense cyclones, as discussed below, these experts attribute this to natural climate cycles (Gray 1997). It is possible that the contrast between media reports linking hurricane severity to global warming and the accounts of several hurricane experts may have fueled some insurers' skepticism about global warming research in general.

Looking farther into the future, a projection of the effects of increased atmospheric moisture and warmer temperatures on tropical storms is complicated by the many factors controlling storm formation and intensification. Some researchers have suggested an intensification of tropical storms is possible with global warming (Holland, 1997; Emanuel 1991; Haarsma 1992). Several very recent attempts to simulate future tropical cyclones under global warming scenarios do show increases in hurricane intensity (Knutson & Tuleya 1999; Tsutsui *et al.* 1999), though a consensus still suggests that climate models need greater resolution of more localized climate features like El Niño before strong predictions of future hurricane threats might be made (Henderson-Sellers *et al.*1998).

Analyses of Claims v Major Weather Events

Two recent studies of weather-related insurance losses also give less recognition to global warming than other influences. One study on hurricane losses (Pielke and Landsea 1998) and another on general weather-related property & crop insurance (Changnon *et al.* 1997) have attributed most of the recent run-up in U.S. insurance losses to demographic factors, policy changes, and cost inflation. The former study suggests that if the 1926 Miami hurricane had happened recently, the losses would have exceeded all records, topping $50 billion. The Changnon *et al.* (1997) study finds that extreme weather-related losses, while excessive for the period 1990-1994, were not too different from losses in the period 1950-1954, when claims are adjusted for inflation, wealth and expanded coverage. While the authors admit that the claims adjustment methods for these studies warrant further study, the underlying message is that at this point changes in insurance claims may not be the strongest proxy for a changing climate.

El Niño: More Convincing Connections to Global Warming?

The record-breaking strength of the 1997-1998 El Niño and its associated spike in global temperatures, however, have drawn much attention to the needs for further investigation. Currently, all of the world's climate research laboratories have initiated attempts to incorporate El Niño/Southern Oscillation (ENSO) predictions into their GCMs (Mazza 1998). Similarly, insurers through the Risk Prediction Initiative have sponsored research into means of parameterizing catastrophe loss models for ENSO predictions (Malmquist 1997). The links between ENSO cycles and various climate risks like wildfires, floods, windstorms but especially hurricanes may present opportunities for collaboration with insurers. Since El Niño events generally impede the formation of intense North Atlantic hurricanes (Gray 1984; Gray and Scheaffer 1991), insurers and climate researchers could benefit from developing more complete historical records of El Niños and investigating El Niño predictions under global warming scenarios.

Earlier studies of El Niño under global warming suggested more persistent and intense El Niño conditions (Meehl and Washington 1996; Knutson and Manabe 1995; Knutson *et al.* 1997)), but more recent studies (Timmermann *et al.* 1999; Collins 2000; cited from Meehl *et al.* 2000) have simulated an intensification of both El Niño and La Niña extremes. As mentioned above, stronger La Niña events could lead to more disastrous hurricane conditions. Clearly, insurers have much to benefit from better forecasting of ENSO trends(Meehl and Washington 1996; Knutson and Manabe 1995; Knutson *et al.* 1997).

Greater familiarity with ENSO research also might offer insurers more compelling evidence for the existence of global warming than has been the case with the study of hurricanes. Recent research suggests that, with statistical significance, the strength of the most recent El Niño was most likely the result of warming from greenhouse gas accumulation and not natural variation (Knutson and Manabe 1998; Trenberth 1999). Recent paleo-climatic research also suggests that current El Niños are approximately twice as potent as compared to 6,000 years ago (Otto-Bliesner 1999).

Weather-Related Catastrophe Modeling

As a result of recent weather-related catastrophe losses, U.S. insurers have acquainted themselves with the climate sciences mostly through investigations of climate extremes and climate catastrophe modeling (CAT modeling). An important consideration in their investigations is the orientation to use parameters based on available empirical evidence, rather than parameters derived from global warming simulations.

Many property insurers employ CAT models for purposes of risk diversification, solvency testing, and insurance rate filing. Reinsurers in many markets are bundling CAT modeling services as part of their overall package to insurance customers (Roberts and Unsworth 1998). As of late 1997, one particular CAT model was in use with 65 insurers representing about 40 percent of total U.S. property insurance premiums and with 80 reinsurers covering 90 percent of the U.S. catastrophe reinsurance market (*Federal and State Insurance Week* 1998).

CAT models draw upon the expertise of actuaries, statisticians, engineers, and climatologists. CAT models include computer modules that simulate the incidence of weather-related disasters, most commonly hurricanes, based on statistical distributions of climate *history*. Subsequent modules assess damages to insured buildings according to wind stresses and construction types, and translate these into losses based on policy provisions (Musulin 1997). Very recent models attempt to reflect the relative protective qualities of risk mitigation measures aimed at fortifying roof coverings and roof-wall connections (*PRNewswire* 1998). The utility of such features will depend on the availability of policyholder data concerning building fortifications. As compared to general circulation models with 3 degrees x 3 degree points of resolution, CAT models estimate losses at resolutions even more exact than zip code regions. However localized, the reliability of these loss estimates is the subject of considerable debate.

Hurricane CAT models offer an alternative to the traditional actuarial procedure for estimating premiums. The existing procedure estimates the cost of excess wind damage as a percentage of the cost of all other property coverages over a 20-30 year period

(Musulin 1997). In effect this procedure reflects loss information in terms of premiums for non-wind coverages. The mixing of claims data with premium information on an industry-wide level was acceptable as long as the relationship between wind damage claims, premiums, and coverage levels remained steady. This method, however, has not adequately accounted for increases in coverage levels resulting from demographic shifts, liberalization of policy provisions, and increases in wealth and costs of building repairs (Musulin 1997). The growth in coverage in coastal areas beginning in the 1960s also has coincided with a relatively mild period for tropical storms. As several hurricane forecasters predict an increase in the frequency of intense hurricanes, the past 30 years of hurricane losses represents an inadequate basis for estimating premiums. CAT models, in contrast, estimate the probability of land falling hurricanes according to longer term historical distributions of storm incidence and severity. CAT models translate the potential impact of excess wind risks in terms of *current* loss exposures and policy provisions.

Insurers in most states must rely on historical loss data to support premium levels. In some instances, they may apply for rate increases if they can identify credible trends in loss severity, frequency, or inflation. Property insurers filing for rate increases along the southern coastal states have argued for the use of CAT models which predict future catastrophe losses based on statistical distributions of climate history. Insurance regulators generally have shown greater sympathy for policyholders, who, in many cases, would face substantial premium increases as a result of modeled catastrophe charges, and have either restricted (South Carolina and Florida), denied (Georgia), or are still investigating (Louisiana and Texas) the use of CAT models (*Insurance Network News* 1997; Bradford, 1997a; Gjertsen 1997). Much of the resistance stems from the fact that CAT models are proprietary and not subject to broad public review. Like insurance consumers and regulators, many insurers lack the expertise to understand or evaluate the inner workings of these models (Ceniceros 1997). Modelers contend that the enormous development costs of computer routines to simulate storms and stresses from wind, precipitation, and flying debris on buildings requires significant investment which would be lost with public review (Musulin 1997).

Regulators in several states including Florida have established expert review panels to test the validity of CAT models. The first model to pass inspection in Florida, from Applied Insurance Research, when tested to simulate losses from 13 hurricanes since 1983, estimated losses at $926.4 million versus actual losses of $964.6 million, a difference of only 4% (Niedzielski 1998). As with any prediction mechanism, CAT model loss estimation improves as the sample number of storms increases. Critics have taken issue with the fact that results for simulating a *single* storm event can vary among different models (Gjertsen 1997).

Regardless, results like these have not satisfied the concerns of many consumer groups nor other elected insurance officials. In Florida, for instance, in spite of CAT model approval, the insurance commissioner, Bill Nelson, has sued to block rate increases based on CAT model calculations, leading to arbitrated settlements (Adams 1998). So far, insurers have gained at least a portion of their rate increases. State Farm won most all of its requested 23% rate increase (averaged statewide), whereas the Florida Windstorm Underwriting Association, a residual insurer for windstorm coverages, gained approximately two-thirds of its requested 3-year rate increase of 62% (averaged statewide) (*The Insurance Regulator* 1998). In light of these rate concessions, Nelson has pushed to have the legislature ban the recently introduced arbitration mechanism for settling rate disputes (Florida Insurance Commission 1998). Thus, while insurers in Florida have managed to gain some measure of rate adequacy due to filings based on CAT modeling, public resistance to the ensuing rate increases has not subsided.

When considering CAT modeling in the context of global warming, reinsurers like American Re have argued that CAT models only reflect the historical record, and may yet be inadequate in the face of global warming (Del Prete, quoted in Bradford 1997a). Given the constraints on insurers for venturing outside the bounds of traditional actuarial practices, any consideration of potential climate changes due to global warming let alone more recent climate cycles would probably meet strong opposition.

Weather Predictions

Several studies and predictions concerning changes in tropical storm intensity also have relied on evidence of climate cycles, as opposed to theories of greenhouse-gas forcing. Several key researchers in the field of hurricane research have offered ample evidence for correlations between the frequency of extreme hurricanes and climate cycles such as ENSO and the multi-decadal oscillations of the Atlantic Ocean's thermohaline circulation (Landsea 1991; Gray 1997).[63] As mentioned above, data indicate that El Niño events produce a wind sheer effect that tends to disrupt cyclogenesis in the Atlantic, resulting in fewer intense hurricanes. Other research, advanced by Bill Gray of Colorado State University, shows connections between intense hurricanes and several climatic cycles of varying duration, including:

- the relative strength of the Atlantic thermohaline circulation,[64] associated with rainfall patterns over the Sahel desert and the Gulf of Guinea; (complete cycle: 50-70 years)
- the strength of an El Niño or La Niña event (complete cycle: 3-7 years)
- the presence of wind sheer over various trophospheric altitudes over the Atlantic (Quasi-Biennial Oscillation) (Gray 1997)

The period from the late 1960s to roughly 1994 coincided with a cycle in the Atlantic thermohaline circulation associated with fewer intense hurricanes, whereas the ensuing period may result in greater hurricane risks.

Some prominent weather experts, including Bill Gray, have downplayed the links between global warming and any recent changes in hurricane severity or frequency. At the April 10th 1998 National Hurricane Conference[65] in Norfolk, VA, Gray said, "the changes in climate that the world is experiencing are natural" and attributed most of the recent global climate changes to shifts in ocean currents and temperatures (*Greenwire* 4/14/98).[66] Two former directors of the National Hurricane Center have taken similar positions. The Director of the National Hurricane Center from 1987 to 1995, Robert Sheets, has essentially affirmed Gray's theories (Leggett 1993; Sheets 1995). Speaking at the same April 10th 1998 conference, another former NHC director, Neil Frank, claimed that climate change "Has nothing to do with carbon dioxide," and that "the atmosphere is too complex and the computers too slow" to make long-term climate forecasts, and that he was aware of no data "that should force the U.S. into quick decision on CO_2 emissions" (*Greenwire* 4/14/98). In addition to the 1994 ISO reports endorsing Gray's position on hurricanes and global warming, others have noted similar adherence among insurers to Gray's views. In an interview with *Claims* magazine, Gary Kerney of Property Claim Services, who hears many U.S. insurer opinions on natural disasters, noted that he found insurers more persuaded by theories on the causes of hurricane frequency of intensity like Gray's than global warming (Thorness 1998).

It should be recognized that even the more credible predictions such as recent ENSO warnings or Gray's hurricane divinations are of limited value to insurers. Insurers have issued numerous public safety warnings for hurricanes, and more recently for extreme weather impacts due to the 1997-1998 El Niño event. Other than a few business coverages for supply disruptions, event cancellations, changes in heating oil prices due to weather events, or waiting periods for flood, windstorm, or crop coverages (Bradford 1997b; Hudson and Craig 1998), insurers have not incorporated climate cycles in their pricing or risk selection (Hofman 1998; Noonan 1997).

Current regulatory resistance to CAT models gives some idea as to the fights insurers might face

[63]The appendix on hurricanes of ISO's report "The Impacts of Catastrophes on Property Insurance" (1994), which questioned the value of global warming theory for predicting future hurricanes, frequently cites the research of Christopher Landsea and Bill Gray.

[64]The thermohaline circulation gets its name from the capacity of salt laden waters in the North Atlantic to sink, perpetuating a cycle of water that flows north along the surface of the East Atlantic, descends in the North Atlantic and continues south at depth along the West Atlantic. The strength of this circulation depends in part on the relative salinity of water in the North Atlantic. Glacial melts from poleward regions can reduce salinity, weakening the current, whereas, salt build up from a weaker current can re-activate the current.

[65]Among the sponsors for this conference are the Insurance Information Institute and the Institute for Business and Home Safety, an insurance organization promoting safety against natural disasters.

[66]In light of these observations, at a May 15, 1997 conference, *Hurricane Mania*, sponsored by Employers Reinsurance, Gray complained that federal funding for tropical storm research paled in comparison to the billions.

trying to reflect short-term climate cycles in pricing and coverage limitations. In response to questions about preparing for ENSO events, some insurance officials have commented that they strive for rate adequacy over the entire course of a 3-7 year climate cycle (Hofman 1998; *Reinsurance Magazine* 1998). Achieving rate adequacy over longer-term cycles, such as the Atlantic thermohaline circulation (50-70 years), is an entirely different challenge given the extreme variability of windstorm losses. Reinsurers, on the other hand, have had greater flexibility in adjusting rates according to short-term forecasts, and generally have been more public in expressing their concerns about global warming. For example, the president of the Reinsurance Association of America (RAA) has frequently advocated for funding for climate change research and insurer awareness of the issue.

APPENDIX C: FEDERAL INSURANCE PROGRAMS[67]

National Flood Insurance Program

A program administered by the Federal Insurance Administration that provides flood insurance under the National Flood Insurance Act of 1968. A number of private insurers are under contract to the NFIP to administer the program. These insurers issue the program's Standard Flood Insurance Policy, they are reinsured for 100% of any flood losses by the federal government, they collect the premium, and they adjust the losses. They receive a percentage of the premium for commission, taxes, and allocated loss adjustment expenses. As of 1998, 4.1 million policyholders participated in the program (III 1999).

Federal Crime Insurance Program

A crime insurance program that protects personal property of homeowners, tenants and small businesses located in high crime areas against burglary and robbery. The program is administered by the Federal Insurance Administration.

Crop Insurance

Growing crops are subject to numerous perils — bad weather, hail, fire, flood, insects, disease. Policies may cover one or more of these perils through the Federal Crop Insurance Corporation or private insurer. Generally, coverage is effective 24 hours after an application is received. Coverage is reduced proportionately as harvesting progresses and terminates when the harvest is complete. There is a long history of federal crop insurance, dating from the establishment of the Federal Crop Insurance Cor-poration in 1938 (GAO 1994). Government has since been in a constant process of trying to make the program actuarially sound, and, despite continued efforts to reduce their exposure, has not attained this goal.

Social Security

The social insurance program enacted by the Social Security Act of 1935 (U.S. Code Title 42, Chapter 7) and amendments (also called Old Age Survivors, Disability and Health Insurance). Benefits are funded by both employer and employee taxes under the Federal Insurance Contributions Act. The program includes pension benefits, survivor benefits upon and employee's death, and benefits for workers younger than retirement age who are physically disabled. Early retirement age under Social Security is 62. Full retirement ranges from 65 years for people born before 1938 to 67 years for people born after 1959. The general view is that the pension program is inadequate as a retiree's sole income, but is merely supplemental to the individual's private pension plan, insurance or annuity, and other investments.

Supplemental Security Income

A program of the Social Security Administration that provides monthly payments from general U.S. Treasury funds to people with limited incomes and assets. The program is designed to assist citizens over 65 years of age and people of any age who are blind or disabled.

Medicaid

A state medical benefit program for persons, regardless of age, whose income and resources are insufficient to pay for health care. As of January 1966, federal matching funds were provided to states under Title XIX of the Social Security Act.

Medicare

A federally administered program of hospital insurance (Part A) and supplementary medical insurance

[67]Unless otherwise noted, the following definitions were taken from Rupp (1998).

(Part B) primarily for people over 65, created by 1965 amendments to the Social Security Act. It also covers people of any age with permanent kidney failure and certain other disabilities. The Health Care Financing Administration in the U.S. Department of Health and Human Services reimburses hospitals and physicians for services to qualified patients. Part A (hospital in-surance) coverage is automatic for all eligible people and is financed by a payroll tax on employers and employees. Part B (supplementary medical insurance) is a voluntary program of government-subsidized insurance requiring participants to make premium payments.

Nuclear Power Insurance

In an example of government-provided reinsurance, the Price Anderson Act of 1957 provided for government payment of claims in excess of a threshold that could be covered by private insurers. Entities involved included the Nuclear Energy Liability Insurance Association and the Nuclear Energy Property Insurance Association (Whitney 2000).

APPENDIX D: CAPITAL MARKET ALTERNATIVES FOR FINANCING RISK

Four major types of alternative risk financing mechanisms are currently in use:

Contingent Surplus Notes

The contingent surplus notes are arranged permitting insurers and reinsurers at their option to obtain funds by issuing surplus notes. The notes are made available to a primary insurer or reinsurer through a contingent surplus note (CSN) trust. The trust holds the investor's funds placing them in readily liquid investments for fixed periods of time. The insurer can exchange the investments in the trust for surplus notes that issues to the trust. Thus, a readily available source that will purchase the notes is present in the event of a catastrophe. The inducement to the investor is the receipt of a higher rate of return than that available from other liquid investments. The cost to the primary insurer and reinsurer for the option to issue the surplus notes is the difference between what the investors receive and the return on liquid securities purchased by the trust. If it exercises its right to issue the surplus notes, the insurer must repay the principal and interest to the CSN trust over time so that funds are available to render a return to the investor.

The sure availability of funds after a catastrophe at a prearranged rate of interest is the major benefit of contingent surplus notes.

Catastrophe Equity Puts

The catastrophe put is a right to sell an insurers' equity stocks at a predetermined price in the event of a catastrophic loss. The "equity put agreement" established with a capital provider, makes available funds at a predetermined price in the event of an agreed upon catastrophic event, and in doing so replenishes surplus, permitting the insurer to continue to operate unimpaired, i.e., write new business and pay losses.

Catastrophe Bonds

Catastrophe bonds are issued to capital providers who receive interest and principal repayments provided no catastrophe loss occurs. In the event of a loss, the bond provides that the repayment of interest and principal, or both, are reduced. The monies derived by not having to pay the interest and principal are used to pay losses thereby transferring that portion of the loss, should it occur, to the investor.

Catastrophe Insurance Futures

Catastrophe insurance futures provide an insurer and/or reinsurer with a type of fence against insured catastrophe losses. The futures contract is an "agreement to buy or sell a specific amount of a commodity or financial instrument at a particular price on a stipulated future date" (Downes and Elliott 1985). Historically futures contracts were used for agricultural commodities, such as barley, oats, wheat, or pork bellies. More recently they have been utilized as financial instruments, such as treasury bills and insurance futures contracts.

The insurance futures contract price is based upon the future value of an index. The "index" is predicated on a loss ratio — a formula used by insurers to relate loss expenses to income: (incurred losses + loss adjustment expenses) ÷ earned premiums. These indices are developed for insured catastrophe losses that occur in a certain geographical area over a specified time period. For example, if there is an unexpectedly large amount of insured catastrophe losses during the specified period, in the prescribed area, then the index rises and the buyer (insurer) of the contract benefits since the contract rises in value. On the other hand, the seller loses since they must advance the money to pay for the increase in value of the contract to the buyer. Conversely, if there was a smaller amount of insured catastrophe losses, the index would fall and the seller would gain.

To calculate the final value of the index, values are established at the start, during and after the loss period. During the loss period the index will rise and fall depending upon the frequency and severity of the experienced events and development of the insured losses. Ultimately, the value of the futures contract may not depend on the value of the index but rather the supply and demand of the buyers (insurers) and sellers in the futures market.

Brokers have arranged several public offerings of these instruments, but they have yet to materialize into a major catastrophe financing resource. CAT bonds and CSN Notes have had perhaps the greatest market penetration with over $2.7 billion in issues through 1998 (McDonald 1999). CAT options as of April of 1998 provided $80 million in reinsurance (Boriaux, 1998). Chicago Board of Trade representative, Sylvie Boriaux (1998) explains that the relatively small market for these options is due to the fact that most states' insurance laws have yet to recognize the reinsurance value of these options. Others suggest that an insurer's book of business may not correlate with an industry-wide catastrophe loss index (*Bestwire*, 1/15/99). Another factor impeding their growth is that traditional reinsurance prices have sunk almost to levels prior to Hurricane Andrew (Nutter 1998 and Figure 12).

Alternatives to Financing Risk in Practice

One interesting development, however, is that reinsurers and insurers increasingly are setting up their own capital market divisions, and investment banks are opening reinsurance divisions (Chookasian and Ward, 1998; *Bestwire* 1/15/99). Lehman Brothers transferred 10% of the firm's capital ($500 million) to start Lehman Re, while Goldman Sachs has launched Arrow Re (*The Insurance Accountant* 2/8/99). These divisions will sell traditional reinsurance for catastrophe and other risks, and securitize their contract, like mortgage backed securities, in the form of CAT bonds, equity puts, or other options (*Bestwire* 1/15/99; Zolkos, 1998). Investor demand for these instruments at this point seems healthy based on a recent, oversubscribed CAT bond offering of $477 million for the United Services Auto Association (McLeod 1998). Like mortgage back securities, CAT bond offerings are packaged into tranches, or subgroupings with different risk characteristics, which recently have accorded ratings from organizations like Moody's, Standard & Poors and Duff & Phelps. One tranche might only put the interest portion at risk, whereas a riskier tranche paying a higher yield might put both interest and principal at risk if a catastrophe trigger occurs. Unlike mortgage securities which tend to be repaid when interest rates fall (and homeowners refinance), CAT bond risks are supposedly uncorrelated to general financial indicators[68]. A test of these instruments is whether investors will want them after a major catastrophe strikes. Boosters for these arrangements predict that if a big catastrophe hits, investors may flee at first but insurer demand will lure them back (McLeod 1998). Some predict that the H.R. 21—Federal Catastrophe Reinsurance—also will spur these arrangements as more state catastrophe funds emerge and need large capital sources (Chookasian and Ward 1998).

Property insurers seeking passage of H.R. 21 have contended that neither derivatives nor private reinsurance nor hybrid combinations thereof can provide the capacity for major catastrophic events at a reasonable cost. Arguing for federal catastrophe reinsurance, Jack Weber (1998), president of the Home Insurance Federation of America, a trade group of the nation's largest property insurers, contended that reinsurance costs for large multibillion dollar catastrophic risks are too high to pass on to the public. Weber cited an example of the cost of coverage for the California Earthquake Authority (CEA), which had maximum loss exposures of $7.5 billion. The CEA self-insured 2/3 of this risk with half of its premium and reinsured the remaining 1/3 with the other half of its premium. In this case, reinsurance cost twice as much as self-insurance. With the use of capital market instruments, Weber argues, investor

[68]The Captial Asset Pricing theory contends that investment risk can be minimized through diversifying asset classes and their underlying industries, such that their asset returns are uncorrellated. Since natural catastrophe losses have no apparent ties to economic cycles, they would appear to help diversify risks in an investment portfolio. This theory remains to be tested in real life. If catastrophes result in substantial economic losses affecting stock markets, financial risks associated with CAT instruments might actually correlate with equity market swings, diminishing their diversification value, however, this seems unlikely (a) scale is too small or (b) reconstruction boom will lift stock market.

demands for return on investment could make their underlying costs even higher for insurers.

As an insurer of last resort, the CEA can charge rates corresponding to these costs, but regulators impede private insurers from charging rates exceeding actuarial costs. The pricing constraints on private insurers for insuring large catastrophe risks, Weber contends, will limit the popularity of reinsurance for large risks, whether or not supported by capital market offerings. As the market for CAT derivatives is still in a development stage and no major events have triggered principal default, one can only speculate on its attractiveness to insurers and state run catastrophe funds.

A False Sense of Security?

Federal reinsurance and reinsurance backed by capital market offerings may offer transitional coverage for areas susceptible to catastrophe risks. Ideally these mechanisms would coordinate with strong and popular financial incentives to mitigate for catastrophes, i.e., not just high deductibles, but low interest loans with offsetting premium credits, as Kleindorfer and Kunreuther (1997) suggest. Several proponents of a federal catastrophe reinsurance program (H.R. 21), home construction and realty groups, have endorsed the flexibility it gives to states to adopt mitigation measures appropriate for their individual circumstances. Critics of H.R. 21, however, argue that the federal catastrophe reinsurance proposal requires too little from purchasers to address mitigation. Given the relative apathy among homeowners about mitigation, the lack of strong language concerning mitigation in H.R. 21 should be a cause for concern.

Another issue to consider is that if federal catastrophe reinsurance increases capacity for underwriting major catastrophic risks, will insurers and states have adequate incentives to mitigate? As reinsurance capacity increases, so does competition among firms, which tends to depress prices and underwriting demands. If federal catastrophe reinsurance and/or expanded reinsurance capacity from capital markets put downward pressure on pricing and underwriting, might insurers and policyholders have less incentive to mitigate in high risk areas? Reinsurers and insurers might still have some incentive for mitigation if they intend to retain CAT bond investors, but this incentive is probably little different from the incentives they face today using their own risk capital, which—as Kleindorfer and Kunreuther (1997) note—they hardly act upon in immediately effective ways.

From the standpoint that disaster mitigation is a feasible solution to enhanced weather related disasters (whether or not related to climate change), current efforts to expand reinsurance capacity probably do not encourage adequate preventive measures. Even if proper incentives for mitigation existed, the effectiveness of current windstorm mitigation efforts against a changing climate is not a certainty. Several weather related preventive measures consider coastal regions, but none seriously consider rising sea levels, one of the more sound predictions related to climate change. If climate change means a more invigorated cycle of El Niño or some other sequence of extreme weather, interior and coastal regions might be at risk, which might call for more widespread preventive efforts.

Until insurers and public authorities can identify risk patterns and mitigation priorities, a changing climate could leave insurers and populations vulnerable to unforeseeable exposures. While preventive measures might be possible with enough political will and economic resources, insurers can only fortify them against identifiable hazards. Rather than rely on a limited capacity to identify and mitigate such risks as they arise, investments in greenhouse-gas mitigation at least might reduce the uncertain hazards of a changing climate. It is for circumstances like these that UNEP/III participants have campaigned to neutralize the advance of global warming. Publicizing the risks associated with global warming and supporting abatement measures probably would substantially advance U.S. insurer demands for hazard mitigation.

APPENDIX E:[69] AMERICAN INSURANCE ASSOCIATION POSITION PAPER

PROPERTY-CASUALTY INSURANCE AND THE CLIMATE CHANGE DEBATE: A RISK ASSESSMENT

Introduction

In the vigorous national and international debate over climate change—also referred to as "global warming"—questions have been raised about the impact of potential changes on property-casualty insurance. Property coverage is an important product offered by the insurance industry, and weather-related events are one of the key perils that people seek to cover when purchasing insurance policies. Thus, some parties in the debate perceive home and business insurance among weather-sensitive industries that could be most adversely impacted by climate change.

The American Insurance Association (AIA) believes that advocates of aggressive climate change action have overestimated the vulnerability of the U.S. property-casualty insurance industry to climate change. A more refined picture of potential risk emerges when information is presented on how the industry operates; its diversity in terms of types of insurance coverage; its financial strength; and how it responds to weather variability, flooding, hurricanes, hailstorms, severe winter storms, and tornado events.

The critical challenge facing the insurance industry with regard to weather-related exposure is the significant risk from hurricanes that has grown exponentially in recent decades due to rapid growth in population and development along vulnerable coastlines. However, current research indicates that projected climate change will not add measurably to this risk. This paper analyzes the extent to which weather exposures impact various lines in the property-casualty insurance industry and the business as a whole. Next, it describes how insurers evaluate risk and respond to changes in loss experience via the rating system. Although many aspects in climate change science are uncertain, the paper discusses how climate change scenarios presented thus far in the scientific debate could impact the property-casualty insurance industry. In addition, the paper reviews how insurers are monitoring climate change science and describes the potential role of property-casualty insurers in the ongoing debate.

Climate Change Background

In 1996, the United Nations Intergovernmental Panel on Climate Change (UN-IPCC) concluded that increasing concentrations of greenhouse gases, including carbon dioxide and methane, have the potential to raise average global temperatures from 1-3.5 degrees Celsius (3-7 degrees F.) during the 21st century. The consensus report of some 2,000 scientists of the IPCC states "that the balance of evidence suggests that humans are having a discernable impact on global climate." The report also hypothesizes that, unless steps are taken to reduce the accelerating levels of carbon dioxide and other greenhouse gas emissions into the atmosphere, an increasingly warmer and more volatile climate will result. The UN-IPCC has projected a variety of weather-related changes that could be generated by the increased warmth including:

- Rising sea levels that could inundate coastal development in the U.S., other nations and some low-lying islands around the world;
- More intense rain, hail and thunderstorms with increased precipitation from single events in some regions resulting in more frequent and damaging floods;
- Severe droughts in some regions, potentially increasing wildfire risk; and
- A variety of impacts on forestland and agriculture, some positive and some negative.

[69]Note: The version included here contains AIA-provided corrections to the data table originally published in the April 1999 version of this paper.

The science of climate change and its potential impact on weather is far from settled, including issues as to how much excess carbon dioxide now being produced by humans can be assimilated by "carbon sinks" such as forests, thriving agricultural land, and the oceans. Some scientists believe that increased cloud formation stemming from a warmer and wetter climate could temper some predicted warming. Others are conducting intensive research on polar ice caps. One hypothesis is that warming may actually increase snowfall in polar regions that are now very dry, adding to Arctic and Antarctic ice-caps and decreasing the risk of sea level rise.

After the 1996 UN-IPCC report was issued, most of the world's nations met in Kyoto, Japan during December 1997 to negotiate commitments for reduction in the release of greenhouse emissions. Follow-up negotiations to address more specific ways of reducing global emissions were held in November 1998 in Buenos Aires, Argentina. A number of the developed nations, including the U.S., made informal commitments to reduce CO2 emissions to below 1990 levels by the year 2012.

As energy usage and emissions in 1999 are already substantially above 1990 levels, reduction will require extraordinary strides in increasing energy efficiency and reduction in energy usage. It also will require significant shifting to cleaner alternative forms of energy such as solar, natural gas, electric or fuel cell-powered vehicles, and possibly even nuclear. The U.S. delegation has in fact committed to a reduction in emissions of 8% ***below*** 1990 levels, a goal that now appears unreachable, without a dramatic restructuring of the economy and American lifestyles. It will be a significant challenge to achieve these dramatic reductions in emissions while still preserving a healthy economy and economic growth in the U.S.

How and whether these goals can be achieved are sources of great controversy in the United States and many other nations. Part of the debate stems from the fact that rapidly developing nations, such as China and India, have thus far been unwilling to commit to any reductions in greenhouse gas emissions. China is expected to exceed the United States in emissions by early in the 21st century at its present growth rate.

As an international treaty among nations, a climate change pact requires ratification by the U.S. Senate. In 1997, the Senate adopted a resolution against signing any climate change treaty that could damage the U.S. economy or that did not include similar commitments to reductions of greenhouse gas emissions from nations such as China and India. After the November 1998 meetings in Buenos Aires, the Clinton Administration signed the Kyoto climate change accords, but has yet to submit the treaty to the U.S. Senate for ratification.

Hurricane Risk A Greater Insurer Concern

For insurers, potential impact of climate change on the frequency and intensity of hurricanes remains the key area of research interest. Climate change or not, insurers, coastal communities and many other groups would like to have a greater understanding of hurricane development and intensification. No other weather event has the potential to deliver catastrophic losses that could endanger the solvency of a substantial number of insurers. At Buenos Aires, the 170-nation climate change delegation passed a resolution to research the causes and impact of severe weather events, such as Hurricane Mitch, a Category 5 storm with torrential rainfall that killed over 10,000 persons in Central American during October 1998. Insurers will follow this and other hurricane-related research with great interest.

On the issue of hurricanes, the UN-IPCC report was inconclusive, indicating that there is little evidence that a general warming would result in an increase in the frequency and severity of hurricanes. Much of the research seems to indicate that global warming would not increase the frequency of hurricanes and might even suppress hurricane development. For example, the El Nino climate phenomenon, triggered by the warming of Eastern Pacific Ocean, is a known suppressor of hurricane development. Some models seem to indicate that climate change will result in more frequent and longer lasting El Nino events.

However, warmer Atlantic Ocean waters from climate change could extend the length of the hurricane season by a week or two, however. Some researchers have also hypothesized that warmer waters further north along the Atlantic coastline could allow hurricanes and tropical storms to maintain strength further north than is currently the case, increasing the risk to Northeastern metropolitan areas. But Colorado State Professor William Gray,

one of the world's pre-eminent experts on hurricane forecasting and climate relationships, believes that there is little or no connection between global warming and hurricane development. Instead, Dr. Gray and other climate experts see hurricane frequency and severity related to other oceanic and weather patterns that tend to run in 20-30 year cycles. It is believed that another 20-year cycle of more active North Atlantic hurricane development began in the mid-1990s, similar to the 1950s and 1960s, according to Dr. Gray's forecasts. Indeed, NOAA and the National Weather Service recently confirmed that 1995-98 was the most active four year period in recorded weather history for North Atlantic tropical storm development, even though 1997 was a year almost devoid of hurricanes due to a very strong El Nino pattern.

Regarding hurricane damage potential, climate change is not the most critical factor. The real problem is the tremendous growth in population, homes, commercial development in the most hurricane-prone regions of the United States, especially Florida and other states along the Southeast and Gulf coasts. The increasing amount of insured exposure in hurricane-prone areas is of substantial concern, whether or not climate change occurs. Several demographic facts help bring this concentration of growth in "harms way" into perspective:

- Three metropolitan Miami Counties in South Florida—Dade, Broward, and Palm Beach—now have a greater combined population than did all of the nation's coastal counties from South Texas to Virginia during the 1930s.
- In 1960, about 45 million people lived in hurricane prone coastal areas that stretch from Texas to Maine. This increased to 64 million by 1990 and is projected to increase again to 73 million by 2010.
- From 1990-2010, population *density* in the nation's most hurricane prone region—the coastal counties of Florida, Georgia, South Carolina, and North Carolina—is expected to increase by 23% outpacing the national rate of increase (14%).

Thus, the lure of southern coastal climate, lifestyles and jobs, continues to concentrate more people, housing, and commercial development into one of the nation's most hazardous areas from the standpoint of natural disasters.

Profile of the P/C Industry: Diversity and Resilience

Even though hurricanes are an ongoing concern regardless of climate patterns, climate change action advocates overestimate the role of weather in the composition of property-casualty insurance products. Damage from weather events is only one of many perils that are covered by different lines and products provided by the property-casualty insurance industry. The table on the following page shows the distribution of the property-casualty insurance business by key lines (types) of insurance. The table illustrates that the majority of the premium supporting property-casualty insurance industry claims is not weather-sensitive or is weather-related only in a minor way, relative to the other factors.

Lines With Moderate or Significant Weather Exposure:

Lines with moderate or significant exposure to weather underwritten by the industry are shown in bold. These include Homeowners, Commercial Multi-Peril Non-Liability, Allied, Inland Marine, Farmowners, and Ocean Marine. Together the five lines represent about 19.2%, approximately one-fifth of industry premiums. The remaining lines, accounting 80.8% the industry's premium base, have a small or no exposure to weather events.

For the one-fifth share of the property-casualty industry that does have a moderate or significant weather exposure, weather is only one of a number of covered perils that contribute to the premium base and stability of the line. The related perils of fire and smoke damage are fundamental and often the most sizable components in all of the property-related insurance policies. Burglary, theft, vandalism, water damage from failed pipes or water heaters, and personal liability provide examples of other key perils covered by homeowners and commercial property policies. So, although weather and weather variability are important to these lines of business, they are in no way the only determinants of premiums and losses.

As previously mentioned, hurricanes can cause billions of dollars in insured losses and extreme events striking in certain regions could endanger the solvency of a significant number of insurers.

However, weather events that are cited as more likely consequences of climate change do not imply levels of loss that could threaten industry solvency. These include tornadoes, hail and other windstorm events, drought-induced wildfires and winter storms. Even if the latter events increase in frequency and severity, they are still not likely to approach major catastrophic levels with regard to insured losses.

One significant insured weather exposure could decrease under the climate change scenario—winter storm and freeze losses. Over the past 10-15 years, property-casualty insurers have paid more than $8 billion in winter storm and freeze losses (e.g. burst pipes, ice damming on roofs, collapsed roofs due to snow loads, downed power lines leading to business interruption losses). Four of the property-casualty

Table E-1. Distribution of property-casualty premiums.

Line of Insurance	Premiums ($ Billions)	Percent of Industry	Impact of Weather on Claim Experience
Homeowners Multi-peril	$28.9	10.4%	Significant. Weather-related claims may account for 20-25% of average claim experience, varying by region. Homeowner also covers and is supported by fire, iability, and theft experience and premiums gathered to pay for these perils.
Commercial Multiple Peril—Non-liability (Property)	$11.3	4.1%	Significant. However, commercial property often built to more weather resistant standards than housing
Inland Marine	$6.8	2.4%	Moderate
Farmowners Multi Peril	$1.5	0.5%	Significant
Ocean Marine	$1.8	0.6%	Significant
Allied	$3.2	1.2%	Significant
Multiple Peril Crop	$1.5	0.5%	Significant. However, program is reinsured by the federal government.
Federal Flood	$1.0	0.4%	Significant. But, flood insurance underwritten by the federal government.
Fire	$4.8	1.7%	Minor
Commercial Multiple Peril—Liability	$9.4	3.4%	Minor
Workers' Compensation	$26.1	9.4%	Minor
Medical Malpractice	$5.9	2.1%	None
Other Liability	$22.5	8.1%	Minor to None
Product Liability	$2.0	0.7%	Minor to None
Private Passenger Auto Liability	$71.3	25.6%	Minor
Commercial Auto Liability	$13.6	4.9%	Minor
Private Passenger Auto Physical Damage	$43.5	15.6%	Minor influence, storm damage claims (hail, flood, falling limbs etc.)
Commercial Auto Physical Damage	$4.9	1.8%	Minor, similar to private passenger auto physical damage
Earthquake	$.86	0.3%	None
Financial Guarantee	$1.1	0.4%	Minor
Mortgage Guaranty	$2.1	0.8%	Minor
Aircraft	$1.2	0.4%	Minor to Moderate
Fidelity	$.84	0.3%	None
Surety	$2.9	1.0%	None
Boiler and Machinery	$.73	0.3%	Minor
Credit	$.43	0.2%	None
Burglary and Theft	$.12	<0.1%	None
Group Accident and Health	$3.7	1.3%	Minor
Other Accident and Health	$2.3	0.8%	Minor
Miscellaneous	$2.2	0.8%	Minor or None
Total Industry	$278.6	100%	19.2% of the business has significant/moderate weather exposures

Source: A. M. Best Company, 1998 and American Insurance Association analysis

insurance industry's largest 20 natural catastrophes as defined by insured dollar losses have been winter storm events. These include severe snow, ice, and freeze events occurring in 1983, 1993, 1994, and 1996. Climate change models indicate that if substantial global warming does occur, it may be most noticeable in raising average night-time and winter temperatures. Impacts are also expected to be greatest in higher latitudes now exposed to severe winters. Higher winter temperatures in the U.S. and Canada could help to lower the frequency and severity of cold outbreaks that cause massive winter storm and freeze losses.

Flood and Crop Losses and Insurance

Flood and Crop Insurance are two lines not included in the overall estimate of the percentage of the property-casualty industry at risk from weather, even though they are fundamentally weather-related. This is because flood insurance and crop insurance are federal programs, underwritten for the most part by the federal government (a small amount of private flood insurance is written privately, usually for large commercial accounts). The industry generates revenue from flood and crop insurance by assisting in administration through education and marketing programs, policy issuance, and most importantly, claims adjustment. However, U.S. insurers generally are not financially exposed to flood and crop losses. Thus, increased flooding or sea level rise would not bring about a significant increase in exposure for the property-casualty insurance industry.

According to the UN-IPCC report, flood and crop losses may increase under a climate change scenario due to more intense thunderstorm, rainstorm, and hail events in some regions coupled with severe drought in other areas. Some observers have speculated that this may be one reason why European insurers have taken a more aggressive position in the climate debate. In the United Kingdom, France, Germany and many other countries in Europe, insurance companies typically cover and underwrite flood damage. If increased flooding and rising sea levels were proven consequences of climate change, European insurers could be somewhat more vulnerable than their American counterparts. In any event, U.S. insurers and reinsurers perceive that hurricane frequency, severity and the concentration of exposures, rather than flooding, is the most important weather-related issue for the domestic industry.

Lines Having Little Weather Exposure

Auto insurance provides a good example of a line with minor exposure to climate change, but one that is also a major source of the property-casualty industry's financial strength and stability. As the table indicates, private passenger and commercial auto insurance account for nearly half (48.3%) of the industry's premium total. It is true that fender bender claims can increase in winter weather, and hail can cause insured physical damage to a vehicle, for example. Comprehensive automobile coverage will also pay for damage to vehicles caused by flooding, and wind or flood damage to vehicles has been the source approximately of 2% of the insured hurricane losses in the U.S. In auto insurance loss experience, however, other factors such as traffic congestion, use of seat belts, impaired driving, driver age and experience, highway design, vehicle safety, the legal environment, and claiming behavior are far more powerful in determining auto insurance claim experience than weather. In some cases, bad weather lowers accident rates by reducing the amount of non-essential driving, reducing speeds and increasing caution.

Assessing Climate Change Risk for Insurers

A common assumption made by those contending that the property-casualty insurance industry would be severely impacted by climate change is that insurers will be unable to respond and adapt. This assumption overlooks the fact that, for any line of insurance, loss experience is always changing in response to a large number of variables. Examples include weather; accident experience; safety improvements; claiming behavior; social and demographic trends; new products, technology and industries; the economy; and the legal climate. Insurers constantly monitor risk, premiums, and loss experience, and are prepared for and accustomed to changing conditions. When conditions in a particular line of insurance change, insurers usually have the ability to manage risk and adjust to the new trend though a number of tools.

Rating and Pricing

The rating process or pricing of insurance policies is responsive to changes in loss experience. For example, when automobile accident injuries and costs decline in severity because of the greater use of seatbelts and air bags, insurers are able to adjust their premiums downward to reflect the better experience.

If climate change did result in increased storm losses from tornadoes, hailstorms and other events, insurers would have the ability to adjust premiums. Granted, these adjustments do not always take place quickly or easily. Property-casualty insurance is heavily regulated in many states, and adjustments are subject to state review and occasionally, to intense political debate. However, the solvency of insurance companies is one of the most important responsibilities of state regulation. Although regulators often review rates to make sure they are not excessive, they also have a responsibility to ensure that rates are not so inadequate that insurers are at risk of becoming insolvent. Given clear evidence of changing loss trends, insurers and regulators would have to respond.

Underwriting

Subject to state regulatory requirements, insurers have some flexibility regarding where they want to do business. If some localities became more hazardous due to climate change, individual companies would have the ability to become less concentrated in those regions to avoid excessive catastrophe exposures. As long as pricing remained adequate for the risk, these marketplace changes could provide new opportunities for insurers less concentrated in the region. Insurance would remain available.

Other insurers could choose to focus on properties that are built to code or exceed building codes, a strategy that might also encourage improvements in the quality of local construction and retrofitting of existing properties. Subject to regulatory constraints, insurers can also increase deductible amounts to lower total exposures and encourage policyholders to prevent or mitigate losses through improvements that make a structure more weather resistant. For example, in response to the perceived increase in risk to catastrophic hurricanes following Hurricane Andrew, insurers began offering alternatives for deductibles on homeowner policies for damage caused specifically by hurricanes.

Some research seems to indicate that climate change may result in less damaging weather in some regions and more damaging in others, or that there may be increased variability from one year to the next. To the extent that insurers have the ability to balance the risks they insure geographically, many of the impacts of climate change should even out.

Natural Hazard Mitigation

As has been the case with automobile and highway safety, insurance companies are strong advocates for catastrophe mitigation. Implementation and enforcement of strong building codes, new building technologies to bring about better roofs, windows, and structural connections will make homes, businesses, and communities more resilient to natural disasters. Land use planning is another technique gaining interest as a strategy for better assessing the costs and benefits of building in areas at high risk from natural hazards.

Mitigation makes sense whether or not the climate is changing. Insurers, homeowners, businesses and communities, are already at risk of various types of natural disasters, even in years where overall weather patterns appear to be relatively benign. For example, Hurricane Andrew, the most expensive disaster the insurance industry has experienced, occurred in 1992 when hurricane frequency was relatively low and suppressed by a mild El Nino climate pattern.

Insurer Role in the Climate Change Debate

AIA and others within the American property-casualty insurance industry have actively monitored climate change science and the accompanying political debate since 1993. Some U.S. insurers and reinsurers are supporting climate-related research conducted by the Risk Prediction Initiative at the Bermuda Biological Research Station for Research Inc.,the International Hurricane Center in Miami, Florida, and the newly-founded World Institute for Disaster Risk Management. During 1995, a series of workshops and discussions were held on climate change organized by the Reinsurance Association of America (RAA) and the industry-sponsored Institute for Business and Home Safety (IBHS). Insurers

heard presentations from a number of meteorologists, environmental scientists, the U.S. Department of Energy (DOE), the Environmental Protection Agency (EPA), company officials from European insurers and reinsurers and others on both sides of the debate. From these discussions, a general consensus emerged on several points that are still relevant in 1999:

- Although some insurers are becoming increasingly sophisticated in their use of climate and weather forecasting models, the insurance industry does not have the expertise to evaluate conflicting interpretations of scientific evidence or positions on climate change. However, insurers can assist in monitoring changing weather through the ongoing process of collection and analysis of data on insurance losses, catastrophes, and causes of loss.
- Property-casualty insurers are already fully engaged in the process of catastrophe mitigation through efforts to improve and educate the public about building codes and their enforcement, building design, construction methodologies and materials, and land use control measures designed to keep the public out of harm's way. This will have positive societal payoffs whether or not the climate change threat becomes a reality, particularly in areas already at risk from weather-related natural disasters.
- There may be opportunities for insurers to work with the Energy Department and energy-related businesses on areas of potential synergy. These might include improvements in energy conservation and building design that save energy and reduce greenhouse gas emissions, but also reduce hazard exposures and insured losses, while enhancing human safety.

Attention has begun to focus on how individual industries could make contributions to energy savings and reduced greenhouse gas emissions. Some groups are advocating strategies linked to the insurance process that they believe will help to reduce emissions and mitigate climate change. Some of these proposals complement the risk assessment, insurance, safety and loss mitigation process, while others create new societal risks that outweigh the value of any contributions they might make. Proposals affecting risk and insurance need to be examined comprehensively to ensure that they do not create new hazards. Following are examples that could provide a good match between risk reduction, insurance, and energy efficiency:

- **Speed Limits Have Both Safety and Environmental Benefits:** Experience during the 1970s and 1980s with national speed limits of 55 mph has conclusively shown that lower speeds not only save energy and reduce greenhouse gas emissions, but also lower deaths and injuries on the highways. The abandonment of a national speed limit and a return to 65, 70, or higher mile per hour speed limits in most states was an unfortunate societal development affecting highway safety, energy usage, and greenhouse gas emissions.
- **Energy savings and loss control:** Working with several property-casualty insurers, the U.S. Department of Energy's Lawrence Berkeley National Laboratory has identified areas where energy efficiency improvements also reduce fire, explosion, or winter storm hazards. Insurers can support improvements in energy efficiency as long as they do not create new, unanticipated risks to human safety and property, particularly when energy efficiency strategies measurably improve safety and loss control.
- **Public Transportation and Other Non-Driving Alternatives:** Property-casualty insurers are generally supportive of increased investments and improvements in public transportation, and other initiatives that encourage less driving including "smart growth" strategies, HOV lanes, and pedestrian and bicycle access. These strategies reduce energy usage and promote cleaner air. For auto insurance and highway safety, they reduce congestion in urban areas and stress on drivers that leads to increased accident rates. Public transportation also helps to enhance and preserve mobility options for young and very elderly drivers that tend to have higher accident rates.

Some well-intentioned proposals for climate change mitigation could have a negative impact on risk, safety, and the insurance process. "Pay-at-the Pump" auto insurance is an example of one climate change proposal that would undermine the basic risk-based insurance process and negatively impact vehicle and highway safety. The insurance industry cannot function as a surrogate regulator to help force energy conservation and greenhouse gas reductions.

Conclusions

The U.S. property-casualty insurance industry is a large and very diverse industry that insures numerous perils and risks besides weather events. The industry writes nearly $300 billion in premiums annually, and industry surplus or reserves stand at more than $300 billion. In addition, a healthy reinsurance industry and increasing involvement of the capital markets help to gird the financial strength of the industry. At most, about one-fifth of property-casualty insurance premium volume is in lines significantly exposed to weather events. Even within that one-fifth, the lines represented are also supported by premiums gathered to cover important non-weather related perils such as fire, theft, and liability. Many weather changes envisioned by climate change models, such as increased rainfall, more intense thunderstorms, hail, and periodic drought, can be addressed through changes in rating, underwriting, building codes, improved construction and land use that encourage loss mitigation and less building in areas most exposed to severe weather events.

Hurricanes remain an area of significant concern for the property-casualty insurance industry. Insurers favor increased research into hurricane development, frequency, intensification, and tracking, whether or not climate change is occurring. The good news is that, thus far, most climate researchers do not see a link between climate change and hurricane frequency and intensity.

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David Unnewehr, Policy Development and Research
April 1999

APPENDIX F: LETTER FROM INSURANCE EXECUTIVES GROUP TO THE U.S. VICE PRESIDENT

September 6, 1995

Vice President Albert Gore, Jr.
Old Executive Office Building
Washington, D.C. 20501

Dear Vice President Gore:

The signatories of this letter represent a majority of property/casualty insurers in the United States. We commend your initiative to address common concerns regarding the effects of weather on lives and property in the United States and throughout the world.

We share your concerns about our changing climate and the impact that it might have. In recent years, insurers and their policyholders have experienced an extraordinary series of losses associated with natural catastrophes. Much of this can be attributed to population shifts to areas at particularly high risk to natural catastrophes, as well as increases in the values of homes and commercial structures located in harm's way.

However, we recognize that an assessment of the financial consequences of natural disasters cannot replace sound scientific research on the nature of weather patterns and changing climatic conditions. These changes, whether due to natural variability or a combination of natural changes and the activities of society, could result in greater vulnerability to loss of life, economic distress, and the destruction of property.

Since we met with you earlier this year, we have taken seriously your challenge that we become engaged in an understanding of these issues.

With the assistance of the Office of Environmental Quality and others in the Administration, we held a series of meetings focused on the current scientific knowledge of the climate. We met with scientists who study climatic conditions from the National Oceanographic and Atmospheric Administration, the Office of Science and Technology Policy, and academia. We met with scientific advisors to international insurers who have focused on the relationship between climatic change and insured property exposure.

In addition, we have been advised of the economic consequences surrounding climate change, the role business plays in these issues, and the potential economic impact on society and our own industry of various approaches to reduce exposure to climate change.

We also had the benefit of advice from Dr. Tim Wirth, Under Secretary for Global Affairs at the U.S. Department of State, about the international politics of these issues.

Our study encompassed a review of current initiatives, including those the Administration has sponsored, to achieve improvement in energy efficiency. This involved meeting with researchers from the civil engineering community; officials form the Department of Commerce who address improvements in building design and techniques; private sector representatives with an interest in alternative energy sources; and those seeking creative ways to improve buildings and construction solutions related to reducing energy consumption.

As you said when we met, the complexity of the climate change issue has become self-evident. We recognize that national and international efforts to address climate change are interwoven with economic and political considerations.

Some aspects of this issue, particularly the scientific evaluation of climate conditions and trends, are certainly beyond our expertise. We are not scientists, and we are not in a position to evaluate computer models or interpret the effects of human behavior on climatic conditions. Yet our companies, and more particularly our policyholders, are directly affected by weather conditions, most notably if climatic conditions are changing. We do recognize that the his-

torical paradigm we have used in the past to assess the catastrophe risk we insure must be reexamined.

As a result of our concerns about massive losses from natural catastrophes, insurers created the Insurance Institute for Property Loss Reduction (IIPLR) in January 1994. The Institute's goal is the reduction of deaths, injuries and property damage caused by natural hazards. It works to improve building codes and their enforcement; building design; construction methodologies and materials; and land use control measures designed to keep the public out of harm's way. The Institute also provides education services for stakeholders.

Working through IIPLR, we believe the insurance industry can make a difference. In its short existence, the Institute has already developed a Building Code Effectiveness Grading Schedule. This Schedule will be used to evaluate building codes and their enforcement in every community in the country in an effort to encourage building code improvements. The Institute, in conjunction with the Underwriters' Laboratory, has developed a hail-resistant roof testing and certification system and is working to establish standards for measuring the effects of windblown debris. The Institute collaborates with a variety of universities to make use of their expertise in natural catastrophes and climate developments, with the purpose of initiating further research into how to reduce losses.

We would like IIPLR to have a meaningful impact on the reduction of losses from natural hazards and to serve as our industry's vehicle for analyzing data and reviewing and conducting research appropriate to our expertise. We believe that the course presently being pursued by the Institute is, in effect, addressing the challenge of climate change.

In the six months since our meeting with you, we have concluded that there is much to be gained by more regular and systematic consultation with the Administration. Scientific initiatives to develop strategies for reducing the destruction of property and loss of life will benefit both insurers and the insured.

When we met in February, you charged us with the following agenda:

- To serve as a communicator of scientific research and to provide input to that research where our expertise was appropriate.

  Recognizing our limited scientific expertise, we do realize that our industry has an important role in determining how climate and changes in climate can affect our policyholders. In that regard, we recognized that we must undertake a more comprehensive review of many of the climate and weather related initiatives that the Administration is pursuing and evaluate their importance to insurers and their customers. The appropriate organizations representing our industry would then be encouraged to support and utilize those programs, which would directly benefit policyholders. In this regard, we are meeting with Secretary Ron Brown on September 15 to review the role the Department of Commerce plays in regard to climate and weather.

- To participate in the identification and development of loss estimation predictive models.

  We are enclosing a recently completed study, which evaluates the potential losses associated with hurricanes and earthquakes. While the study was prepared for other purposes, it could serve as a benchmark in looking at potential insured losses. It could also prove useful in conjunction with climate change models. We can help identify entities that can provide input and analysis of studies the Administration wishes to pursue in an effort to integrate climate change model data into models that look at current property exposures. We can also serve as a liaison to organizations that our industry utilizes for this assessment and provide interpretive analysis of the results.

- To serve as a catalyst in bringing together various stakeholders.

  We believe that we can build on the work begun by the Insurance Institute for Property Loss Reduction in its collaboration with scientists and academics studying weather and climate as that research relates to the mitigation of losses. We commit to explore with you and the business community: the synergies between initiatives associated with alternative and sustainable energy; improvements in construction design and techniques; and other areas where the insurers' perspective on hazard exposure, safety and loss mitigation will be constructive. Our long-term involvement in research and advocacy to make

energy efficiency cars safer is evidence of the appropriate role we can play.

We recognize that on matters of weather and climate change, our interest is one among many spheres of interest. We agree that our perspective – that of financing recovery from the effects of natural disasters and encouraging improved safety and hazard mitigation – should not stand apart from the interests of others in climate and climate change. We believe that these varying perspectives should be patched together into a quilt of interests addressing the effects of natural hazards on people and property to improve research and apply the results to the benefit of human health and safety.

We look forward to a continuing relationship with the Administration in the areas mentioned and to pursuing these mutual objectives.

Alliance of American Insurers
American Insurance Association
Insurance Institute for Property Loss Reduction
National Association of Independent Insurers
National Association of Mutual Insurance Companies
Reinsurance Association of America
State Farm Insurance Companies

APPENDIX G: POSITION PAPER OF THE INSTITUTE FOR CATASTROPHIC LOSS REDUCTION (INSURANCE COUNCIL OF CANADA)

We *Are* Doing Something about The Weather
(Insurance Council of Canada's Institute for Catastrophic Loss Reduction)
by Paul Kovacs
April 1999

In January, more than two hundred of the world's leading scientists met in Geneva to discuss what we should do about our changing weather. This gathering is part of an even larger working group that has been making progress on this file for more than ten years. But as each new storm passes, it reminds us that there remains a great deal more to do.

Some other questions we are working on include the following: What factors have lead to the increase in the frequency and severity of extreme weather? Are these changes in the climate due to human influences? What changes should we expect over the next few years? Can we do anything to reduce the harmful impact of climate change?

Insurers from Europe and now Canada are represented in this process, and this work is increasingly having a positive impact on the actions taken in the business community and by governments. As decisions are made, however, it will take decades to resolve some issues. Nevertheless, I am optimistic that efforts working together will deliver welcome results over the longer term.

The United Nations and the World Meteorological Organization established the Intergovernmental Panel on Climate Change (IPCC) in the late 1980s. The official mandate of the Panel is to study the available scientific information about climate change, assess its impact on the economy and society, and formulate response strategies. The scientific community was looking for a forum to discuss concerns about our changing weather. IPCC has filled this void by holding regular meetings, like the one in January.

The Panel is also driving an international research and publication program. Much of this work is conducted and disseminated through the Internet. It is difficult to imagine how such a large group of people located around the globe could work together so effectively without this creative use of our modern communication technology. There has never before been such a large-scale research program, bringing together analysts from the full range of scientific disciplines to work co-operatively to resolve an international societal challenge.

Scientists with Environment Canada remain leading contributors to this project. IPCC have also been successful over the last few years in their efforts to involve more scientists from Asia, Africa and South America to provide a better balance to the continuing strong input from the United States and Europe.

During the early years, the project focused on clarifying the science of weather and climate variability. Almost immediately a consensus emerged in the scientific community that the world's climate is changing because of human intervention. The research also confirms that these changes are complex and the impact is material, including the impact on insurers.

Exhausts from the use of fossil fuels to power vehicles, heat homes and operate factories are an important contributor to our changing climate. Population growth, urbanization and industrialization are also contributing factors. The result is global warming, where temperatures are moving higher, rising above the long-term cyclical changes and contributing to a variety of other changes in climate.

Warming is most evident near the Arctic and Antarctica, including Australia, Russia and northern Canada. It is less evident near the equator. Warming is also most evident in the evening, while there is a smaller change taking place in daytime temperatures. Within our oceans the change in temperatures is greatest a few hundred metres below the surface. The

extent of change is smaller near the surface and at great depths. Similarly air temperature changes are greatest a few hundred metres above sea level, and lower near the sea; or at very high elevations. Last year was the warmest on record, and the pace of warming has increased.

Liquids expand and require more space as the world grows warmer, and this includes expansion of the water in our oceans. Accordingly, sea levels are rising. At the current rate of warming a number of island nations will be completely below sea level in a few decades. Much of coastal Florida and low lying regions in Europe are also extremely vulnerable. The combination of rising sea levels, more storm activity, and more people living in vulnerable communities has lead to increasing sea-surge damage around the globe.

In a warmer world the water cycle is changing and more of our water remains in the air. This has lead to an increase in the number of very heavy and prolonged rain storms. The frequency and severity of hail storms and winter storms are also rising. At the same time there has been a decrease in the number of small rain storms, and an increase in the frequency of drought and brush fires. In many ways the world's weather is becoming more dangerous, including increasing risk of a number of insured perils — storm damage, hail, flash flooding, fire, and sea-surge.

The pace of climate change is increasing. Weather patterns are noticeably different from the recent past. IPCC has provided an international forum for scientists to project future changes in a rigorous setting where assumptions are tested and retested. Some studies look several hundred years into the future, although most focus on the next fifty years. Other reports seek to provide climate forecasts for specific parts of the world. Some research seeks to better include long term climate variability through factors like El Niño models. All of this work has increasingly been directed toward the analysis of options for reducing the pace of climate change.

The point of this work is to provide a scientific foundation for ongoing work directed to slowing then eventually reversing the pace of dangerous human-induced climate change. Elements of global warming are helpful, like the longer growing season across Canada. But there are many aspects that are dangerous and unwelcome. All participants agree that we should work to avoid bringing further large changes in the weather.

Some of the challenges here are very daunting. For example, actions taken in one region immediately affect the world's climate systems, so international planning and programs are needed. Experience shows, however, that international agreements take a long time to put in place. A common understanding of the problem from the IPCC project will assist this effort, but the diplomatic challenge remains great. As decisions are made, there are considerable lags before there is a favourable impact on the weather. In particular, sea levels will rise for several hundred years more even if we become very aggressive in reducing the exhausts from energy use around the world.

Insurers are not experts on energy use or emission controls. The insurance industry does not plan to also show leadership in the debate about long-term strategies to control international greenhouse gas emissions. These are important discussions, and insurers are pleased to observe the increased importance that has been given to this work.

The contribution of the insurance industry to the broader effort is to focus attention increasingly on extreme events. We need more research into the science of severe weather, and more work to develop ideas for adapting to our increasing vulnerable world. The insurance community is also pressing that these be treated as immediate needs, as severe weather is happening right now, and we must learn to better manage this risk before it causes even greater loss of life and property damage.

In Canada, the Insurance Bureau of Canada is leading the lobby to establish a national mitigation strategy. There will be public hearings across the country this year to debate our proposal. We believe that governments should invest $60 million to $100 million a year in projects that will protect Canadian homes and businesses from our increasingly dangerous weather. The Winnipeg floodway and the Alberta weather modification program are two examples of the kinds of investments that should be put in place across the country. Modest investments in protection will reduce the annual $500 million cost to governments of disaster recovery. Catastrophe loss payments by insurers are also high and rising, and would directly benefit from a mitigation strategy.

Canada's insurers have also established the Institute for Catastrophic Loss Reduction. This is a

forum for insurers to work more actively with the research community and others to better understand severe weather and options for managing this risk. There is an active program of workshops and conferences that the Institute has developed to help insurers to become more informed about extreme events.

The first report of the IPCC was published in 1990. It was updated in 1995 with more detailed information about climate change in specific countries. Currently we are writing the third report that will be completed next year. This work of the scientific community to explain the factors that are changing our climate is increasingly taking a form that can be directly applied by insurers and governments. The volume of research on extreme weather events is increasing, although this will likely be most evident in the 2005 IPCC report because much of this information is very new and still emerging.

The Canadian insurance community is growing increasingly aware of the importance of this work to understanding the factors changing our climate. Participation in the work of the Institute for Catastrophic Loss Reduction is one means to stay informed about the emerging research and how it can be applied to the risks managed by Canada's insurers.

Source: Kovacs, P. 1999. *Canadian Underwriter* magazine, pp. 34-38.

APPENDIX H: UNITED NATIONS INSURANCE INDUSTRY INITIATIVE

The Statement of Environmental Commitment by the Insurance Industry
http://www.unep.ch/etu/finserv/insura/const.htm

The insurance industry recognises that economic development needs to be compatible with human welfare and a healthy environment. To ignore this is to risk increasing social, environmental and financial costs. Our industry plays an important role in managing and reducing environmental risk, in conjunction with governments, individuals and organisations. We are committed to work together to address key issues such as pollution reduction, the efficient use of resources, and climate change. We endeavour to identify realistic, sustainable solutions.

1. General Principles of Sustainable Development

1.1 We regard sustainable development, defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs, as a fundamental aspect of sound business management.

1.2 We believe that sustainable development is best achieved by allowing markets to work within an appropriate framework of cost efficient regulations and economic instruments. Government has a leadership role in establishing and enforcing long term priorities and values.

1.3 We regard a strong, proactive insurance industry as an important contributor to sustainable development, through its interaction with other economic sectors and consumers.

1.4 We believe that the existing skills and techniques of our industry in understanding uncertainty, identifying and quantifying risk, and responding to risk, are core strengths in managing environmental problems.

1.5 We recognise the precautionary principle, in that it is not possible to quantify some concerns sufficiently, nor indeed to reconcile all impacts in purely financial terms. Research is needed to reduce uncertainty but cannot eliminate it entirely.

2. Environmental Management

2.1 We will reinforce the attention given to environmental risks in our core activities. These activities include risk management, loss prevention, product design, claims handling and asset management.

2.2 We are committed to manage internal operations and physical assets under our control in a manner that reflects environmental considerations.

2.3 We will periodically review our management practices, to integrate relevant developments of environmental management in our planning, marketing, employee communications and training as well as our other core activities.

2.4 We encourage research in these and related issues. Responses to environmental issues can vary in effectiveness and cost. We encourage research that identities creative and effective solutions.

2.5 We support insurance products and services that promote sound environmental practice through measures such as loss prevention and contract terms and conditions. While satisfying requirements for security and profitability, we will seek to include environmental considerations in our asset management.

2.6 We will conduct regular internal environmental reviews, and will seek to create measurable environmental goals and standards.

2.7 We shall comply with all applicable local, national and international environmental regulations. Beyond compliance, we will strive to develop and adopt best practices in environmental management. We will support our clients, partners, and suppliers to do likewise.

3. Public Awareness and Communications

3.1 Bearing in mind commercial confidence, we are committed to share relevant information with

our stakeholders, including clients, intermediaries, shareholders, employees and regulators. By doing so we will improve society's response to environmental challenges.

3.2 Through dialogue with public authorities and other bodies we aim to contribute to the creation of a more effective framework for sustainable development.

3.3 We will work with the United Nations Environment Programme to further the principles and goals of this Statement, and look for UNEP's active support.

3.4 We will encourage other insurance institutions to support this Statement. We are committed to share with them our experiences and knowledge in order to extend best practices.

3.5 We will actively communicate our environmental activities to the public, review the success of this Statement periodically, and we expect all signatories to make real progress.

23rd November 1995.

List of Signatories to the UNEP Statement by the Insurance Industry

By Country
As of 1 August 2000

Members of the Insurance Industry Initiative for the Environment, in association with UNEP are in Italics and underlined

Argentina
- Grupo Fortuna SA

Australia
- QBE Insurance Group Ltd.

Austria
- VJV VolksfürsorgeJupiter Allg.Vers.AG
- Wiener Städtische Allgemeine Versicherung Aktiengesellschaft

Canada
- Dominion of Canada General Insurance Company

China
- Sumitomo Property & Casualty Insurance Co. (HK)

Denmark
- Copenhagen Re ******

Finland
- Sampo Group

France
- SOREMA

Germany
- Aachener Rückversicherung (mergered with Employers Re)
- Aachener und Münchener Versicherung
- Bayerische Beamten Versicherung AG
- DaimlerChrysler's debis Assekuranz Makler GmbH (Associate Member)
- Delvag LuftfahrtversicherungsAG
- ERC Frankona (for Aachener Rückversicherung)
- Gegenseitigkeit Versicherung Oldenburg
- Landesschadenhilfe Versicherung V.a.G.
- Gerling-Konzern
- Mannheimer Versicherungen
- Muenchener Rueckversicherungs-Gesellschaft (Munich Re)
- Nürnberger Allgemeine VersicherungsAG
- Oeco Capital Lebensversicherung AG *****
- R & V Allgemeine Versicherung
- RheinLand Versicherungs AG
- Stuttgarter Allgemeine Versicherung AG
- Stuttgarter Lebensversicherung a.G
- Vereinte Versicherung AG
- Victoria Versicherungen
- Volksfürsorge Holding AG
- Wüttembergische Versicherung AG

Indonesia
- Sumitomo Marine & Pool

Italy
- Generali Assicurazioni Generali S.p.A.
- Istituto Nazionale delle Assicurazioni
- La Fondiaria Assicurazioni S.p.A.
- Riunione Adriatica di Sicurta

Japan
- ACE Insurance ***
- Daiichi Mutual Fire and Marine Insurance Co.
- JI Accident & Fire Insurance Co.Ltd.
- Mitsui Marine & Fire Insurance
- The Sumitomo Marine & Fire Insurance Co., Ltd
- Tokio Marine and Fire Insurance Co. Ltd.
- Yasuda Fire and Marine Insurance Co.Ltd.

Korea (Rep. of)
- Hyundai Marine and Fire Insurance Co.Ltd.

The Netherlands
- Achmea

New Zealand
- National Insurance
- Sovereign Assurance

Norway
- Skogbrand Insurance Company (Associate Member)
- Storebrand

Portugal
- Império S.A.

Russia
- City Insurance Co.
- Energogarant, Ltd.
- Industrial Insurance Co.
- Lider Insurance Co.
- Rosno Insurance Co.
- Siberian Russian Insurance Co. (Sibrosso)
- SOGAZ Co., Ltd.
- Spasskiye Vorota Insurance Co.

Singapore
- Overseas Union Insurance Limited

South Africa
- AEGIS Insurance Company Ltd.

Spain
- MAPFRE Mutualidad de Seguros y Reaseguros a Prima Fija's
- MUSINI
- Pool Español de Riesgos Medioambientales

Sweden
- Folksam
- Skandia Insurance Company Ltd.
- SPP Försäkingsbolaget
- Trygg Hansa
- WASA Försäkring **

Switzerland
- Basler VersicherungsGesellschaft
- Elvia Versicherungen
- Helvetia Patria Versicherungen
- Rentenanstalt/Swiss Life
- Schweizerische MobiliarVersicherungsgesellschaft
- Swiss Reinsurance Company
- Union Suisse Insurance Co.
- Vaudoise Générale Compagnie d'Assurances
- Winterthur Versicherungen
- Zurich Insurance Company

Tanzania
- National Corporation of Tanzania Ltd.

Thailand
- Bangkok Insurance Public Company Limited

United Kingdom
- Aon Group (Associate Member)
- Barlow Lyde & Gilbert (Associate Member)
- CGU Plc. ****
- Co-operative Insurance Society Ltd.
- Independent Insurance Company
- Iron Trades Insurance Group
- NatWest Insurance Services (Associate Member)
- NPI *
- Sumitomo Marine & Fire Insurance Co. (Europe)

United States of America
- Employers Reinsurance Corporation
- HSB Group, Inc.

Number of Signatories: 84 plus 5 Associate Members in 27 Countries

* NPI is part of AMP Group, Australia (1999)

** WASA has merged with Länsförsäkringar Miljö, Sweden (summer 1998)

*** (Ace Insurance, Japan formerly known as CIGNA Insurance Company - Change since 1st October 1999)

****(General Accident Fire and Life Assurance Corporation merged with Commercial Union, June 1998)

***** Oeco Captial Lebensversicherungs AG is now part of Colonia Insurance, Germany

****** (Copenhagen Re, Denmark formerly known as Alm.Brand - Change 1st October 1999)

APPENDIX H (CONT'D): UNEP INSURANCE INITIATIVE

Position Paper on Climate Change: 9 July 1996

http://www.unep.ch/etu/finserv/insura/position.htm

(1) PREAMBLE

1.1 The property insurance industry is the financial sector most likely to be directly affected by climate change, since it is vulnerable to variability in the frequency and severity of extreme weather events. Life insurance and pension fund investment portfolios are also likely to be affected.

1.2 The cost of such events could escalate dramatically as a consequence of the increased greenhouse effect due to human activities. The resultant climate change may alter the frequency and/or severity of extreme weather events and/or their regional distribution. The exact influence is not yet known, due to the limitations of today's understanding of the climate system. It is clear, though, that even small shifts of regional climate zones and/or storm patterns carry the potential of increased property damage, exacerbated by inadequate planning and construction in certain areas.

1.3 The implication of climate change for other lines of insurance cannot be assessed with confidence but cannot be ignored. Changes in human health (e.g. spreading of diseases) may affect the life assurance and pension industries. Returns on long-term investments and capital projects may be affected by mitigation measures that alter the economics of whole industries - for example, shifting from carbon fuels to renewable sources. The economics of selected regions, such as coastal zones and islands, may be disadvantaged.

1.4 Through its experience in managing the risk of natural catastrophes, the insurance sector can help to improve the response to property damage from extreme events by co-operating with the relevant authorities.

1.5 It is anticipated that structural changes in energy-intensive industries in response to measures to control greenhouse gas emissions will result in opportunities and challenges for the investment community, including for example alternative energy, efficiency programmes, and public transit systems. However, without political initiatives, market forces alone may not result in the efficient use of investment potential.

(2) CONCLUSIONS

2.1 Based on the current status of climate research and on their experience as insurers and reinsurers, the member companies of the UNEP-Insurance Industry Initiative conclude that:

2.1.1 Human activity is already affecting climate on a global scale, e.g. through the enhanced greenhouse effect. According to IPCC 'the balance of evidence suggests a discernable human influence on global climate'"

2.1.2 Man made climate change will lead to shifts in atmospheric and oceanic circulation patterns. This will probably increase the likelihood of extreme weather events in certain areas. Such effects carry the risk of dramatically increased property damage, with serious implications for property insurers and reinsurers.

2.1.3 Potentially there could be large implications for investment activities as society plans for, and adapts to, the new climate regime.

2.2 We are convinced that:

2.2.1 In dealing with climate change risks it is important to recognize the precautionary principle, in that it is not possible to quantify anticipated economic and social impacts of climate change fully before taking action. Research is needed to reduce uncertainty but cannot eliminate it entirely.

2.2.2 In the case of climate change risks, the most efficient precautionary measure is a substantial reduction of greenhouse gas emissions

with respect to a 'business as usual' scenario of greenhouse gas emissions.

2.2.3 The problem of climate change can be counteracted only by the joint efforts of governments, political and social institutions, industrial and commercial enterprise [including insurers and reinsurers], and of all individuals. This requires an enhanced level of public discussion and international political agreement.

2.3 We insist that:

2.3.1 In accordance with the precautionary principle, the negotiations for the Framework Convention on Climate Change must achieve early, substantial reductions in greenhouse gas emissions.

2.3.2 The Framework Convention on Climate Change should urgently try to establish what concentration level and rate of increase of greenhouse gases is likely to be 'dangerous', through further scientific research.

2.3.3 Mechanisms be created for direct inputs of NGOs [including business NGOs] to the negotiations, and for communicating the issues and decisions to all stakeholders.

2.3.4 The position of the insurance and reinsurance sector be represented when discussing or negotiating possible solutions.

2.3.5 A transparent framework of political, social and economic measures be established to promote sustainable development, taking into account the risks of climate change, and considerations of equity between emerging, transitional and mature economies, and over time.

This paper has been discussed and approved for publication by the members of the UNEP Insurance Industry Initiative as a contribution to the climate change debate. It does not claim to represent a unanimous view of UNEP I.I.I. members, nor does it in any way represent a UNEP position.

APPENDIX H (CONT'D)

POSITION PAPER ON CLIMATE CHANGE: DECEMBER 1997

Presented at the Conference of the Parties of the United Nations Framework Convention on Climate Change, Kyoto, December 1997

http://www.unep.ch/etu/finserv/insura/ccpp.htm

1. Climate change - Implications for the insurance industry

1.1 According to IPCC the balance of evidence suggests a discernible human influence on global climate change. The global mean surface air temperature is expected to increase by 1 to 3.5 °C by the year 2100. Sea levels are expected to rise beyond critical levels in several regions, as a consequence of thermal expansion and melting of ice masses.

1.2 According to simulations based on known physical mechanisms, man-made global warming would contribute to an enhanced global mean hydrological cycle and to shifts in atmospheric and oceanic circulation patterns. This may affect regional storm paths and alter the frequency and intensity of extreme weather events and/or their geographical distribution. The exact influence is not yet known due to the limitations of today's understanding of the climate system.

1.3 Even small shifts in regional climate zones and/or storm patterns carry the risk of a large increase in property damage, exacerbated by inadequate planning and construction, in certain areas. Because of the non-linearity of the relationship between the intensity of a meteorological event and the property damage incurred, damage can increase rapidly (e.g. increasing the wind gust speed of a 200 km/h storm by 10 % leads to a damage increase of about 150%). Especially when a critical value for the intensity is surpassed and protective measures fail, property damage increases sharply.

1.4 A change in weather patterns is likely to affect the property insurance industry, since it underwrites risks related to natural events such as storms and heavy rainfall. Already, computer simulations show that in several areas of the U.S.A. a single storm could result in economic damage of U.S.$ 100 billion, of which 50% can be expected to be insured. Other lines of insurance are also likely to be affected. For example, changes in human health (e.g. due to spreading of diseases) may affect the life assurance and pension industries. Shifts in agricultural production due to climate change may affect crop insurance, adding to the inherent difficulties of loss control and evaluation in this field.

1.5 There are also likely to be implications for investment activities as society plans for, and adapts to, the new climate regime. The economic situation of selected regions, such as coastal zones and islands, or of whole industries could be affected. As much as one third of investments in global stock markets (with a total capitalization of more than U.S.$ 15 trillion) are presently managed by the insurance industry and pension funds. It is therefore in the interests of the industry to understand better the investment opportunities and challenges which will arise from measures to reduce greenhouse gas emissions and to reduce the vulnerability of society.

2. The need for international cooperation, research and preventative action

Based on the current status of climate research and on their experience as insurers and reinsurers, the member companies of the Insurance Industry Initiative for the Environment in Association with UNEP (UNEP Insurance Industry Initiative) are convinced that global climate change entails significant environmental, economic, social, and geopolitical risks. A precautionary approach should be taken in dealing

with the issue by international cooperation, research and preventative action.

International Cooperation, Research

2.1 The risks of climate change can only be counteracted by the joint efforts of governments, political and social institutions, industrial and commercial enterprise (including the insurance industry), and of all individuals. This requires mechanisms which allow input from a wider range of stakeholders, including the private sector.

2.2 Developed countries need to take the lead in redirecting their economies to a path of reduced per capita greenhouse gas emissions. The developing countries are encouraged to identify the areas where they need assistance in terms of information, technology, capacity building etc. In particular, developing countries should take note of the environmental problems already being experienced in the developed areas of Europe, America and Asia. They need to raise public awareness of the need to follow a sustainable development path or future generations will have to face a heavy bill. Ultimately, only if all nations contribute to a preventative climate policy, can the overall goal of stabilization of atmospheric greenhouse gases be achieved.

2.3 To achieve climatic objectives at a minimum cost flexible, market-based policies should be favoured. These include international technology transfer, joint implementation and international emissions trading schemes. Counterproductive subsidies should be eliminated and a fiscal framework for energy consumption established which is truly sustainable.

2.4 Additional research concerning climate issues is needed to reduce uncertainty but cannot eliminate it entirely. We urge the parties to the United Nations Framework Convention on Climate Change (UNFCCC) to support scientific research to establish what concentration level and rate of increase of greenhouse gases are likely to be dangerous for society and to find an agreement on a safe path in managing climate risks.

Preventative Action

2.5 In accordance with a precautionary approach, considering the risks associated with different emission scenarios, and taking into account the inertia of the climate and of the socio-economic systems, we urge the Parties to the UNFCCC to agree on measures which will decouple the emission pathway from a business-as-usual scenario.

2.6 Policy-makers have a leadership role in establishing and enforcing long term priorities and values in the management of natural hazards. This encompasses short and long-term planning of land-use, infrastructure projects and building quality regulation, education, and implementation of incentives (or disincentives) to promote sound risk management by all sectors of society.

2.7 Cost-efficient technological options are available to achieve considerable greenhouse gas reductions and other societal goals. Structural barriers that prevent the introduction of such options should be removed. Efficient energy conversion technologies (e.g. cogeneration, fuel cells, high-efficiency gas turbines), renewable energy technologies, demand-side energy management and carbon-free energy sources should be promoted.

The insurance industry's role and contribution

3. Insurance companies have a role to play in defining solutions for managing climatic risks and contribute through risk management/insurance and through asset management.

Risk Management, Insurance

3.1 The general principle of insurance is to "share the risk". In managing the risks of climate change all parties involved must contribute: the insured should assume a substantial part of the risk, because this would encourage efficient loss prevention up front. The insurance and reinsurance industry should continue to provide risk management know-how and coverage for commercially insurable risks. For the remaining, commercially non-insurable part of the risk, risk management strategies should be developed with the support of governments with the aim of ensuring affordable insurance coverage against natural perils for the largest possible number of property owners.

3.2 Some of the risks of climatic change will remain uninsurable and thus become a burden for society, e.g. damage to ecosystems, gradual degrada-

tion, loss of economic value of coastal property. The extent to which insurers will be able to underwrite risks related to climate change will depend on the availability of adequate information, including the frequency and severity of extreme events, and on the availability of a sufficient risk spread.

3.3 The Member Companies of the UNEP Insurance Industry Initiative actively support the build-up of know-how in the field of natural hazards related to climate change, by assessing, quantifying and mapping risks. They are committed to managing internal operations and physical assets under their control in a manner that reflects environmental considerations, and thus contribute to a preventative climate change strategy.

3.4 Making available their experience in improving emergency response and recovery, and promoting loss prevention, the Member Companies of the UNEP Insurance Industry Initiative intend to support Governments and Industry in coping with the risks associated with natural catastrophes. An appropriate forum might be for the United Nations to extend the International Decade for Natural Disaster Reduction (IDNDR), with the particular remit to consider mitigation of hazards related to climate change.

3.5 There are important advantages in involving the private insurance sector in planning for disaster mitigation. It provides access to international resources, efficient claims handling, fraud control, and avoidance of duplicate administration, contributing considerably to an efficient risk management system.

Asset Management

3.6 Insurance companies, pension fund managers and banks have taken the lead in creating new investment instruments which favour companies that are committed to substantially lowering their greenhouse gas emissions and demonstrate best practices in energy efficiency. However, the amount of money under management in such funds is still very small. Investment managers of insurance companies, pension funds and banks should work together to develop environmental reporting standards which are generally accepted and therefore used in practice besides benchmarks for profitability and security.

3.7 The insurance industry along with other members of the financial services sector has invaluable experience to share with regard to investment risk analysis and environmental investment strategies. Exploiting the capabilities of the financial services sector will help to minimise economic upheaval and maximise the benefits of capital allocation. The economic consequences of climate change include opportunities for new technological and industrial development. The capital resources of both the public and private sectors should work in synchrony to promote alternative energy generation and use.

This paper has been discussed and approved for publication by the members of the UNEP Insurance Industry Initiative as a contribution to the climate change debate. It does not claim to represent a unanimous view of UNEP Insurance Industry Initiative members, nor does it in any way represent a UNEP position.

APPENDIX I: FLOOD INSURANCE COVERAGES: SOME EXAMPLES OUTSIDE THE U.S.*

Canada — There is no residential flood insurance available in Canada. There is some coverage for livestock, equipment, vehicles and sewer backups which can be insured in the private market. Businesses are provided some coverage in DIC coverage. In response to rapidly increasing disaster assistance payments in the early 1970s, the federal government introduced the Flood Damage Reduction Program (FDRP). Under this program, flood plain mapping, use restriction, education, flood mitigation, and flood forecasting are used to discourage the construction of vulnerable structures in areas likely to flood, and to protect ones already in such areas. In flood-forecasting operations, meteorologists and hydrologists cooperate to produce stream-flow and flood forecasts for major rivers, saving lives and reducing losses during flood events. When all these measures fail, private insurance, the provinces and the Federal Disaster Assistance Program (FDAP) contribute to the recuperation of losses. According to Environment Canada (1993, the FDAP, which is only activated when losses are more than the provinces can reasonably deal with, paid out $250 million ($451 million in 1991 $'s) in the period 1970-1988. This represents about 75% of all FDAP payments. Each province sets its own limit on individual disaster requests. For example, Manitoba increased its share of disaster assistance to homeowners from $30,000 to $100,000 per resident following the Red River Floods in 1997.

France — No coverage was provided for floods until 1982. Then, Caisse Centrale de Reassurances (CCR), was set up by the French government to serve as a reinsurance facility for flood, mudslides, earthquakes, landslides, subsidence, tidal waves, flowing water, mud, lava, moving ice or avalanches. The facility is governed by French law and is funded by charging a surcharge on premiums paid for basic property policies, regardless of exposure. Covered risks are subject to two conditions: a state of natural disaster must have been declared by an inter-ministerial decree. This decree determines the areas and periods of the disaster and the nature of damages resulting from it. The damaged property must be covered by a property damage policy. Premiums are charged as a flat surcharge to existing property properties: 9% on top of basic property insurance premiums for commercial and personal buildings and 6% on top of premiums for overland vehicles. The premiums are collected by the direct insurers and then reinsured under a combination of quota share and stop loss reinsurance with the CCR. The direct insurers' proportion of the quota share is 60% with CCR taking 40%. The stop loss comes into play when the direct insurers' total annual losses from covered catastrophes exceed 150% of annual premiums retained. CCR is reinsured to an unlimited extent by the state. The program is voluntary, but all of the French insurers except one participate in the program. All policyholders pay the same premium and deductibles, and there is some talk about creating new policies that would be more flexible.

Germany — Prior to reunification, flood insurance was compulsory in East Germany. Since 1991, companies have an option to buy the insurance, which many say they cannot afford. The price for flood insurance depends on the risk circumstances in individual cases. As a rule, flood insurance is offered only when an adequate deductible is retained, normally 0.05% of the insured sum. In most cases involving risk of a total loss, limits of indemnity generally begin at 10%. A precondition for insurance is that the policy cover only freak floods, no adverse selection takes place, and insurance is provided on a full value basis with a deductible. Insurers look at previous losses, the vertical and horizontal distance from bodies of water and the building class of the structure. Contents are assessed based on how far they are above ground and their susceptibility to water. Flood insurance premiums are calculated on

*Hausmann (1998) provides additional analyses of international flood insurance programs.

loss potential, but probable maximum loss is not just the sum of flood sources and the concentration of values in them. A lot of uncertainty is involved, and this drives the cost of the insurance up. There has been some talk of creating a facility, but it has not progressed far.

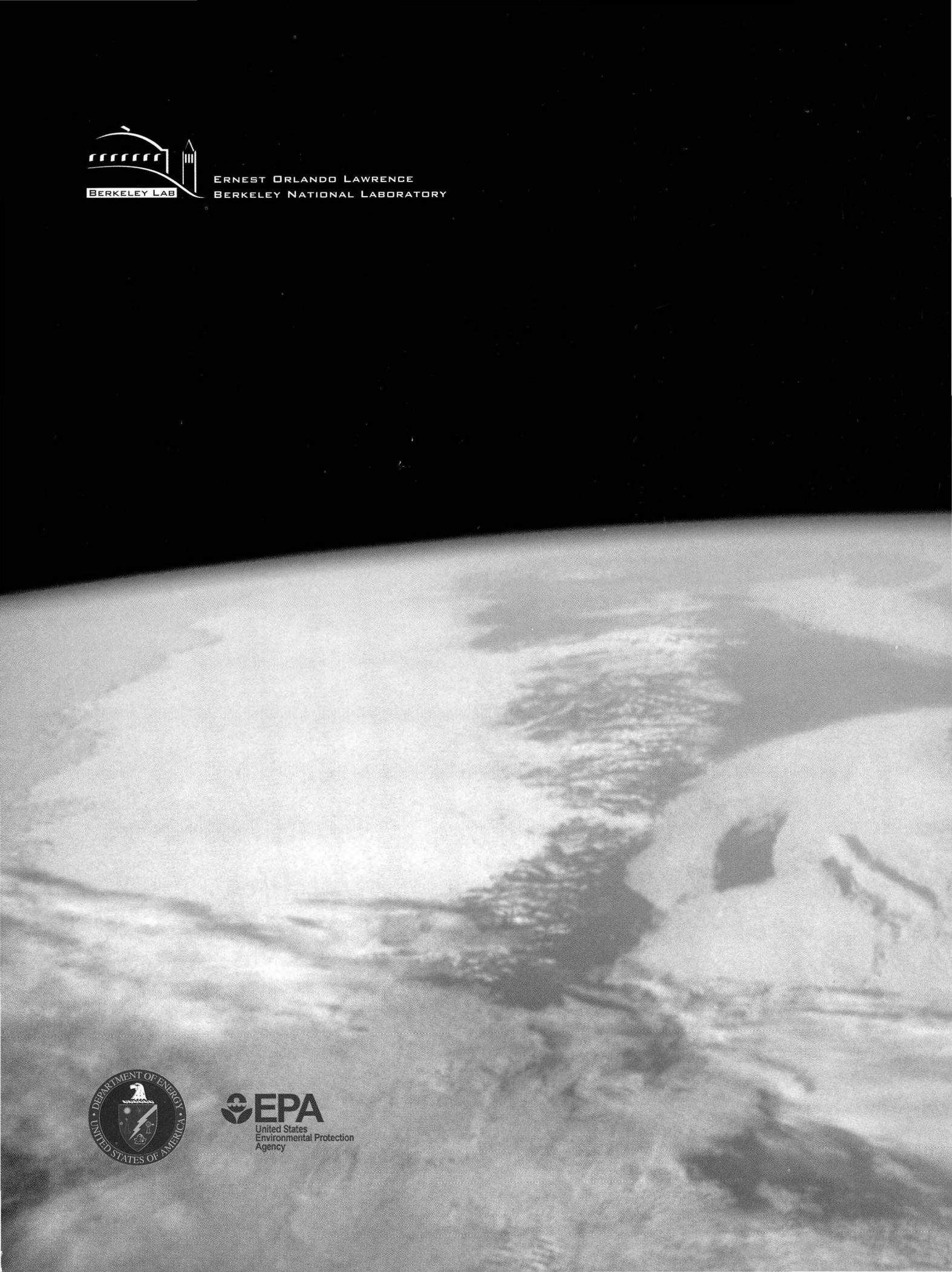
Spain — Spain has a similar arrangement as France regarding the payment of flood losses. The Consoricio de Compensacion de Seguros handles flooding events. Spain has established a public law fund, using the Consorcio as the facility. Private insurance reports claims to the Consoricio, which gets a fixed premium share from private insurers and settles claims out of the fund. The 'Consorcio de Compensacion de Seguros' is a compulsory Government catastrophic risk insurance applying to: Fire, Boiler & Machinery / Engineering, Goods in Transit, Personal Accident, Homeowners, Burglary and Employers' Liability. Insured perils include: earthquake, flood, storm / tempest, burst water pipe, strike, riot / civil commotion, volcanic eruption, windstorm / hurricane, landslide. Note: This Government scheme covers direct physical damage. Any resulting Business Interruption losses would be covered under the commercial insurance policies.

United Kingdom — The UK does not have any type of specific flood insurance program. Flood insurance is covered under the standard fire perils portion of the property insurance property. The standard portion provides coverage for fire, lightning, aircraft, explosion, earthquake, flood, storm/tempest, burst water pipe, riot/civil commotion, malicious damage and vehicle impact. At least one study has been completed in the Insurance Journal of the UK that suggests the creation of a reinsurance facility for flood losses, but nothing has happened nationally since this study was published in 1996. The major flood risk is coastal inundation, and the Association of British Insurers is carrying out a program of risk-mapping any hazard prioritization in collaboration with Government bodies.

* Prepared by the Institute for Business & Home Safety Information Center based on Insurance Services Network (1999), Kielmas (1996), Lewis (1997), Canoe (1997), and personal communication Insurance Bureau of Canada (February 25, 1999).

ACRONYMS

AAI	Alliance of American Insurers
AIA	American Insurance Association
AIRAC	All-Industry Research Advisory Council
ART	Alternative Risk Transfer
BCEGS	Building Code Effectiveness Grading System
CAT	Catastrophe (insurance, losses, models, etc.)
CDC	Centers for Disease Control
CDI	California Department of Insurance
CEA	California Earthquake Authority
CFP	California FAIR Plan
CO2	Carbon dioxide
DOE	U.S. Department of Energy
DRBA	Disaster Recovery Business Alliance
ENSO	El Niño/Southern Oscillation
EPA	U.S. Environmental Protection Agency
FDAP	Federal Disaster Assistance Program (Canada)
FDRP	Flood Damage Reduction Program (Canada)
FEMA	Federal Emergency Management Agency
FIA	Federal Insurance Administration (part of FEMA)
GAO	General Accounting Office
GCM	General Circulation Model
IBC	Insurance Bureau of Canada
IBHS	Institute for Business and Home Safety
ICC	Insurance Council of Canada
ICLR	Institute for Catastrophic Loss Reduction
IDNDR	International Decade for Natural Disaster Reduction
IFRC	International Federation of the Red Cross
IIAA	Independent Insurance Agents of America
IIHS	Insurance Institute for Highway Safety
III	Insurance Information Institute
IIPLR	Insurance Institute for Property Loss Reduction
IPCC	Intergovernmental Panel on Climate Change
IRC	Insurance Research Council
ISMA	International Securities Market Association
ISO	Insurance Services Office
JUA	Joint Underwriting Association
NAIC	National Association of Insurance Commissioners
NAII	National Association of Independent Insurers
NAMIC	National Association of Mutual Insurance Companies
NCAR	National Center for Atmospheric Research
NCPI	National Committee on Property Insurance
NOAA	National Oceanic and Atmospheric Administration
OECD	Office of Economic Cooperation and Development
OSHA	Occupational Safety and Health Administration
PCS	Property Claim Services
P/C	Property/Casualty insurance
PML	Probable Maximum Loss
RAA	Reinsurance Association of America
RIMS	Risk and Insurance Management Society
RMMs	Residual Market Mechanisms
RPI	Risk Prediction Initiative
SBA	Small Business Administration
SIR	Society of Insurance Research
UNEP/III	United Nations Environment Program, Insurance Industry Initiative
UNFCCC	United Nations Framework Convention on Climate Change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