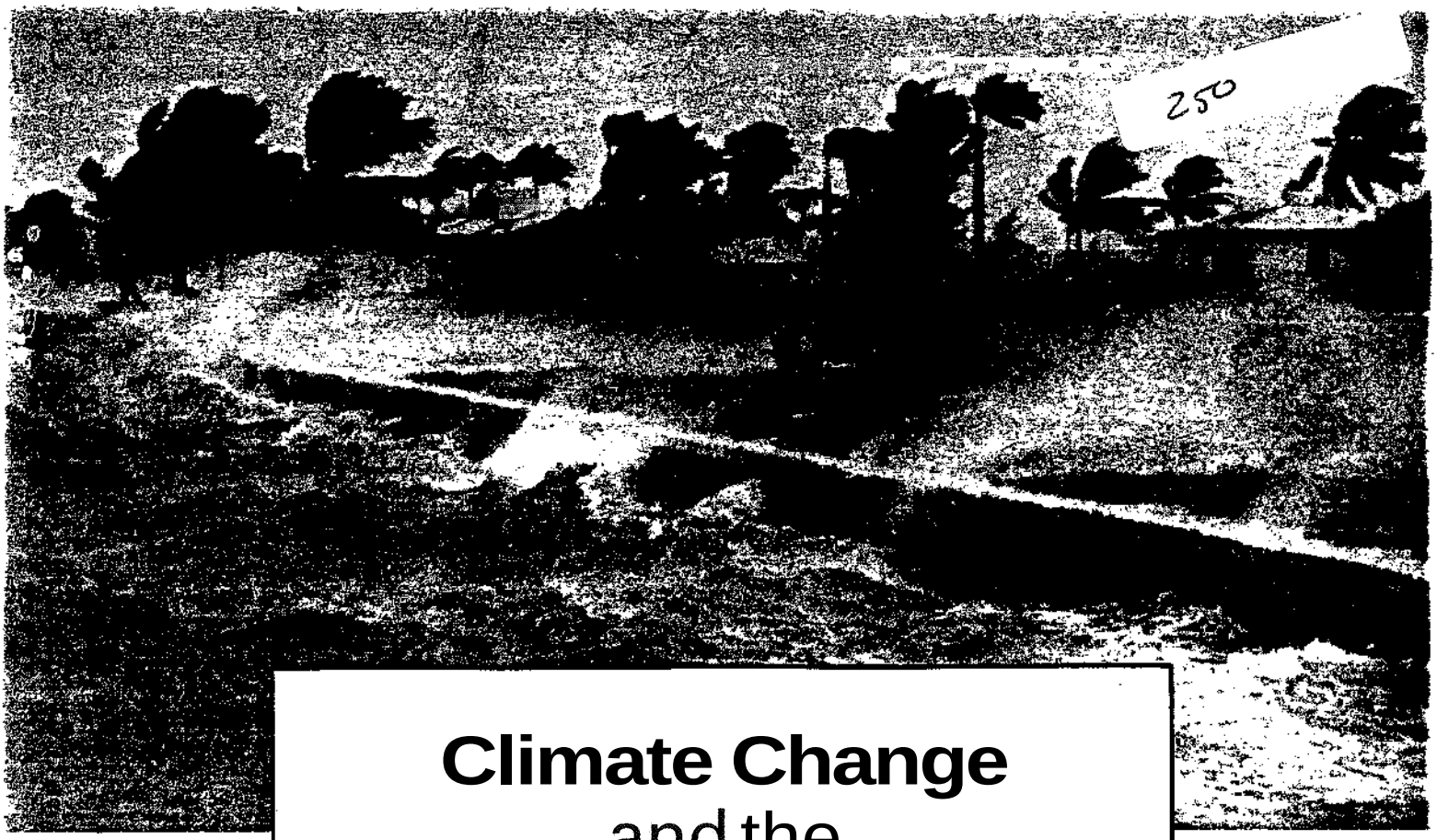

Climate Change and the Insurance Industry

Solidarity among the Risk Community?

Dr Jeremy Leggett
Scientific Director
Climate Campaign
Greenpeace international

Is human-induced climate change a real threat?
How will it affect the world's biggest industry?
What can the insurance business do to safeguard its future markets?

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GREENPEACE

EXECUTIVE SUMMARY

The threat posed by the human-enhanced greenhouse effect to economies and ecosystems has led to more than 150 governments signing a Climate Convention setting the international community on track for limitation of greenhouse-gas emissions to the atmosphere. The world's major climate-forecasting centres now predict that if current rates of greenhouse-gas emission are maintained, dangerous rates of warming - unprecedented during human history - will occur in the decades ahead. Furthermore, there are worrying indications that some of the kinds of climatic phenomena to be expected if these forecasts are correct may already be occuring. 1990 was the hottest year since records began more than a century ago. 1991 was the second hottest, despite the significant cooling effect of the Mt Pinatubo eruption. The seven hottest years have all been since 1980. Coral reefs are beginning to bleach and die, in waters of unprecedented warmth in the Caribbean, Pacific and Indian oceans. Hurricanes of record strength are hitting the Caribbean. Cyclones of record strength are hitting the Pacific. Anomalously intense droughts have struck southern Africa, northern Brazil, California, SE England, and other places.

The unprecedented losses incurred by insurance companies in recent years are due in part to unusual windstorms: hurricanes Hugo and Andrew, cyclones Iniki and Mireille, the '87 and '90 winter storms in Europe, and others. Unusual droughts in areas like the south and east of England are causing unprecedented subsidence damage. A globally warmer atmosphere is expected to herald stronger and more frequent windstorms, storm surges, rising seas, floods, droughts, increased subsidence following soil shrinkage on clay substrates, and many more unpleasant impacts.

The insurance industry has started to wake up to the threat that climate change poses to its profitability. Some industry analysts are looking at the results of climate modelling, and wondering how much of their current misfortune can be put down to human-induced climate change. They are also asking a far more significant a question: if the majority view among climate scientists proves correct, how much worse might the future be? In high places in the industry, there are real fears for the very future of stable insurance markets should current climate models prove accurate, or even worse - underestimates.

The options for the industry are threefold. First, it can opt for the business status-quo, and hope that the windstorm-related experiences of insurers and reinsurers in the period 1987-92 will prove to be a passing trough. Another trillion-dollar-a-year interest-group, comprising the oil and coal industries, has essentially opted for this course. It has conducted a co-ordinated international lobbying effort to persuade governments that there is no need to limit the burning of fossil-fuels,

which are the overwhelming source - direct and indirect - for the dramatic contemporary build up of heat-trapping greenhouse-gases in the atmosphere.

The second option is to begin a dramatic overhaul of the way business is conducted by the insurance industry. This would include substantially increasing deductibles, a reappraisal of excess-of-loss arrangements between insurers and reinsurers, increased use of coinsurance, an attempt at realistic rating (though this will prove difficult in a world where, because of the intervention of human-induced factors, the past no longer provides records offering a guide to the future), selective withdrawal of cover, and other measures. There are clear signs that this kind of industry-wide upheaval is already underway. It is already motivated in some quarters, at least in part, by the prospect of climate change.

But if the "balance-of-probabilities" view of global warming, as crystallized in the 1990 and 1992 Intergovernmental Panel on Climate Change (IPCC) Science Assessment reports, is correct, this second strategy would not be sufficient. In a world where no efforts are made to limit greenhouse-gas emissions, any changes in business practice by insurers - no matter how far-reaching - will only buy time for the industry. Unless greenhouse-gas concentrations in the atmosphere are stabilized, their known radiative properties and long atmospheric lifetimes will ensure that global average temperatures go right on rising, and consequent threats to the stability of climate, the viability of ecosystems, and ultimately the health of entire economies, go right on multiplying. Furthermore, unless atmospheric greenhouse-gas concentrations are stabilized at or close to present-day levels, scientists have warned that committed warming runs the real risk of awakening profound synergistic natural amplifications of the human-enhanced greenhouse effect.

This introduces the third option for the insurance industry. In addition to passive adaptation of business practice, the industry can look to active strategic protection of the market in which it operates. This would involve lobbying - of industry, government, consumers, and shareholders - in pursuit of the kinds of cuts in greenhouse-gas emissions that can provide the only guarantee of healthy economies in the face of the climate-change threat. If one trillion-dollar-a-year business - the fossil-fuel lobby - can lobby so successfully, why not another? The difference would be that whereas the fossil-fuel business is prosecuting perceived short-term interests in direct contradiction of robust evidence that risk is great, the insurance industry would be prosecuting the interests of all at risk, and acting on odds that are overwhelming.

What would be the goal of this strategic effort to safeguard future insurance markets? The battle to cut greenhouse-gas emissions sufficiently to stave off the climate-change threat will be fought, won, or lost on the extent to which the

international community can, over the next few decades, recast the global energy infrastructure. The goal must be to replace today's status-quo - a fossil-fuel dependent, energy-profligate one - with a new infrastructure based on state-of-the-art energy efficiency and renewable energy-supply. Achieving this goal must, above all, involve transforming the oil and coal companies of today into the total-energy companies of tomorrow: companies operating on a levelled energy playing-field in which multi-billion dollar industries have emerged in demand-side management and solar energy. The technologies on which such a future can be based exist today. There are many ways in which the insurance industry can help fast-track them, most importantly through strategic deployment of investment capital.

Healthy economies are impossible without a healthy international insurance industry. It is becoming increasingly clear that a healthy insurance industry will not be possible in a world in the grip of human-induced climate change. Healthy economies are also impossible without healthy human populations, which are in turn ultimately dependent on healthy ecosystems. As the world approaches the twenty-first century, the insurance industry, human communities, and ecosystems are all at risk from human enhancement of the greenhouse effect. It is time to expand one of the underpinning concepts of insurance: the solidarity of the risk community.

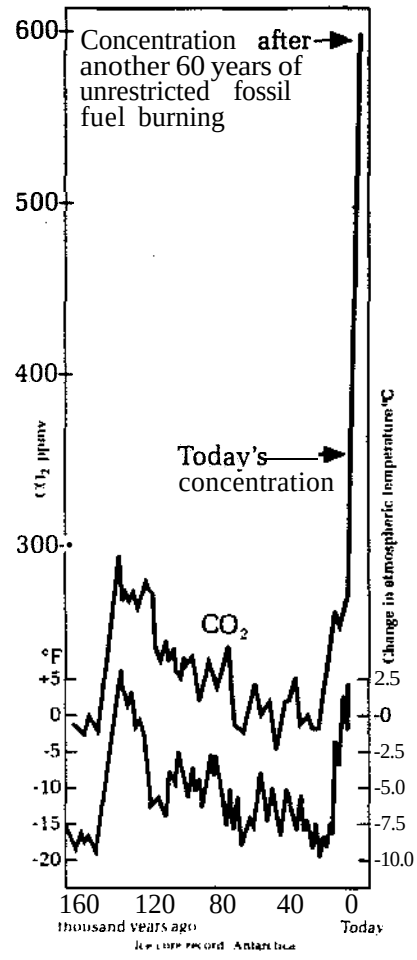

Figure 1. The past and future concentrations of carbon dioxide in the atmosphere. The 160,000 year record of carbon dioxide concentrations and air temperature comes from the Vostok ice core in Antarctica (Source: Intergovernmental Panel on Climate Change, Scientific Assessment Report 1990). Continued business-as-usual emission of greenhouse gases gives 600 ppm of carbon dioxide within 60 years and 600 ppm of carbon dioxide-*equivalent* within less than 50 years. (Source: Vostok core profile as reproduced in IPCC 1990 Report, with future carbon dioxide from the IPCC 1992a scenario, a fossil-fuel dependent scenario close to the 1990 IPCC "business-as-usual" scenario). N.B. Carbon dioxide equivalent, otherwise known as the effective carbon dioxide concentration, is the heat-trapping capability of the sum of greenhouse gases, expressed in terms of the amount of carbon dioxide fin parts per million, or ppm) that would have the same effect.

1. THE CLIMATE-CHANGE THREAT

Where the human-enhanced greenhouse effect is concerned, we can be certain of two critical issues, and very uncertain of a third. We know that greenhouse gases - principally carbon dioxide, methane, halocarbons, nitrous oxide, and ozone - are capable of trapping heat in the atmosphere: this is based on simple physics. We know that atmospheric concentrations of these gases are soaring: this has been measured by sensitive instruments the world over (Figure 1). The debate centres on a key uncertainty - exactly how much the temperatures will go up in consequence, and what the response of the climate system will be.

The purpose of this report is not to review the science of the human-enhanced greenhouse effect in detail. We refer the interested reader to the reports of the Intergovernmental Panel on Climate Change (IPCC).[1] The main points are these. We have a clear "best-estimate" view, that of the several hundred scientists, representing more than 40 governments, who compiled the IPCC reports. It suggests that the "best guess" estimate for business-as-usual emission of greenhouse gases will be to raise the global average temperature by something approaching 3 degrees C by the end of the next century.[2]

[1] Intergovernmental Panel on Climate Change. "Climate Change: the IPCC Scientific Assessment." Cambridge University Press. 1990. UK Prime Minister Margaret Thatcher described this report when it was finished in May 1990 as follows: "We have an authoritative early warning system: an agreed assessment of some 300 of the world's leading climate scientists of what is happening to the world's climate...a report of historic significance ...what it predicts will affect our daily lives." See also "The Supplementary Report to the IPCC Scientific Assessment," Cambridge University Press, 1992, which concluded as follows: "findings of scientific research since 1990 do not affect our fundamental understanding of the science of the greenhouse effect and either confirm or do not justify alteration of the major conclusions of the first IPCC Scientific Assessment." Commentaries on the IPCC reports can be found in J.K. Leggett (ed) "Global Warming: the Greenpeace Report," Oxford University Press, 1990; and J. K. Leggett, "Global warming: the scientific evidence and its implications," Journal of Transnational Law and Contemporary Problems, v.2, p. 2 - 59, Special Issue for the UN Conference on Environment and Development, Special Issue, June 1992.

[2] The contribution of CFCs in the decade of the '80s was thought at the time of the 1990 IPCC science assessment to have been some 24V By the time of the 1992 IPCC report, scientists had realized that CFCs were depleting ozone (another greenhouse gas) so fast that their net contribution was much less than 24%. Additionally, sulphate-aerosols - largely derived from coal-burning - had been shown to be reflecting more solar radiation than was the case in 1990. Hence, whereas the IPCC 1990 Report showed a "best guess" increase in global average temperature *by* 2100 of more than 3 degrees C , the 1992 Report showed slightly less than 3 degrees.

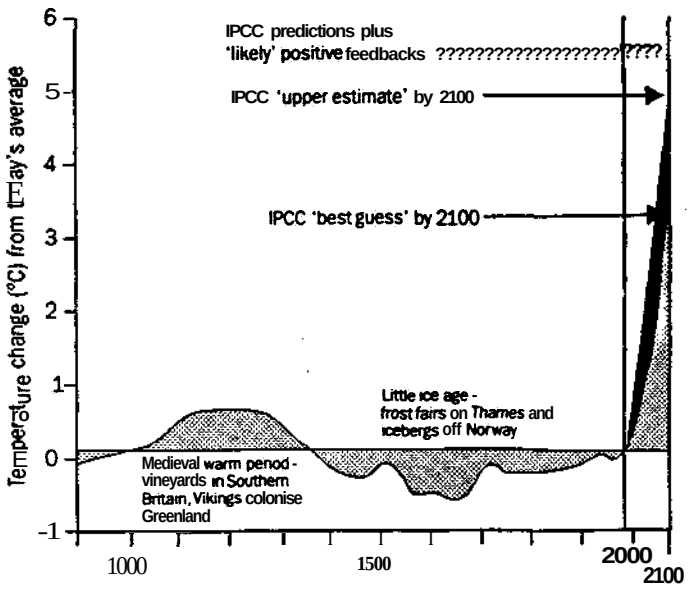

Figure 2: Generalised global average temperatures during the past 1,000 years, and those predicted for the next 100. The averages depict a range of analyses from sediment- and ice-cores. The black peak is the 'best guess' of the IPCC scientists for the next century. The grey peak is the upper range of the estimates from the IPCC models. The 1990 IPCC scientific assessment, to which ecologists contributed, concluded that the likelihood of positive feedbacks - unaccounted for in climate models - means that the real temperature rise in the next century would be 'likely' to be even higher than that predicted. (After International Geosphere Biosphere Program Report no. 6 'Global Changes of the Past,' July 1988, and UK Department of the Environment 'Global Climate Change,' May 1990, with the predicted future - the IPCC scientists' results - added). According to another authoritative international scientific study, co-ordinated by the Stockholm Environment Institute,[3] allowing temperatures to build higher than 2 degrees C above pre-industrial is to run the gauntlet of a threshold beyond which "risks of grave danger to ecosystems, and of non-linear responses, are expected to increase rapidly." So far this century, according to the IPCC, global average temperatures have already risen 0.3 to 0.6 degrees C above the pre-industrial average (an observation which excludes the urban "heat-island" effect). Yet the levels of carbon dioxide-equivalent at which the world is committed to a 2 degrees rise are either 560 parts per million if the climate sensitivity is low, or 400 ppm if the climate sensitivity is high.[4] And there are already 410 ppm of carbon dioxide- equivalent in the atmosphere.

[3] Stockholm Environment Institute, "Responding to Climate Change: Tools for Policy Development", October WO.

[4] Climate sensitivity is the amount temperature would go up, at equilibrium, as a result of doubling carbon dioxide in the atmosphere. The low climate sensitivity cited here is 2 degrees C, the high climate sensitivity is 4 degrees C.

Many ecologists fear that such a thermal stress, and associated climatic changes, will exceed the critical thresholds for the successful adaptation of many ecosystems (Figure 2).[5] This is turn would build incremental, and inevitably intolerable, stress on food security, water security, economic wellbeing and social cohesion.

Either side of the best-estimate analysis, we have a "best-case" analysis estimate, and a "worst-case" analysis. The best-case is proposed by a bare minority of climate scientists, which suggests that natural suppression mechanisms (so-called negative feedbacks) will be awakened as greenhouse-gas concentrations rise, suppressing global warming to negligible levels.[6] Given the extent of uncertainties over the multivariant entity that is global climate, this view could, just conceivably, be correct. But given the robust nature of the best-estimate view, and the science on which it is based, the odds are atrocious.

They appear all the more formidable given the stakes. Bad though the best-estimate future would be, there is a worst-case view, which is that the IPCC estimates will prove to be underestimates, that natural amplifications of warming (so-called positive feedbacks) will be awakened, potentially even generating a point-of-no return beyond which might lie unstoppable heating of the planet. This view is discussed in detail elsewhere.[7]

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[5] The IPCC summary of the world's climate models leads to a predicted average rate of temperature increase approaching 0.3 degrees C per decade. The record of the effects of past relatively-rapid rates of change on ecosystems, particularly at the end of the last ice age, suggest that rates higher than 0.1 degrees C per decade are unsustainable without ecological trauma. The rates predicted by the IPCC may be as much as 10 to 100 times faster than anything ecosystems have experienced in the last few million years, at least. See Huntley, B. in "Global Warming: the Greenpeace Report," Oxford University Press, 1990.

[6] e.g. R. Lindzen, "Global Warming: the origin and nature of alleged scientific consensus," paper for the OPEC Seminar on the Environment. Vienna. 13-15 April 1992. S. Fred Singer, "Warming theories need warning label," Bulletin of the Atomic Scientists, v. 85, p. 34-39. Lindzen, perhaps the most eminent of the greenhouse sceptics, believes that increasingly vigorous circulation in the lower atmosphere, as greenhouse-gas concentrations rise, will wring water vapour from the air, a major negative feedback which would counteract the human-enhanced greenhouse effect.

[7] J.K.Leggett, "Global warming: the worst-case," Bulletin of the Atomic Scientists, v. 85, p. 28-32. And "Running down to Rio," New Scientist, 2 May 1992, p. 38-41. In these articles, the results of an opinion survey show that almost half of surveyed world climate scientists believe that a runaway greenhouse effect is possible if action is not taken to cut greenhouse gas emissions. And more than one-in-ten of those polled believe this worst-case analysis - a point ot no return beyond which lies unstoppable heating of the atmosphere - to be probable. Greenpeace International polled 400 climate scientists during December '91 and January '92. The sample included all scientists involved in the 1990 study of the Intergovernmental Panel on Climate Change, and others who have published on issues relevant to climate change in 'Science' or 'Nature' during 1991. Scientists were asked whether they thought there would be a point of no return at some time in the future, if emissions continued at their present rate. By the end of January '92, 113 had replied, in the following way: probably - 15 (13%), possibly - 36 (32%), probably not - 53 (47%). In other words, 45% believe the runaway greenhouse effect to be possible.

2. THE EMERGING INTERNATIONAL RESPONSE TO THE THREAT.

Governments have recognized the threat in innumerable individual publications and joint declarations in recent years, some of which refer darkly to threats to a viable future for life on the planet and read in places not unlike the rhetorical essays of environmentalists.[8] After 18 months of negotiations, beginning in February 1991, more than 150 governments finally signed a Climate Convention at the Rio Earth Summit of June 1992 which established the objective of *"stabilization of greenhouse gas concentrations in the atmosphere at a level which would prevent dangerous anthropogenic interference with the climate system."* This is reinforced with a sentence which stipulates that such a goal should be realized *"within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure food production is not threatened and to enable economic development to proceed in a sustainable manner."*

To achieve that objective, however, would require deep cuts in greenhouse-gas emissions.[9] That, in turn, would entail a fundamental rethink in the way the world uses energy. The global community would have to move, over a period of decades, away from economies based on fossil-fuel dependence and energy profligacy, to a global energy infrastructure based on renewable supply and

[8] As long ago as 1988, an intergovernmental declaration at a conference in Toronto spoke of global warming posing risks "second only to nuclear war." The Ministerial Statement of the Second World Climate Conference, November 1990, signed by 137 governments, read: "We agree that the ultimate global objective should be to stabilize greenhouse-gas concentrations at a level which would prevent dangerous anthropogenic interference with climate... Where there are threats of serious or irreversible damage, lack of full scientific consensus should not be used as a reason for postponing cost-effective measures to prevent such environmental degradation." This was later estabished as the objective of the Framework Convention on Climate Change, signed at the Earth Summit of June 1992. The Final Report of the Advisory panel on Environment and Culture to the Environment Agency of Japan, "Towards the creation of an Environment-Friendly Culture," April 1991, concluded that if humans continue using natural resources including fossil fuels at today's rates: "We run the risk of creating a crisis which will not stop with the ruin of one country but will cause the destruction of the entire planet and every living thing on it."

[9] Fossil-fuel combustion produces carbon dioxide directly, and ozone indirectly as a result of the interaction of nitrogen oxides and carbon monoxide with sunlight. The mining of coal and extraction of oil and gas cause venting to the atmosphere ot methane. Additionally, petroleum feedstock is required for making chlorofluorocarbons (CFCs) and fertilisers which release nitrous oxide. The IPCC concluded that stabilisation of atmospheric concentrations of carbon dioxide (atmospheric lifetime 50-200 years) would require cuts in emissions of 60-80%, and nitrous oxide (atmospheric lifetime 150 years) would require cuts of 70-80%. Methane, with its shorter atmospheric lifetime of c.10 years, would require cuts in emissions of 15-20%. CFCs (atmospheric lifetime up to 130 years) need to be cut completely because of their ozone-depletion powers, and under the present Montreal Protocol, governments have agreed to phase out most CFCs by 2000. Recent alarming evidence that ozone depletion is proceeding much faster than anticipated, it must be hoped, will lead to an emergency revision of the Montreal Protocol.

maximal energy demand-management.[10]

Every industrialized country except the USA wanted to sign a Climate Convention that would, as a first step towards the treaty's stated objective, at least limit the flow of greenhouse-gas emissions into the atmosphere by putting a cap on the burning of fossil-fuel. Coal, oil and gas are, of course, by far the dominant means - direct and indirect - of elevating atmospheric greenhouse-gas concentrations. Six governments even wanted the Convention to set targets for cutting such emissions.[11] But the eventual treaty, as signed, entailed no commitments to targets and timetables for limiting emissions.[12] The robust lobbying of the international oil, coal, and auto industries, throughout the negotiation process and in the Earth Summit preparatory process, had much to do with this unsatisfactory state-of-affairs.

The climate negotiations are ongoing. Meanwhile, the Clinton Administration has committed, at minimum, to freezing US carbon dioxide emissions at 1990 levels by 2000, in line with the rest of the industrialized world. When the climate negotiations reconvene in 1993, every industrialized country will be committed to at least that first step towards the deep cuts in emissions that the international community must bring about a few decades hence if greenhouse-gas concentrations are to be stabilized - as the Climate Convention stipulates - at levels which pose no danger (Fig. 3).

[10] A detailed defence of the feasibility of what seems at first sight like an impossibly visionary upheaval in world energy-policy is not the purpose of this paper. Greenpeace has done so in a detailed energy-scenario study ("Fossil fuels in a changing climate," Greenpeace Special Publication, in press). Consider, meanwhile, the opinions of two eminent consultants to industry and government on the two energy options which must be brought to the fore - energy efficiency and renewables. "It is generally cheaper today to save fuel than to burn it. Avoiding pollution by not burning the fuel can, therefore, be achieved, not at cost, but at a profit - so this result can and should be widely implemented in the market place" (Amory Lovins, 1990). "Technology exists that can produce electricity, or any temperature heat (up to 1,400 C) directly from natural resources available at a remote location in nearly any country. The demand can be satisfied without tranporting a continuous, long-distance stream of fuel or running long- distance electric power transmission lines - or emitting vast quantities of greenhouse gases.... there is no qualification needed for these statements. Technically, it is possible. Economically, it is a more limited situation, but not nearly as limited as most observers and analysts believe..." (Carlo LaPorta, 1990). Lovins and LaPorta defend these opinions in detail in J. K. Leggett (ed), "Global Warming: the Greenpeace Report," Oxford University Press, 1990.

[11] Germany, Netherlands, Denmark, Australia, New Zealand, Austria.

[12] For further analysis of the Climate Convention - positive and negative - see J.K.Leggett and P. Hohnen, "The Climate Convention: A Perspective from the Environmental Lobby" Security Dialogue, v. 23, p. 75-81, December 1992.

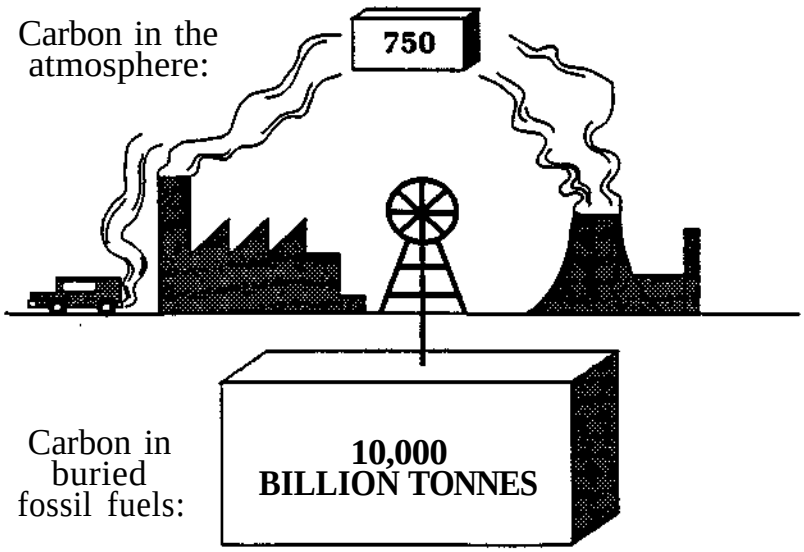

Figure 3: Continuing fossil-fuel dependence: the arithmetic of **unsustainability.** We know from analyzing ancient air in ice-cores that for thousands of years before the mass burning of coal, oil and gas began there were only around 580 billion tonnes of carbon in atmosphere as carbon dioxide. Largely because of accelerating fossil-fuel burning since World War Two, there are now more than 750 billion tonnes of carbon in the atmosphere. We are currently adding 6 billion tonnes each year from the burning of oil, coal, and gas - by far the predominant source of greenhouse gases.[13] Ecologists warn that dangers from consequent enhancement of the greenhouse effect are increasing rapidly, and that producing even 300 billion tonnes more carbon from the burning of fossil fuels risks ecological catastrophe.[14] Beyond that point, the concentration of carbon dioxide in the atmosphere would be such that the prospect of natural amplifications of global warming rise rapidly and the rate of increase in global average temperatures would be beyond the ability of many, if not most, animals and plants to adapt. Society should therefore be trying to replace fossil fuels with energy-efficiency and renewable energy well before that much fuel is consumed. However, the total amount of carbon in discovered and yet-to-be-discovered fossil fuel deposits, is around 10,000 billion tonnes.[15] Of that, some 200 billion tonnes is oil, almost 1,000 billion tonnes is gas, and the rest is coal. Burning just 3% of this fossil fuel reserve - 300 billion tonnes - may well make global ecological catastrophe almost certain.

[13] All figures Intergovernmental Panel on Climate Change, ibid.

[14] Stockholm Environment Institute, ibid. and F. Krause, W. Bach, and J. Koomey, "Energy policy in the greenhouse," International Project for Sustainable Energy Paths, September 1989. And see Stockholm Environment Institute, ibid.

[15] Intergovernmental Panel on Climate Change, ibid.

3. A COMMON QUESTION: HAS GLOBAL WARMING ARRIVED?

According to the Enquete Commission, a prestigious body set up by the German Bundestag to investigate climate change, and which includes several of Germany's top climate scientists, we need deliberate no further about whether we can see human-enhancement of the Earth's natural greenhouse effect in action. In a recent report, the chair of the Commission wrote: "our planet is already warming at an increasing rate. The first signs of climate change are already measurable and noticeable."[16] The IPCC, in contrast, concluded that "the unquivocal detection of the enhanced greenhouse effect is not likely for a decade or more, when the commitment to future climate change will be considerably greater than today."[17]

Left to its own devices without human-enhancement of the natural greenhouse effect, climate varies naturally over time. Because of this, it could yet just be a coincidence that the seven hottest years since records began have all been in the last ten, that 1990 was the hottest ever, that 1991 was the second hottest - despite the cooling effect of the Mt Pinatubo eruption,[18] and that "never before, at least in the last 7 centuries, has there been the same succession of mild and dry winters in Central Europe as in the years from 1987 to 1990."[19] But whether the Enquete Commission or IPCC view is correct does not really matter. The crucial point is made in the closing phrase of the IPCC statement above. Because of the long lifetime of greenhouse gases in the atmosphere, and because of the lag-effect on warming due to the slowness of the oceans to warm up, we are virtually certain to face dangerous rates of global warming in the decades to come if we keep pumping greenhouse gases into the atmosphere at anything like the rates we do today. The point at which we can say that human-enhancement of the Earth's natural greenhouse effect is provenly clear is in a certain sense irrelevant.

In the interim, there is a growing catalogue of circumstantial evidence that all may not be well with the climate. It behoves us all to pay attention to these signs. Average snowfall over the northern hemisphere has dropped by about 8% since 1973. In northern Canada, lake temperatures have increased by 2 degrees C in the

[16] Enquete Commission "Protecting the Atmosphere" of the German Budestag, "Climate Change - A Threat to Global Development," March 1992.

[17] IPCC Scientific Assessment 1990, as note 1, p. xxiv.

[18] Testimony to the US Senate on global temperatures. P.D. Jones, 11 October 1990, Committee on Commerce, Science and Transportation, US Senate. Note that the Climate Research Unit of the University of East Anglia is widely recognised as one of the world's premier centres for analysis of global temperature records. And see "Global Warming Trends," P.D. Jones and T.M.L. Wigley, Scientific American, August 1990.

[19] Dr G. A. Berz, Head of Munich Re's Geoscience Research Group: "Greenhouse effects on natural catastrophes and insurance," The Geneva Papers on Risk and Insurance, 17 (No. 64, July 1992), p. 386-392.

last 20 years.[20] In the Arctic, the extent of the ice-cap declined by about 2 per cent between 1978 and 1987, and there are worrying indications that it may be thinning, and water beneath it warming.[21] Mountain glaciers are in retreat almost everywhere, and ice cores from glaciers in China, Russia and Peru show that temperatures for the 50 years between 1937 and 1987 were higher than for any 50 year period in 12,000 years.[22] Anomalously warm waters have been found by scientists over large areas in the Mediterranean,[23] and the Eastern and Western Pacific.[24] Corals are particularly temperature-sensitive, and coral bleaching - a stress reaction which if maintained can kill entire reefs - has been observed at historically-unprecedented levels around the world.[25] Five leading American marine biologists, called upon to testify to the US Senate on this worrying development in 1991, said "we may be witnessing an early warning of global

[20] "Effects of climatic warming on lakes of the central Boreal forest." D.W. Schnindler et al, Science, 16 November 1990.

[21] "Arctic ocean's glacial retreat," International Herald Tribune, 5 July 1991. If the Arctic ice cap melts, global warming will be significantly amplified as a result of the lower albedo of seawater, and, worse even than this, the stability of ocean currents would be disturbed, leading to unpredictable but potentially catastrophic impacts on climate. See Leggett, J. "Unfreezing the secrets of the Arctic: the inadequacy of the Arctic Environmental Protection Strategy," Greenpeace International briefing paper, 13 June 1991, and references therein. The possibility that the Arctic ice cap may be thinning is described in P. Wadhams, "Evidence for thinning of the Arctic ice cover north of Greenland," Nature v. 345, p. 795-797, 28 June 1991. According to this research, by the British Scott Polar Research Institute, an area of 300,000 square km of the ice-cap north of Greenland was shown to be an average of 5.3 metres thick in 1976, and 4.5 m thick in 1987, a thinning of 15%, and an ice-volume loss of more than 200 cubic kilometres. This need not necessarily indicate global warming, however, and could yet be due to inter-annual variability. But other reasons for concern are clear: maximum temperatures in waters north of Frans Joseph Land in the Arctic were warmer by 1 full degree C in 1990 than they had been 1987. From the team that found that worrying pointer, came an understated plea: "it seems clear that there is need for careful monitoring of the heat fluctuations in the Arctic, a region so vulnerable to changes in global climate." See Quadfasel, D. et al, "Warming in the Arctic," Nature v. 350, p. 387.

[22] L. Thompson of the University of Ohio, testifying to the Senate Committee on Commerce, Science and Transportation, February 27, 1992, quoted in "Scientists say global warming is definite," United States Information Service Backgrounder, Canberra, March 3 1992.

[23] The Mediterranean deep layer (> 400 m) warmed steadily by 0.12 degrees C between 1959 and 1990. "Warming trend in the western Mediterranean deep water." J. P. Bethoux et al, Nature, 347, p. 660-662. 18 October 1990.

[24] Temperatures in the upper 100m ot sea off California have warmed by fully 0.8 C since 1950: D. Roemmich, "Ocean warming and sea level rise along the Wouthwest U.S. coast," Science, v. 257, p. 375). Across a large area south of Japan the sea- surface temperature has increased by about 0.7 C since 1984. The Maritime Safety Agency of Japan did the monitoring, and they told the Asahi Shimbun in September 1992 that "global warming phenomena has been proved by the change in the water temperature."

[25] Corals will inevitably be among the first organisms to show the impacts of a sustained increase in sea-surface temperatures. This is because of the fragile temperature- dependence of the symbiosis whereby unicellular algae called ?ooxanthellae live in the coral's cells. The algae are the coral's "vegetable garden": without them, the coral loses its colour, does not build its rocky skeleton (so arresting reef-growth). The coral and its zooxanthellae thrive in waters up to 28 C, but if exposed to temperatures just 2 to 3 C warmer - for just 2 to 3 days - the algae are expelled from the coral, causing it to bleach. Subjected to prolonged, or regular, bleaching in this way, corals die. Unprecedented bleaching has been observed in recent years in the Caribbean, French Polynesia, the Andaman Sea, and elsewhere.

changes which should represent a serious concern for humankind."[26] Meanwhile, sea-level has been rising at 1-2 mm per year for decades, and the IPCC predicts rates of 3-10 mm in the decades ahead, threatening the physical and cultural existence of dozens of low-lying island nations, and coastal infrastructure everywhere. Anomalously intense droughts can be found in many places: California is in its seventh successive year, SE England in its fifth, Southern Africa is in the grip of the worst drought in living memory.

All this occurs at a time when the challenge of feeding the world is compounded by eroding topsoils, diminishing groundwater reservoirs, and exploding population, following the first-ever decade wherein the amount of land under cultivation failed to increase.

Then there is the pattern of windstorms. It is worthwhile reviewing the recent developments in this impact-category in some detail, and from the insurance industry's viewpoint.

[26] Coral bleaching events occur naturally from rime to time, but on October 11th, 1990, a group of five coral experts testified before the US Senate that disastrous coral bleaching is in progress in many areas of the Caribbean. One, Dr Tom Goreau from the Discovery Bay Marine Lab in Jamaica, said: "I am confident that the mass coral bleaching events of the last 4 years are unprecedented as long as reefs have been studied..." Examining evidence of sea-surface temperatures from NOAA satellite readings, and the few sites in the Caribbean where direct measurements had been taken during the 1980s, he and his colleagues concluded that there had been an increase of mean temperature of 0.5 to 1 C. According to Goreau, "...when Caribbean regional mass bleaching began in 1987, many, including myself, found it hard to accept that so severe an impact could be provoked by so small an increase in temperature.." Testimony to Committee on Commerce, Science and Transportation, US Senate: 11 October 1991.

4. THE COST OF RECENT CLIMATIC PHENOMENA

Considering only events which have involved insured losses of over a billion 1992 US dollars, 1966 to '87 was a period which - although far from catastrophe-free - had no catastrophes which topped the billion-dollar. But in the period from 1987 through the first quarter of 1993, there have been no less than 16 catastrophes for which insured losses exceeded $1 billion.

They were (windstorms in bold):

October 1987, N.W. Europe:	Un-named windstorm.	$2.5 bn
July 1988, North Sea:	The Piper Alpha explosion.	$1.4 bn
March 1989, Alaska:	The Exxon Valdez oilspill.	$1.5 bn
September 1989, USA:	Hurricane Hugo.	$5.8 bn
October 1989, USA:	San Francisco Earthquake.	$1.5 bn
October 1989, USA:	Phillips Petroleum Explosion.	$1.5 bn
January 1990, N.W. Europe:	Windstorm **Daria**.	$4.6 bn
February 1990, N.W. Europe:	Windstorm Herta.	$1.3 bn
February 1990, N.W. Europe:	Windstorm Vivian.	$3.2 bn
February 1990, N.W. Europe:	Windstorm Wibke.	$1.3 bn
July 1990, USA:	Colorado storms.	$1.0 bn
September 1991, Japan:	Typhoon Mireille.	$4.8 bn[27]
October 1991, USA:	Oakland Bush fire.	$1.7 bn[28]
August 1992, USA:	Hurricane Andrew.	$16.5 bn[29]
September 1992, USA:	Cyclone **Iniki.**	$1.6 bn
March 1993, USA:	Un-named **storm.**[30]	$1.6 bn[31]

In addition to this have been the recent crop of windstorms which broke records other than the fiscal:

February 1990: Cyclone Ofa - one of the strongest-ever Pacific cyclones.
December 1991: Cyclone **Val** - stronger even than Ofa, devastating the Samoas for the second year running.
August 1992: Cyclone Omar - the strongest cyclone to hit Guam in 16 years.
December 1992: Un-named storm, New England - flooding parts of Manhattan,

[2] All the figures to this point come from Anon., "The Spiral in Context," unpublished Lloyd's briefing 1992, updated by pers. comm. from a leading Lloyd's syndicate.

[28] Catastrophe Reinsurance Newsletter, April 1993.

[29] "The weather has home insurers running scared," Business Week, 5 April 1993.

[30] Dubbed in many newspapers "the storm of the century."

[31] "US winter storm damage claims top $1.6bn," Lloyd's List, 31 March 1993.

including the subway, killing at least 16, and leading to *a* state of emergency in New York, New Jersey, and Connecticut.[32]
January 1993: Cyclone Kina - Fiji's second in four weeks, and worst for 20 years.[33]

It is instructive to look at the pattern of catastrophe in terms of what climate scientists are now concluding about climate change. Of the 16 catastrophes passing the billion-dollar mark, 11 were windstorms. Of the total loss of $51.8 billion in the 16 catastrophes, $44.2 billion (>85%) was lost in windstorms, and $7.6 in earthquake, oilspill, fire and explosion. Given that the Oakland bush fires were connected with the anomalous drought in California, itself not inconceivably connected with global warming, and given that three of the five non-windstorm catastrophes affected the oil industry's operations (Piper Alpha, the Exxon Valdez, and the Phillips explosion), it is possible (though it will never be provable) that of the 16 catastrophes, the only one not to be directly or indirectly related to climate change and its causes was the San Fransisco earthquake.

In 1992, global catastrophe losses reached a record of $27.1 bn, an increase of 87% on 1991 even allowing for inflation. Swiss Re, in a 1993 report,[34] found that both the size and frequency of catastrophes seemed to be increasing. Munich Re, analysing the 1992 record, listed more than 500 natural catastrophes compared to around 400 in previous years. The ten-year period 1983 to 1992 showed 10 times the insured losses as the 1960s, after adjustment for inflation.[35]

If 1992 was the worst year ever (the "Year of the Cat," as many insurers call it), 1993 shows little sign of improvement. The first quarter, which included the March 12-14 winter storm which caused havoc from Cuba to Canada, saw insured losses of $2.2 bn.[36]

[32] "Global warming blamed for big New York storm," Independent on Sunday, 13 December 1992.

[33] NZ Herald, Tues 5th, 1993

[34] Swiss Re, Sigma 2/93, Naturkatastrophen und Grossschaeden 1992: neuer Rekord der versicherten Schaeden. Reported in Lloyd's List, 27 April 1993.

[35] Lloyd's List, 27 April 1993.

[36] "Best predicts heavy losses for 1993," Lloyd's List, 20 April 1993.

5. RECENT EXPERIENCE IN THE INSURANCE INDUSTRY.

5.1 Lloyd's of London.

The period free of billion-dollar catastrophes from 1966 to 1987 had the effect of attracting capital and competition, and reducing reinsurance prices. Investors queued up to join the Lloyd's market, which saw a proliferation of syndicates and agents. From the late 1970s onwards capital flowed ever faster into Lloyd's, running at around $2 billion in 1978, more than $10 billion by 1987, and peaking at $17.87 billion in 1991. This generated from 1986 onwards sizeable overcapacity - too much money chasing too little business. In 1986, profits exceeded $1,000 million. In 1987, they were c. $700 million. By this time there were 30,000 "Names" and more than 400 syndicates.[37]

Then the losses began, with the high storm-catastrophe payouts compounded by rocketing asbestosis and pollution losses in the USA, and with balance sheets weakened by junk-bond holdings, low interest rates, and generally weak stock markets. In 1988 the losses exceeded $1,000 million. In 1989 they ran to $3.3 billion. Half this was borne by less than half-a-dozen syndicates, and 37% by just two. The latest estimate for the 1990 loss is $4.45 billion (£2.8).[38] The 1991 loss is reportedly close to $2 billion.[39] Time magazine described the crisis this way in the spring of 1991: "Lloyd's is reeling, and as the fine print catches up with them, many investors face financial ruin - down to the last cuff-link."[40] Early in 1993, Lloyd's List quoted a respected analyst as saying "we will have to wait for 1993 to possibly make a profit and 1996 to once again receive a cheque from Lloyd's, for those who can still afford to underwrite by then."[41]

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[3] Anon., "The Spiral in Context," unpublished Lloyd's briefing 1992. To give the non-insurance industry reader a feel for the scale of these figures, the worldwide insurance market is worth some $1,200 billion per year ("Sailing into calmer seas," Financial Times, 7 September 1992). Worldwide non-life insurance premiums run at around $600, having grown from around $100 billion in 1973 and around $300 billion in 1984 (i.e. they have doubled in size in less than a decade). The reinsurance industry today has income from worldwide non-life premiums of under $100 billion per year, having throughout the '60s, '70s and '80s been fairly consistently about 15% of direct insurance premiums (Anon., "The Spiral in Context," unpublished Lloyd's briefing 1992). Additional information from "Corporate capital at Lloyd's," Lloyd's List, 21 December 1992.

[38] "Revolution unveiled at Lloyd's," Lloyd's List, 30 April 1993. Note that Lloyd's operates a three-year delay in its accounting system to wait for all claims to be dealt with.

[39] "Chatset lifts Lloyd's 1990 loss forecast," Lloyd's List, 22 January 1993.

[40] "Risky business," Time, July 8, 1991.

[41] "Chatset lifts Lloyd's 1990 loss forecast," Lloyd's List, 22 January 1993.

The 1989 and '90 losses forced consolidation and closure among syndicates and reinsurance companies alike. Capacity contracted. The price of reinsurance went up steeply. As a Lloyd's briefing puts it, "the number of underwriters prepared to write reinsurance and retrocessional business has reduced dramatically to the extent that the spiral barely exists in 1992. Losses suffered by Names on retrocessional syndicates will deter capacity being attracted to any potentially new retrocessional syndicates."[42] Between 1988 and 1992, almost a third of all Names resigned (from over 30,000 to around 22,000). By 1991, the number of syndicates had fallen to 278. Uncertainty over the future of the market, through which runs some 30% of international catastrophe reinsurance, abounds. As the Observer put it on 2 August 1992: "the time has come when sane people question whether this 304-year old will survive to the next century, let alone traditionalists' dreams of a fourth century."

Others are more sanguine. A study commissioned by the Corporation of Lloyd's concluded in May 1992 that "it would appear that there are two years in which Lloyd's has been materially less profitable than insurance companies, 1965 and 1989. In both years, generally poor results in both Lloyd's and insurance companies were exacerbated by the impact of notable natural catastrophes." (These natural catastrophes were Hurricane Betsy in '65 and Hurricane Hugo in '89).[43]

The losses associated with Hurricane Andrew, despite its $16.5 billion total insured losses, will not be nearly as bad as for Hurricane Hugo: much more of the risk will be absorbed in the US industry.[44] Additionally, the collapse of the retrocession market has had the effect of switching the power to set rates and conditions out of the hands of brokers working for the insurance companies, into the hands of the big reinsurance companies in Europe and North America, companies like Munich Re and Swiss Re.[45] Also on the plus-side for Lloyd's, it still has reserves significantly higher than most UK companies and generally higher than US companies, and has appreciably stronger solvency margins than either US or UK companies.[46]

[42] Lloyd's briefing, ibid.

[43] C. Hitchins, "Lloyd's of London: Profits, Reserves, and Solvency - A Comparison with the Insurance Industry," Hoare Govett Investment Research, May 1992.

[44] "Lloyd's profit outlook good despite record £2.06bn loss," Guardian 29 August 1992.

[45] "Sailing into calmer seas," Financial Times, 7 September 1992.

[46] C. Hitchins, ibid. And "Lloyd's still stronger on solvency," Lloyd's List, 18 May 1993.

Despite the losses from '88 to '91, Lloyd's received £1 billion in new Names' money in 1992.[47] But real concerns for the capital base of the market persist.[48]

Some in the business see recent events as a potential blessing-in-disguise, an opportunity to enforce greater discipline in the market. As the Chief Executive of SCOR (France's biggest reinsurance company and the world's seventh biggest), Mr Patrick Peugot, put it recently: "we should be able to set rates that will provide cover for the medium and long term, not go up and down all the time. That is one of our aims - to stabilize the market."[49]

But to be able to do that, insurers must know the return times of their catastrophe events, and the degree of exposure faced. And with the emergence of the global-warming threat, the extent to which they can do that comes into question. Historical records become less likely to provide a key to future risk, and vulnerability. This is a central point of this report, and one which is examined in detail later.

5.2 Elsewhere in the London Market.

Though most of the publicity has focussed on the downturn at Lloyd's, both the Lloyd's market and insurance companies have suffered. The composites saw a significant downturn in 1990, when the top 5 in the London market lost more than $1 billion. Though much of the blame lies with non-climate-related factors, such as the disaster of the mortgage-indemnity market, companies bore significant burdens from the windstorm catastrophes, for example 69% of the total reinsurance costs for the October storm of 1987, and 64% of all Hurricane Hugo reinsurance costs.[50]

To make matters worse, a report from the Institute of Insurance Brokers showed that as of September 1992, 4 of the top 17 British composites are trading below their solvency margin.[51] As one British commentator has put it, "the chaps nobody wants to sit next to at dinner parties are concerned that sliding reserves and shrinking solvency margins make it possible, if not probable, that an insurer will, in the near future, announce it is unable to pay out on claims. ... the mismanagement that has allowed the insurers to squander up to 100 years-worth

[47] "£1.6 billion loss predicted for Lloyd's," The Guardian, 22 January 1993.

[48] "Chatset lifts Lloyd's 1990 loss forecast," Lloyd's List, 22 January 1993, and interviews with Lloyd's underwriters granted on condition of anonymity.

[49] "Sailing into calmer seas," Financial Times, 7 September 1992.

[50] C. Hitchins, ibid.

[51] "Top insurers are trading below solvency margin," Guardian, 3 September 1992.

of hard-earned reserves is going to be paid for by the public. It could be time for sensible people to cancel their policies and buy a big dog instead."[52]

The 1992 results for the composites showed a marked improvement on 1991.[53] Nonetheless, the Policyholders' Protection Board warned in April of 1993 that it was unable "to encourage anyone in the industry to expect the worst was over." It anticipated a shakeout for the UK industry in which numerous small and medium sized companies, including household names, would become insolvent. [54] The Guardian, reporting the bad news, noted that "actuaries confirm that in their view the worst is over for non-life insurers - if only because of the absence of major disasters, such as the great storm, in recent years."[55] But how many of these actuaries are familiar with the scientific deliberations of contemporary climate modellers?

5.3 United States.

Between 1970 and 1992, the insurance industry had taken $10.8 billion in premiums in Florida. In the few hours it took Hurricane Andrew to pass across the state in August 1992, the industry lost all that and $ almost 6 billion besides.[56] Shares in the estimated $17 billion bill for gross insured losses associated with Hurricane Andrew and Cyclone Iniki, which hit Hawaii just a few weeks later, had by December 1992 put nine insurance companies out of business.[57]

Florida was forced to take legislative action to protect homeowners. On 16 December, the State passed legislation proposed by the state Insurance Commissioner to pay $500 million in claims to hurricane victims who had been left stranded by the companies' bankruptcies. The legislation imposes a 2% assessment on homeowners policies held with Florida insurance companies, aiming to raise $65 million per year.[58]

Things were little better in Hawaii, where Cyclone Iniki caused more a billion dollars of insured losses. Facing $300 million in claims, Hawaiian Insurance

[52] Alex Brummer, "Barking watchdogs sound alarm tor insurance groups," Guardian, 3 September 1992.

[53] "Composites' results improve as underwriting losses fall," Lloyd's List, 19 April 1993.

[54] "British insurance industry stands by for swelling stream of financial disasters," Guardian, 19 April 1993.

[55] ibid

[56] "Insurers seeking to limit coverage m high-risk areas," New York Times, 4 May 1993.

[57] "Hurricanes led to failure ot nine companies," Lloyd's List, 18 January 1993.

[58] "Florida insurance bail out," Associated Press, 16 December 1992.

Group - the State's fifth biggest insurer - announced on 3rd December that it was to cease trading. Other island insurers then issued a moratorium on the writing of new policies "indefinitely." A spokeswoman for First Insurance, Hawaii's biggest insurer, said that this was while insurers assessed the significance of attempts by reinsurers - including Lloyd's - to renegotiate terms with insurers. "The reinsurers are taking a hard look at the Hawaiian islands in particular and the world situation in general," she said.[59] 16,000 homeowners were thrown into panic by HIG's move, unable to find replacement cover. A week later, First Insurance announced it would cease renewing existing policies as of February 1st 1993. The number of stranded homeowners would then reach 38,000.[60] By April, rating agency A. M. Best Co. were estimating that 40% of Hawaiians, or 80,000 homeowners, would lose insurance during 1993.[61]

The last cyclone before Iniki to hit Hawaii had been Iwa, in 1982. That had been considered, until Iniki, a freak event.

Hawaii's Insurance Commissioner expanded a special programme for fire and windstorm insurance in areas threatened by Hawaii's volcano statewide, and formed a team of insurance industry representatives to investigate the prospect of a windstorm insurance pool. In Texas, an insurance pool exists for exposed counties along the Gulf Coast."

As of May 1993, the industry retreat had spread from Florida and Hawaii to Louisiana, Texas, New Jersey, and even New York. Dozens of companies had announced they were to stop selling or renewing policies on homes and other property in coastal areas of these states. Those still doing business in Florida had hiked premiums by as much as 40%. Up to half a million Florida residents were facing the prospect of relying for home insurance on a newly-established Joint Underwriting Association, which provided minimum coverage for a cost 25% higher than the standard market.[62]

Some in the American insurance business saw the aftermath of Andrew and Iniki as heralding healthier market conditions. President of the Reinsurance Association of America, Frank Nutter, said "the losses will do what we refer to as hardening the market. It will cause some of the soft pricing that has existed for

[59] "Property owners panicked - insurers issued moratorium," Hawaii Tribute-Herald, 10 December 1992.

[60] "Special property insurance program to expand," The Honolulu Advertiser, 18 Dec 18, 1992.

[61] "The weather has home insurers running scared," Business Week, 5 April 1993.

[62] "Special property insurance program to expand," The Honolulu Advertiser, 18 Dec 18, 1992.

[63] "Insurers seeking to limit coverage in high-risk areas," New York Times, 4 May 1993.

several years to be dropped. So these catastrophes have an almost counter-intuitive effect on values." New York buy-out firm, Kohlberg, Kravis, Roberts and Co, for example, bought American Re for just $1.4 billion in September 1992, and went for a quick resale, arguing that the shake-out in the insurance industry would leave the industry poised for explosive growth.[64]

Analyses like these, of course, depend on there not being a continuing trend of extreme events like Andrew and Iniki, and with the threat of human-induced climate change, that is far from guaranteed. Such analyses also take a sanguine view of the potential for future loss. Had Hurricane Andrew - the costliest catastrophe in American history - hit a downtown area of Miami, to bill would have been much higher. Some estimates suggest that the loss for an East Coast hurricane could reach $75 billion: around half the $160 billion-plus the property-casualty industry holds worldwide for all catastrophe losses.[65]

5.4 The Caribbean Region.

According to the Insurance Association of the Caribbean, the Caribbean nations are suffering an insurance crisis. [66] As of January 1993, 24 reinsurers had withdrawn from the region altogether.[67] William Tomlin, General Manager of one of the Caribbean's biggest insurance brokers, General and Marine, painted a grim picture of the problems at the May 1993 US National Hurricane Conference in Orlando, Florida. Finding enough capacity for his clients' insurances had suddenly become "a nightmare," he said, and the impacts on economies, in island nations heavily dependent on tourism, were appalling. 1993 policies require rates of 2% or more on the property insured. On top of that come deductibles of 2%.[68] How are existing policyholders reacting? Cancelling or reducing coverage in many cases, according to Tomlin. This in turn is leading to problems for banks and other financial institutions, who "are quickly realising their potential exposure from the very high hurricane deductible and the fact that some of their mortgagees are cancelling or reducing coverage."[69]

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[64] "The skies look brighter for reinsurers," International Herald Tribune, 28 November 1992.

[65] "The weather has home insurers running scared," Business Week, 5 April 1993.

[66] "Barbados warning of Caribbean crisis," Lloyd's List, 10 March 1993.

[67] "Reinsurers disenchanted with the Caribbean," Lloyd's List 28 January 1993.

[68] This means that if the property is hit by a hurricane, the policyholder must pay 2% of the sum insured (not 2% of the claim).

[69] William Tomlin, "Insurance and mitigation: problems of reinsurance," Paper presented at the US National Hurricane Conference, Orlando, Florida, 13 April 1993.

5.5 **The Pacific Region.**

In the aftermath of Cyclones Ofa and Val - two devastating cyclones within less than two years - Western Samoa's only fire and general insurer, National Pacific Insurance, announced it would be removing all cover once existing policies ran out. The company "invited" clients to reapply only if they obtain an engineers certification that their properties had been rendered cyclone-proof.[70] In neighbouring American Samoa, Travelers Insurance Company similarly withdrew cyclone cover.

Samoan Attorney General Leaupepe Sanerivi, went to the climate negotiations in New York in May 1992 to draw attention to his country's plight. He told a press conference at the United Nations, "we have had three cyclones in the past four years, each of a ferocity that is supposed to occur every 80-100 years."

The incidence of anomalously intense Pacific cyclones seemed to be continuing in early 1993. Cyclone Kina hit Fiji on 4th January, and was the strongest in 20 years. The early death toll was at least 19, up to 10,000 were left homeless, and initial damage estimates stood at $135 million. Meanwhile, Cyclone Nina hit the Solomons, leaving another 10,000 homeless.[71]

5.6 Australia

Australia is prone to costly natural disasters. In order of importance to the insurance industry, in terms of total payout, are cyclones, hailstorms, earthquakes, floods, storms, bushfires and tornadoes. The Insurance Council of Australia has been keeping records of all natural disasters causing more than A$l million damage since 1967. Cyclone damage (in A$1991) ran to a maximum of A$689 (Cyclone "Tracy" of 1974), and the 46 events in the period 1967-1990 averaged A$33.5 million. Damage resulting from hailstorms ran to A$369 (the March 1990 Sydney hailstorm) and the 17 events between '67-90 averaged A$62.9 million. Floods ran to A$269 (the Australia Day floods in Brisbane during 1974), and the 38 events between '67-90 averaged A$21.9 million. Storms ran to A$80 million and the 88 events averaged A$7.6 million. Bushfires ran to A$267 million (the "Ash Wednesday" bushfires in Victoria and South Australia in 1983), and the 22 events averaged A$22.6 million. Tornadoes ran to A$8 million and the 7 events averaged A$4.9 million. In terms of total economic cost, however, drought is the most important of all the potentially greenhouse-related costs to the Australian economy. The total economic costs of the 1982-83 drought

[70] "Insurers quit Western Samoa as cyclone losses mount," National Business Review (NZ), 1 May 1992.

[71] NZ Herald, 5 January 1993.

ran to A$5-7 billion.[72]

The record for an annual payout (in 1991 dollars) was A$l,180 in 1974, and the second most costly year was 1989, at about A$850 million. Most years the total insurance payout varies between about A$100 miilion and A$300 million, averaging A$226 million. About 80% of the total has been related to the various meteorological phenomena, and 20% to earthquakes.[73]

The last decade has seen a string of natural disasters, both in Australia and overseas, which have left - according to the managing director of the Mercantile Mutual Group - "a trail of damaged companies, failed managers, spoilt insureds, and angry shareholders."[74] The Australian Financial review reports that "American Re-Insurance's general manager for Australia and New Zealand, Mr Tony Richardson, echoes the views expressed overseas by the likes of Lloyd's of London's deputy chairman, Dick Hazell, that there is no reason to expect the recent spate of disasters was just bad luck or a statistical oddity. The long-term impact of global warming on the world's weather patterns and the high incidence of disasters due to man-made constructions or industry pollution may both ensure that a significant number of of large-scale catastrophes occur somewhere around the world each year."[75]

The major general insurers are only too well aware of the role of climate in their profitability. Recent annual reports show this clearly. Grahame Bond, Chief Executive of the Insurance Council of Australia, claimed that "the impact of an unprecedented spate of natural disasters" along with other factors had a severe impact on the industry in 1989/90. National Commercial Union's Managing Director Philip Clairs cited "catastrophic losses from natural causes" as a major factor impacting on his company's performance and the performance of the industry as a whole in their 1991 Annual Report. Colonial Mutual mirrored this point of view. Mr Rodney Adler, FAI's Chief Executive, stated in their 1991 Annual Report that one of the four main reasons for his company's $191 million underwriting loss was "the continuing impact of natural disasters which not only included the Newcastle earthquake and the Sydney hailstorms, but the more recent storms in Sydney's upper north shore, Adelaide and Brisbane." According to National Commercial Union, the storms that hit Sydney's upper north shore "caused damage resulting in insurance industry losses of $175 million."

[72] R. J.Blong, Natural disastersll: An Australian view. Australian Institute of Insurers Journal, July 1991, p. 14-18.

[73] "Natural disasters take heavy toll of industry," Australian Financial Review, 26 August 1992.

[74] ibid.

[75] "Catastrophe cover likely to become harder to get," Australian Finacial Review, 26 August 1992.

What of the future? Writing in the Australian Insurance Institute's journal in July 1991, Professor Russell Blong of Macquarie University's Natural Hazards Research Group showed that the insurance industry in Australia faces a special challenge. The database on which its predictions and risk assessment are made is limited in its scope, deficient in its categorisation and has a relatively short history. The ICA's records only began in 1967. The Bureau of Meteorology documents frequency and magnitude of climatic events but only the ICA's database records property damage. This lack of historical perspective and the uncertainty presented by human-induced climate change will be the central challenge for the industry in the future.

5.7 Conclusions.

The insurance industry, almost everywhere in 1993, is in greater-or-lesser degrees of trouble. Though the reasons for this state of affairs are manifestly compound, anomalously intense climatic events in recent years have much to do with it. These may or may not be the product of human enhancement of the greenhouse effect. The important point is that ahead, on the massive balance of probabilities, lie more such anomalously intense events. This prospect befalls an industry where capital is shrinking and exposure - even if catastrophe magnitude were static - is rising.

Lloyd's List, describing a report by Standard and Poor's Insurance Rating Services, summarized the overall situation as follows in January 1993:

> *"....it is believed that there is no more than $250m to $300m of catastrophe reinsurance available on a global basis for an individual company. The report says that with losses in excess of $1 bn for individual companies it is apparent that catastrophe reinsurance is insufficient for many large insurers and the situation is forcing the industry to rethink its business practices."*[76]

[76] "Hurricanes led to failure of nine companies," Lloyd's List, 16 January 1993.

6. THE INSURANCE INDUSTRY AWAKENING TO THE THREAT.

Until 1987/8, climate change had not emerged as an issue either or insurance, or indeed in government. For example, in a 1986 report on European windstorms, Swiss Re analysts wrote: "This publication ...assumes that the meteorological conditions have been stable in the past 25 years and will continue to remain so in the near future."[77] And in a 1989 report, they wrote "For certain regions, e.g. the east coast of the United States, hurricane records date back over about 100 years. The hazard can therefore be assessed more or less reliably."[78]

But these views quickly proved dubious. The 1986 opinion came before the 1987 October windstorm, which clocked up $2.5 billion in damage. The 1989 opinion came before Hurricane Hugo, which exceeded $5 billion, and would have been far higher had it hit any of an eastern-seaboard city instead of the Carolina coast. Then came the 1990 windstorms. Eight severe storms hit central and western Europe within a five week period from 25 January to 1 March, causing more damage than any other natural catastrophe experienced in Europe. They cost the industry a total of at least $10 billion, and caused a total economic loss roughly twice that figure.[79] Some 8 million individual insured losses were assumed by about 1,000 insurers, who had spread their cover to 100 reinsurers. The latter took two-thirds of the total loss.[80]

The Reinsurances Offices Association commissioned a report on the implications of the greenhouse effect for the reinsurance industry early in 1990. It concluded that:

> *"even a cursory glance at some of the basic principles of reinsurance reveals the concern that ought to exist about the greenhouse effect scenario ...If ever there was a case for moving the goalposts this is it."*[81]

Swiss Re's reaction, in a November 1990 paper by their General Manager, provided an interesting contrast with the analysts' views from 1986 and 1989.

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[77] "Storm in Europe: Losses and Scenarios," Swiss Re, 1986.

[78] "Natural hazard and event loss," Swiss Re, 1989, p. 27.

[79] "Winter storms 1990," Swiss Re Annual Report, 1990.

[80] H. R. Kaufmann, "Storm damage insurance - Quo Vadis?" Swiss Re, November 1990.

[81] J. C. Doornkamp, "The scientific background to the greenhouse effect and its implications for insurers." Reinsurance Offices Association, Special Publication, 1990.

> *"There is a significant body of scientific evidence indicating that last year's record insured losses from natural catastrophes was not a random occurrence. Instead it may be the result of climatic changes that will enormously expand the liability of the property-casualty industry."*[82]

The Annual Report that year stressed the core problem. "If gale occurrence extends to areas which were previously rarely affected, rating and capacity allocation will become very difficult."

The IPCC report had appeared by that time, of course. The IPCC scientists' conclusion about increases in global average temperatures was alarming, but their discussion of windstorm patterns was cautious: "Although the theoretical maximum intensity is expected to increase with temperature, climate models give no consistent indication whether tropical storms will increase or decrease in frequency or intensity as climate changes: neither is there any evidence that this has occured over the past few decades."

At least one Lloyd's syndicate - one of the most successful, and a market leader - sought advice that went beyond the IPCC's lowest-common-denominator conclusion. What they heard, from one of Britain's leading climatic research teams, made them review all cover in Florida. As one of their underwriters told us recently:

> *"Somebody had got off the fence ....they said, if you're asking us, yes, we think there's a direct link, and this could have an affect on your business. ...We started to incorporate the statements that we had received and the areas we had been warned about, into our whole rating base, which we are glad to say resulted in us reducing our commitments in areas like Florida."* [83]

When Hurricane Andrew hit, in August 1992, this syndicate saved millions of dollars.

The Swiss Re General Manager's November 1990 essay said of the debate over global warming that "in the light of the magnitude of these losses, it would be prudent for the property/casualty industry to act is if that theory is correct. Failure to act would leave the industry and its policyholders vulnerable to truly disastrous consequences ...if the rapid increase in worldwide storm damage is due

[82] H. R. Kaufmann, ibid.

[83] Interview on condition of anonymity.

to a trend that has hitherto gone unnoticed, the situation is indeed highly ominous: even a flourishing industry cannot be stretched beyond its limits."

Much of the increased losses had to do with proliferation and concentration of values, of course: simply stated, with the increasing wealth of people seeking insurance and their increasing tendency to live in harms way. But the Swiss Re GM cautioned as follows:

> *"The growing settlement density is, however, no explanation for the higher frequency of wind and hail storms clearly evident in recent years nor for their increasing vehemence. A plausible explanation is that this is an initial conseqence of climatic change. . . . Research meteorologists are in no doubt that this climatic change has already begun. ...In the Pacific, for example, the area where the sea temperature exceeds 26 degrees Celsius has grown by more than 15%. This increases the likelihood of tropical cyclones."*

He was forthright in the extreme about the risks:

> *"There might be local extremes, particularly in northern latitudes. If this is so, the implications for many parts of the world would be devastating. Entire countries such as Bangladesh would be threatened. The danger of storm floods along the European Atlantic coast would be drastically increased. In view of the potentially vast damage to be expected from natural catastrophes, reinsurers can hardly afford to wait until actual events provide conclusive answers to the questions scientific methods are unable to explain in advance. . . . Should the number and intensity of storms continue to rise ...risks will multiply exponentially and with gathering speed. The statistics of the past three years already make this development alarmingly clear. As far as the insurance industry is concerned, this development calls for immediate action."*

Munich Re, in a 1990 report entitled "Windstorm," joined the debate in equally forceful terms. "For the first time in the history of our planet," it concluded, "mankind is about to change the climate significantly and possibly irreversibly, without having any idea of the consequences that will have. . . . With economic and insured losses increasing in volume by a factor of 3 and 5 respectively since the '60s, we definitely have a trend which, without exaggeration, may be regarded

as dramatic." Where was this leading the industry? "In future, we must anticipate a further, probably dramatic, increase in catastrophe losses from currently US$20 billion to a magnitude of US$100 billion per year in overall economic terms."[84]

Munich Re's data came from a Natural Hazards Research Group, which had collected over 30 years of data, involving an average of between 20 to 50 new loss events per month. Events classified as "great" disasters - those involving damage which exceeds $100 million and/or people rendered homeless in tens or hundreds of thousands - numbered 14 in the 1960s and 70 in the 1980s. Writing in July 1992, Head of Munich Re's Geoscience Research Group, Dr Gerhard Berz, said:

> *"The present problems will be dramatically aggravated if the greenhouse predictions come true. The increased intensity of all convective processes in the atmosphere will force up the frequency and severity of tropical cyclones, tornadoes, hailstorms, floods and storm surges in many parts of the world with serious consequences for all types of property insurance. ...In areas of high insurance density the loss potential of individual catastrophes can reach a level where the national and international insurance industries run into serious capacity problems."*[85]

Dr Berz clearly considers it likely that the greenhouse predictions are likely to be true. He also observes that:

> *"...today there are more and more alarming factors indicative of the gradual but noticeable increase in the worldwide temperatures. Let us consider for example that the areas of the Pacific with a water temperature of over 27 C ...have increased in the last 20 years by roughly l/6th. The extreme intensity of the super-hurricanes "Gilbert" in 1988 and "Hugo" in 1989, as well as the extraordinary series of winter gales last year, can be regarded as a further indication that the warming of the global climate is gradually*

[84] "Windstorm," Munich Re, 1990.

[85] G. A. Berz, "Greenhouse effects on natural catastrophes and insurance," The Geneva Papers on Risk and Insurance, 17 (No. 64, July 1992), p. 386-392. And see "Global Warming and the Insurance Industry," Paper for the MIT Symposium "The World at Risk: Natural Hazards and Climate Change," Cambridge, Mass., January 14-16, 1992.

beginning to have some noticeable effects."[86]

A senior Swiss Re analyst told us recently in graphic terms of the potential for disaster offered by the longer-term build-up of the greenhouse threat and the shorter term weaknesses of the market (catastrophe rates too low worldwide, a failure of the industry to appreciate proliferation and concentration of values). "We are on a train driving in the wrong direction. ...The market is expanding, buying in bigger and bigger exposures, at the same time as the retrocession end of the market has collapsed, at the same time as nobody wants to pay a realistic price. . . .There could be a machine gun fire of catastrophes." On the other hand, "we could be lucky. It could be all quiet on the Western Front. But then things would be worse. Why? Because machine-gun fire down the road will hit us even worse."[87]

Neither are these fears for the future of the insurance industry limited to Europe. In Japan, Toshifumi Kitagawa, Director of the New Fire Insurance Business Department at the Tokyo Marine and Fire Insurance Company, told Asahi Shimbun in February 1993 that "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, wrote Asahi's correspondent Keiji Takeuchi, "has the same sense of crisis as his counterparts abroad," In 1992, the 25 member companies of the Marine and Fire Insurance Association of Japan formed a panel on global warming within their Safety Technology Committee. An unidentified person in the Marine and Fire association's public relations office told Takeuchi that "if more disasters like (Typhoon Mireille) follow, it could affect the industry's very existence." Typhoon Mireille losses were ten times higher than for any previous typhoon.[88]

[86] C. A. Berz, ibid.

[87] Interview with senior official granted on condition of anonymity, Swiss Re, Zurich, 15 October 1992.

[88] "Insurance industry concerned about the Earth: Companies begin research on global warming," Asahi Simbun, 3 February 1993.

7. SPECIFIC CATASTROPHE THREATS

7.1 Windstorms.[89]

Many meteorologists anticipate that increasing greenhouse gas concentrations in the atmosphere will increase cyclone frequency and intensity.[90] Prof Kerry Emanuel of MIT calculated in 1987 that doubling carbon dioxide concentrations would increase hurricane intensity by 40% or more.[91] The Munich Re assessment of future windstorm risk in the "Windstorm" report is daunting indeed:

> *"A warmer atmosphere and warmer seas result in greater exchange of energy and add momentum to the vertical exchange processes so crucial to the development of tropical cyclones, tornadoes, thunderstorms and hailstorms. Accordingly, such natural hazards will increase not only in frequency and intensity but also in duration and size of areas at risk. This applies above all to tropical cyclones, which will penetrate moderate latitudes and thus also affect areas so far not exposed to risk. Hence, risk conditions are not only growing worse in the population centres and industrial regions along the north-east coasts of the USA, Australia and New Zealand or in the whole of Japan already exposed to such hazards in the past, but possibly also along the coasts of Western Europe, which have already been hit from time to time by heavy rainfall following in the wake of hurricanes. Now such parts of Western Europe might even be reached by a full-fledged hurricane. Similarly, the "explosive" development of low pressure systems already observed time and again in the Mediterranean region, with features quite comparable to tropical cyclones, might well result in full-scale hurricanes causing incredible damage in these densely populated regions."*

The Munich Re report stresses the importance of sea-surface temperatures. Hurricanes cannot develop until the sea-surface builds to almost 27 degrees Centigrade. For the Atlantic, "if water temperatures increase by 0.5 to 1 degree (C)

[89] Windstorms with mean windspeeds of more than 73 mph are called cyclones. Cyclones are generally called hurricanes if they occur east of the dateline and typhoons if they are west of it. A supercyclone is a cyclone with windspeeds in excess of 150mph.

[90] O. Granger, "Climmate change interactions in the Greater Caribbean," The Environmental Professional, 13, p. 43-58, 1991.

[91] K. Emanual, "The dependence of hurricane intensity upon climate," Nature 326, p. 483-485.

in the course of the next few decades, we can expect an extension of the hurricane season by several weeks and a considerable increase in the frequency and intensity of hurricanes."

By 1992, Swiss Re had a specialist Greenhouse Effect Project Team working on the greenhouse effect. An April 1992 internal report expands the threat assessment from windstorm, and concludes that "the exposure of important concentrations of values such as New York or Tokyo can rise sharply with serious consequences for the industry."[92]

Other meteorologists take a different view. Dr Robert Sheets, Director of the National Hurricane Center in Coral Gables, Florida, has recently emphasised that, in his opinion, global warming has nothing to do with the storms experienced in the Caribbean in recent years.[93] Dr Bill Gray, a University of Colorado meteorologist well known for his predictions of Caribbean hurricanes, similarly attaches no significance to greenhouse gases when it comes to hurricane frequency or intensity.[94] There is genuine uncertainty over this issue among the climatological community. Note, however, that both Gray and Sheets anticipate a return to an era of more intense hurricanes on the US East Coast. The 1940s and '50s experienced more storms than the '60s and '70s, but an increase seems to have begun in the mid 1980s, they observe, and they expect it to continue.[95]

Whatever the truth about the origin of the superhurricanes Gilbert, Hugo and Andrew, the important point concerns qualitative risk-assessment for the future. Dr Berz of Munich Re, weighing the proven heat-trapping effect and long atmospheric lifetime of greenhouse gases, observes that "the number and intensity of natural meteorological catastrophes will grow, because the atmospheric heat engine is operating at a faster speed than ever before."[96]

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[92] Greenhouse Effect Project Team, Swiss Re, "Greenhouse Effect Scenarios for SR." Swiss Re internal report, April 1992.

[93] "Year of extremes," Associated Press, 5 January 1993, and "US weather experts see era of more hurricanes," Reuters, 5 January 1993.

[94] Pers. comm., April 1993.

[95] Gray bases his predictions on weather patterns in Africa. The years 1988 and '89 saw the heaviest rains in the Sahel since 1966-67, when a two-decade period of drought (the worst in 150 years) began. Gray links dry periods in the Sahel with periods of less intense hurricanes, and vice versa. In relatively wet periods, a wavy jet of wind blows out of west Africa into the Atlantic. Atmospheric disturbances associated with it, Gray suggests, provide a trigger for hurricanes. (See for example "Hurricane-drought link bodes ill for US coast," Science, 12 January 1990). Note that Gray predicted, at the April 1993 National Hurricane Conference, that no less than 6 storms of hurricane force would reach the US coast in 1993, three of them severe.

[96] C. A, Berz, ibid.

7.2 **Inundation.**

Pointing to the agreement of climate models that increase in temperature largely correlates with increased rainfall, the 1992 Swiss Re Greenhouse Effect Project Team report concludes that "over middle to high latitudes the processes of convection will tend to accelerate and intensify. More and more abundant rainfalls of shorter duration are expected and, therefore, also more inundations." If winter precipitation leads to more snow, and its melting coincides with intensive spring rains, the overlap could lead to "extreme" increase in the risk of inundation.[97] This warning seems all the more sobering in the wake of costly floods resulting from "tropical"-type downpours in England during September 1992, and the ruinous floods in the Indus valley in Pakistan.

In an earlier publication, Swiss Re had drawn attention to the potential for climate change to amplify risk from inundation by acting in concert with deforestation in mountain areas to boost peak discharge. Deforested areas - including pastures, ski-slopes and paths - absorb far less rainfall than forested slopes. The human community is enhancing deforestation in most mountain areas, and has been for some time. Meanwhile, warm clouds contain far more water vapour than cool clouds, and the world has been warming.[98] Calculating peak load for a 10m-wide river 125 years ago, compared to today, Swiss Re's analysts found that the combination of increased water vapour and decreased absorption burdens today's river - for a given set of realistic assumptions concerning other parameters - with 400,000 cubic metres more water. This was one of the factors that might have contributed to the ruinous flood damage in the Alps during July and August 1987, they argued. More importantly, the quicker the world warms, the more the risk is amplified.[99]

7.3 Thunderstorms, hailstorms, and tornadoes.

The inundation risk stands to be intensified by regional storms (thunderstorms, hail and tornadoes), according to the analysis by Swiss Re's Greenhouse Effect Project Team. "At middle latitudes where these storms occur," they conclude, "a less stable atmospheric layering is expected in future. Both frequency and intensity of such storms will therefore increase ...The link with the hazard of inundation following heavy rain ...is obvious. ...it must be assumed that the effects will reinforce each other."

[97] Swiss Re Greenhouse Effect Project Team, 1992, ibid.

[98] O.3 to 0.6 degrees C so far this century, according to the IPCC.

[99] "The Force of Water," Swiss Re, 1988.

1992 was a record year for tornadoes in the United States, with 1,381 reported. The figure for 1991 was 1,133.[100]

7.4 Landslides and mudflows.

Landslide- and mudflow-risk would be enhanced by increased inundation, the Swiss Re Greenhouse Effect Project Team argued. Furthermore, in the polar regions and the Alps, thawing of permafrost would add substantially to the risk.

7.5 Storm surges.

Storm surges would join the catalogue of risk-proliferation. They form on the seas where high tides coincide with strong winds. The Swiss Re Greenhouse Effect Project Team concluded as follows. "If storm paths shift southward (European storms) or northwards (tropical cyclones on the Northern Hemisphere) more and higher storm surges must be expected, also in regions with little present exposure."

With sea levels expected to rise in future, areas of particular risk will be low-lying cities where subsidence is also in progress. Swiss Re lists London and Venice as cities at particular risk.[101]

7.6 Drought and bushfire.

"Some regions will experience less rain in the summer, such as continental areas north of the subtropical dry zone, in particular the Middle West of the USA, the south of the former Soviet Union and the entire Mediterranean basin. These regions may, therefore, experience an increase in drought catastrophes." With that, the Swiss Re Greenhouse Effect Project Team observed, the risk of bush and forest fires increases.

In recent years, the warmest years of the century, the spectre of catastrophic wildfires indeed seems to have grown. The casebook since 1987 gives a feel for the kind of catastrophes that the global-warming world might expect to encounter on a regular, growing, and escalating basis. In April 1987, one of largest fires in recorded history erupted in tinder-dry larch forest in eastern Siberia. It destroyed the town of Xilinji and over 11 million hectares of Siberian forest. In the summer of 1988, after practically no rain in June, July or August, almost half the forest in Yellowstone Park was lost to fires. In 1989, it was Canada's turn. Drought in Manitoba led to the loss of 2.7 million hectares of forest to the worst

[100] "Year of extremes," ibid.

[101] Swiss Re Greenhouse Effect Project Team, 1992, ibid.

fires ever experienced in that state. Some 5% of Manitoba's land area was affected, and over 25,000 people, from dozens of Manitoba towns, became refugees.[102]

The October 1991 East San Francisco Bay fire had an insured price tag of at least $1.7 billion, and the economic losses may well have topped twice that. It was the third biggest fire in US history, and hit a type of mixed forest-and-home development, with a high proportion of combustible shrub, which made the fire spread as though in a forest and cause the same damage as though it were in a city. Swiss Re sent a team of investigators to the site within three days. Their conclusions: "This fire may well prove to be a harbinger of a new type of catastrophe that could reoccur on an even larger scale in the US, Japan Western Europe or in any other economically advanced industrialized nations. ...The issue at stake is best illustrated with the term coined by the American fire fighters at the occasion of the East Bay hills fire. They called it 'the fire of the future'." [103]

Could the drought have had anything to do with the fire? That goes without saying. But could global warming have had anything to do with it? "We ...cannot rule entirely rule out the possibility that the East Bay hills fire was at least encouraged by these global rises in temperature, even though there is no concrete indication of this development to date."[104]

[102] K. Jardine, "Climate change and the boreal forest," Greenpeace Canada Special Publication, 1993, and references therein.

[103] "Fire of the Future," Swiss Re, 1990.

[104] "Fire of the Future," ibid.

8. ACTION RECOMMENDED WITHIN THE INSURANCE INDUSTRY

The 1990 Munich Re "Windstorm" report concluded as follows. "Long-term business results will show a downward trend if, as in the past, insurers determine the risk premium required in accordance with loss experience so far." Among the implications, Munich Re concluded, "insurers in our opinion must make full use of their various facilities for limiting the catastrophe risk," including recognition that "liability should be limited wherever exposure becomes excessive." Measures recommended for reinsurance included, "where applicable, determination of cession or loss limits, that is a ceiling for cessions per country or zone."

Actions recommended by Swiss Re in their 1990 Annual Report were:

- , adjustment of insurance premiums (eroded during the tougher competition of the 1980s, and now manifestly inadequate);
- increases in insurance deductibles;
- redistribution of relative risk-sharing between insurers and reinsurers in excess-of-loss treaties, including promotion of coinsurance participation in reinsurance;
- changes in the extent of cover.

The underwriters in the Lloyd's syndicate mentioned above told us that they thought that their prescience in avoiding areas of particular hurricane exposure might prove to be the opening move of an industry-wide trend, and that if the industry does not follow their lead, then its future must be in doubt. I asked them what would happen if the insurance industry just maintained course with the status quo. This was the reply of one underwriter: "Number one, the catastrophe reinsurance pool would start to disappear - which is happening now. Number two, the insurance support for certain areas would go. This is happening in certain areas now, for example the Virgin islands. What then happens is you have an uninsured public."

As Dr Gerhard Berz of Munich Re puts it, "how long the insurance industry will be able to continue fulfilling its function depends on the speed and agility with which it can adjust to a changing environment." He advocates full participation by the industry in the UN's International Decade for Natural Disaster Reduction, which includes programmes for global co-operation on mapping of hazard zones, assessment of loss potentials, landuse regulations/restrictions, standardization of building codes, forecast and warning services, and public information/ awareness.[105]

[105] G. A. Berz, July 1992, ibid.

9. THE PRACTICAL CHALLENGE FOR UNDERWRITING IN THE FUTURE: CALCULATION OF ESTIMATED MAXIMUM LOSS IN A WORLD WHERE THE PAST IS NO LONGER NECESSARILY A GUIDE TO THE FUTURE.

For the purposes of event-loss estimation, insurers use the so-called exposure method. This requires quantification, and subsequent integration, of four critical factors: hazard, vulnerability, insured values and insurance conditions. Hazard, involving as it does the frequency and strength of events, requires historical records. Vulnerability, involving as it does the quality of insured interests, requires assessment of the Mean Damage Ratio, and this also requires past records - examination of past claims events, and assessment for example of the effect of different peak wind speeds on different categories of building. Insured values, involving the amount and distribution of commitments, and insurance conditions, pertaining to the hazards covered and the conditions of that cover, can be quantified from systematic databases, and are less of a problem.

This leaves the rating problem dependent to a greater or lesser degree on historical records for two of the four factors critical to determining Estimated Maximum Loss (EML). As things stand, without the wild cards introduced by the threat of the human-enhanced greenhouse effect, things are difficult enough for the underwriter. Natural hazards such as earthquake and storm differ greatly from "conventional" hazards such as fire and explosion in being lower-frequency and larger size. The high frequency and (relatively) contained size of fires and explosions allows accurate rating from historical records of loss experience. For catastrophic earthquakes and windstorms, the relative infrequency of events gives a shaky database, resulting - as things stand - in a "pronounced tendency to underestimate the premiums needed."[106]

Assuming no climate change, an attempt can be made to represent storm hazard by the return period of peak windspeeds, and vulnerability can be weighed by looking at the impacts on building types of different levels on the Saffir-Simpson scale of hurricane intensity. This is easier to do for tropical cyclones than it is for extratropical cyclones such as European windstorms, because with the damage depends on many factors (e.g. peak windspeed, direction, storm duration, storm path, topography etc). For example, storm damage correlates far more with peak gusts than with mean wind speeds.[107]

But assuming that the world's climate modelling centres are correct that we face historically-unprecedented climate change in the decades ahead - seemingly an

[106] "Natural hazard and event loss," Swiss Re, 1989, p. 9.

[107] "Winter Storms 1990," Swiss Re, 1990 Annual Report.

odds-on certainty - how does the underwriter assess EML? He/she may have excellent data on the spread of insured values and insurance conditions, but how much confidence can be attached to hazard and vulnerability? General Circulation Models, on which the estimates of future climate change are based, can tell us little about regional changes, because of the scale on which they operate, and are unlikely to be capable of regional-scale estimations for more than 10 years. Meanwhile, there is the problem of weighing the odds where the many feedbacks in the climate system - most of them simply excluded from GCMs - are concerned. What are the odds of a negative feedback, or feedbacks, dominating? What are the odds of positive feedbacks dominating? The IPCC scientists refer in both their 1990 report and the 1992 Update to the complexity of the climate system giving "scope for surprises." This is essentially the same community of scientists which failed to foresee the ozone hole (and even - in many cases - ozone depletion). It has consistently underestimated both the pace and extent of ozone depletion since the discovery of the ozone hole in 1985. It has a proven record of underestimating, rather than overestimating threats.

One can only conclude that accurate actuarial work is going to be difficult in the extreme in the years ahead. With the fruits of the climate-change research bandwagon now beginning to flood into the technical journals, it will be essential for the insurance industry to keep abreast. The early indications are that scientific developments will be fast moving, improving understanding in some areas, and requiring expansion of the boundaries of ignorance in others.[108]

[108] J. Leggett, "On the communication of science in climate-change policymaking - a Greenpeace view," In Wiman, B, (ed), "Science in policymaking," University of Lund Press, in press.

10. THE FUTURE FOR THE INSURANCE INDUSTRY: THREE OPTIONS.

i. The status-quo, or near-status-quo, future: taking the advice of the fossil-fuel lobby.

Business-as-usual seems to be an unlikely scenario for the insurance industry. It seems certain, from the evidence chronicled above, that dramatic changes in insurance business practices are in train. The future for an insurance industry which fails to react at a fundamental level to the composite stresses imposed during the period 1988-92 must be grim indeed.

In contrast, producers and users of fossil-fuels very much hope for a status-quo, or near-status-quo, approach to the future where their businesses are concerned. The coal lobby at the climate negotiations, in the shape of organisations like the World Coal Institute, adopted a position indistinguishable from that of OPEC governments - a willingness to protect continuing mass-dependence on fossil-fuels seemingly at any cost to future environmental and long-term economic security. Yet if there is one natural resource whose use ad-infinitum has to be deemed unsustainable, it is coal. There are 750 billion tonnes of carbon in atmospheric carbon dioxide, and fully 10,000 billion tonnes in estimated reserves of fossil fuels, most of it as coal (Figure 3). We know from ice-core data that for thousands of years, before the mass incineration of fossil fuels began, there was about 580 billion tonnes of carbon in the atmosphere.[109] Clearly, we cannot afford to burn more than a fraction of the 10,000 billion tonnes in the fossil-fuel reservoir.

The oil companies were only marginally less sophisticated, during the climate negotiations, in the defence of their perceived interests. Their lobby groups, such as the International Petroleum Industries Environmental Consciousness Association, together with multi-interest groups like the Business Council for Sustainable Development, argued for bolt-on adjustments to the status-quo such as minimal utilization of energy-efficiency opportunities, but their bottom-line flew in the face of the IPCC science: they argued, ultimately, that there should be no targets or timetables for limiting (or even freezing) the flow of carbon dioxide into the atmosphere from fossil-fuel burning, and no measures by government (such as carbon taxes) to stimulate alternative energy supply or demand-side management. At the highest levels, they are wedded to the goal of extracting and

[109] IPCC Report 1990, as note 1.

burning all the remaining oil reserves on the planet.[110]

And there is a lot of oil left with which humankind can continue to destabilize climate, and undermine its capacity to insure economies. We have burnt less than 700 billion barrels of oil to date, there are 1,000 billion in proven reserves below ground, and almost certainly more than another 700 billion yet to find.[111]

This defence of perceived short-term interests leads the oil lobby into same strange contradictions. Those who seek to deny the problem of climate change, for example, must also deny that there is much chance of windstorm activity being any more of a problem in years to come than it is today. A few days after Hurricane Andrew, with a dozen oil and gas rigs toppled, nearly 200 others damaged, and 79 oil slicks spreading across the Gulf from 83 pipeline ruptures, the oil industry's bill for damage passed the $200 million mark. The New York Times asked Scott Sewell, the Director of the US government agency responsible for offshore oil and gas licencing, for his reaction. "This," came the reply, "was truly a one-hundred year storm." How many knowledgeable analysts in the insurance industry would give him odds another 100 years passing before the next one?

Daniel Yergin, in his Pulitzer-winning history of the oil companies, summed up the rather precarious future for the seemingly invincible giants built during more than a century of unmitigated oil-dependence. "With the fate of the planet itself seeming to be in question, the hydrocarbon civilization that oil built could be shaken to its foundations ...It will be remarkable if we reach the end of the century without the preeminence of oil being tested yet again by political, technical, economic, or environmental crises - perhaps foreseen, perhaps coming by surprise."[112] It remains to be seen whether the oil industry will be able, or allowed, to extract and sell oil until supplies run out.

[110] The Business Council tor Sustainable Development, "Changing Course," Special Publication for the Earth Summit. The energy chapter of this book contains much constructive langauge about energy efficiency, but skirts the critical issue: is the BCSD (and the oil companies, like Shell, who are party to it) in favour of limiting carbon dioxide emissions from the burning of oil and the other fossil fuels? Or are they in favour of using oil deposits to exhaustion? The answers, as became clear in their press conference at the Earth Summit, and in related interviews, are respectively no, and yes.

[111] J. K. Leggett, "Environmental responsibilities in the oil industry: a view from the environmental movement," Paper presented at the First International Conference on Oil and Gas Exploration and Production and the Environment, the Hague, November 1991, and references therein.

[112] D. Yergin, "The Prize," Simon and Schuster, 1991.

ii. Profound intrinsic-change: reaction to the writing in the sky.

The insurance industry seems to be in the midst of a waking process where climate change is concerned. This, as has been argued above, is clear from an increasing range of recent industry literature, and statements, and has led to the first example of insurers saving significant monies by factoring climate change into their calculations.

The pace of change is not necessarily an inherently fast one. The industry, according to one Lloyd's underwriter "is rather like a dinosaur. You stamp on their tail and a week later they say ouch." But around the corner, in the years to come, can only lie a paradigm shift in the type of insurance cover offered, and the terms of that cover.

The indirect economic implications of such an industry-wide rethink stands to hit other business sectors, if they don't see it coming, like a tidal wave. Take coastal development. According to a Swiss Re underwriter, writing in an industry journal, revisions in original rates may be required in concert with "a restriction in the cover given in areas exposed below the five metre contour level."[113] Restriction in cover below even the fifty centimetre contour level would have the most far-reaching implications for coastal development plans in the residential, tourist, and industrial sectors alike. Today new homeowners in Western Samoa and Hawaii are being left unable to find cover. Tomorrow the same could apply to a wide range of infrastructure around the Florida and Gulf coasts. The day after tomorrow, hitherto-unaffected Atlantic, Mediterranean, and Australian coasts - threatened by cyclones as Munich Re believes them to be - could find themselves in the firing line.

Very recently, certain sectors of the industry have made the first public demands for action from governments and businesses. Analyses of the 1992 catastrophe statistics by both Munich Re and Swiss Re in April 1993 were accompanied by calls for action. Munich Re called on governments, businesses, and insurers alike to "take immediate action" to address the "dramatic development of natural catastrophes." "The threatened climatic changes demand urgent and drastic measures," the company said.[114]

Commenting on the analyses of the two big reinsurers, Lloyd's List wrote: "the convenient theory that the increase in the size of losses is mainly a reflection of higher wealth - and consequently, of insured values - in those countries affected by natural disasters seems to be incorrect. It is far more likely that other causes,

[113] J. Hindle, "Warming signals," The Review, March 1989, p.34-37.

[114] "Munich Re plea for catastrophe action," Lloyd's List, 23 April 1993.

such as climatic changes, have already taken over as the main factors pushing losses upwards."[115]

iii. Strategic defence of insurance markets: lobbying **for** extrinsic policy change.

Passive adaptation of business practice is not the only option open to the insurance industry in the face of the emerging global-warming threat. The industry can ask whether there is anything it can do to foster its chances of having viable global markets to operate in, come 2030 or 2050. Many climate scientists and ecologists believe that if the fossil-fuel businesses are given their head, and persist with mere bolt-on adjustments to status-quo dependence on hydrocarbons and coal, viable markets will become increasingly rare as economic, ecological, and social stresses explode in the face of a spiralling greenhouse effect. At the World Climate Conference of November 1990, for example, over 600 scientists "urged" governments to commit to cuts in emissions.[116]

Perceptions of extreme threat are not limited to environmentalists and scientists. Vice President Al Gore is the best known of the new generation of environmentally super-aware politicians. In his best-selling book, 'Earth in the Balance', Gore went so far as to say that society should adopt measures to stave off the global environmental crisis as its "central organising principle."[117] He believes that global warming is the number one threat, and hence high on the agenda for the "Strategic Environment Initiative" he proposes are technologies capable of achieving deep cuts in greenhouse-gas emissions. Such deep cuts are essential. To stabilize atmospheric concentrations at levels which pose no danger, as described earlier, requires deep cuts in emissions - 60 to 80% in the case of carbon dioxide. And this in turn requires massive reductions in reliance of fossil-fuels.[118] Accordingly, for example, Gore advocates the goal of eliminating the internal combustion engine within 25 years. This he could not do unless alternative technologies existed today, and they do. Most auto manufacturers have prototype electric- and hydrogen cars, but they are far from production.

This is not the place to explore the feasibility of a future virtually free of fossil-fuels. Such a future seems unlikely when viewed in today's frame-of-reference. But it is achievable, given political will, governmental effort akin to that thrown in the past into the Manhattan and Apollo projects, and industrial effort akin to

[115] "Catastrophes in a new climate," Lloyd's List, 27 April 1993.

[116] Scientists Declaration, World Climate Conference, Geneva, November 1990.

[117] Al Gore, "Earth in the Balance," Earthscan, 1992.

[118] IPCC, ibid, note 1.

that thrown into replacing the horse with the motor car. Greenpeace has completed a collaborative study with some of the world's most experienced energy modellers of how such a future might come about, and the interested reader is referred to that study.[119] All that can be elaborated in the space available here are the very broadest outlines of such a future.

It would involve switching today's profound societal addiction to fossil fuels, and the energy profligacy that pervades every sector of life - commercial, residential, and transport alike - with multi-billion dollar solar industries, and ubiquitous state-of-the-art energy efficiency. This should happen - in order to stop potentially critical atmospheric concentrations building up (Fig. 2) - within a matter of a few decades.

If the IPCC's scientists are to be believed, the viability of insurance markets in the future may well depend on this replacement process coming to fruition.

There is much that the insurance industry could do to help foster the transition. Insurance capital is one of the world's largest reservoirs for investment. It would behove the industry to look very closely, seeking legislative help from government as necessary, at where all capital is invested. Fossil-fuel-related operations should be eschewed, and solar energy and energy-efficiency projects favoured.

There are small-scale precedents for this which provide microcosms of how the future might look. For example, one of the most important investors in Luz of California - the largest solar-thermal operator in the world - was an insurance company, the Prudential - America's largest. The Prudential invested $200 million in all.[120] Note that Luz became bankrupt in 1991, victim of tax and investment disadvantages on a playing field grotesquely skewed in favour of the fossil fuels. Had an insurance lobby as powerful as Washington's fossil-fuel lobby argued the case for favouring Luz and other solar pioneers, things might have been different.

Then there is the question of premium rating and other potential economic levers the industry could apply to encourage change if it chose. Again, there are small-scale precedents, and also economic benefits-by-default. It has long been known that conventional (electric, oil or gas) heating causes many fires. This is reflected in contemporary insurance pricing. For example, the Hannover Insurance Company gives a 10% rebate for insurance on solar-heated buildings.

[119] "Fossil Fuels in a Changing Climate," Greenpeace Special Publication, April 1993.

[120] H. N. Rostvik, "The Sunshine Revolution," Sun-Lab Publishers, Stavanger, August 1992.

Economies bringing solar-powered buildiings into the fast lane would offer significantly reduced fire risk, plus reduced business-interruption claims (many of which derive from lost electric power), as well as reduced greenhouse-gas emissions.

The same win-win situation would apply in the transport arena. Battery vehicles would be safer on the whole than cars powered by the internal combustion engine. In Switzerland, for example, premiums are lower for electric cars than for diesel or petrol cars, for this reason.[121]

From such small beginnings much can spring to favour technologies which work to the advantage of stable insurance markets.

As I have argued in this report, there are undoubtedly many in the insurance industry today who are sufficiently worried about the prospect of an unmitigated human-enhancement of the greenhouse effect to support a proactive stance by the industry. As Dr Gerhard Berz of Munich Re wrote in September 1992:

> *"The insurance industry can only hope and wish, in its own interest, that the convention to protect the world's climate which has been passed by the UN Conference in Rio in June 1992 will help achieve a politcal breakthrough for the many good plans that have been proposed and succeeds in healing the earth from the 'fever' which is beginning to afflict it."* [122]

This serves to introduce the most important single step the insurance industry could take. The ongoing sessions of the climate negotiations to which Dr Berz refers will be attended by representatives of a multi-million dollar lobby representing fossil-fuel interests. For example, the representatives of the anodyne-sounding "Global Climate Coalition" will be there with a large lobbying budget provided by a wide consortium of oil, coal, and auto companies. They will be there to do everything they can to stall progress, the same way they have throughout the climate negotiations to date. The Global Climate Coalition favours a Climate Convention without teeth - one which commits no nation to even stabilizing emissions at *present day* levels. Put another way, the Global Climate Coalition will be at the negotiations to lobby for policies which are diametrically opposed to the interests of the insurance industry. As will the rest of the fossil-fuel lobby.

It is time the insurance industry redressed this situation.

[121] H. N. Rostvik, ibid.

[122] G. A. Berz, "Heat of the Moment," The Review, September 1992.

11. CONCLUSIONS: BUYING INSURANCE FOR A VITAL INDUSTRY, BUYING INSURANCE FOR THE PLANET.

Swiss Re has published a report on environmental protection which includes a graphic description of where environmental stresses such as climate change are leading the planet.

> *"In a restricted system such as the earth, long-term, unlimited growth cannot be possible. The hope that we could still afford to grow at the same rate as before until it finally ebbs of its own accord is certainly rather foolhardy in view of the unmistakable signs that many stress limits have already been reached, if not even surpassed. There is certainly no need to be hesitant as we apply the brakes ... An increasing number of regulations cannot be avoided. It is the price we have to pay to prevent the further increase in power (that man has gained from nature) spelling doom for the environment and thus for us too."*[123]

This reads like environmentalists' rhetoric, but is the conclusion of one of the largest reinsurance companies in the world. As Swiss Re's General Manager concluded in November 1990, "if the feared climatic change is confirmed, it will obviously stretch the insurance industry to its limits. Extending these limits will require the equitable distribution of added burdens between policymakers, insurers and reinsurers based upon their relative financial strength. The burden sharing must go beyond the concept of the solidarity of the risk community upon which insurance is originally based. We must marshall our talents for innovation."[124]

It is time for an expansion of that concept of "solidarity among the risk community." The response to that risk, for the insurance industry, must go beyond adaptation of business practice, which is likely only to be effective in the short-term anyway, to defence of the business environment in the longer term. That involves lobbying for the type of regulations that the Swiss Re report on environmental protection refers to, and doing so with resources, human and financial, to rival those deployed by the fossil-fuel interests in their misguided defence of short-termism and the unsustainable status-quo. In buying insurance for its own future markets, the insurance industry would be buying insurance for the planet, and the wider risk-community thereon.

[123] "Environmental Protection - a safeguard to life," Swiss Re, 1989

[124] H. R. Kaufmann, ibid.

ABOUT THE AUTHOR:

Before he joined Greenpeace in 1989, Dr Jeremy Leggett spent 11 years as an earth scientist on the faculty at the Royal School of Mines, Imperial College, where he won two major international awards for his research on the past history of oceans. He sat on several advisory committees for the UK government's Natural Environment Research Council, and was a consultant to the oil industry in the UK, Japan, and Pakistan.

ABOUTGREENPEACE:

Greenpeace is an international organisation dedicated to the protection of the environment. Since its formation 22 years ago, Greenpeace has expanded considerably and currently has offices in 30 countries, and over four million supporters worldwide. This expansion is partly a reflection of growing public concern over the environment, but is also due to Greenpeace's record of campaigning successes. Greenpeace's operations are funded solely from public contributions. One of the organisation's key strengths is its independence from any government, political party, pressure group or sectarian or business interest. The work of the campaigns, (Climate, Nuclear, Toxics and Ocean Ecology) includes publications, media briefings and political lobbying. Believing as it does that current unsustainable practices are imperilling the planet's future, Greenpeace is prepared to physically disrupt activities which damage the environment. But such direct action is always non-violent. For Greenpeace, the 'peace' is as important as the 'green', the means as important as the end. Further details of Greenpeace's atmosphere-and-energy policy prescriptions can be read in the best-selling "Global Warming: the Greenpeace Report", edited by Jeremy Leggett (Oxford University Press, 1990).