Dangers and thresholds in climate change and the implications for justice

by Stephen Schneider

Presentation to

Justice in Adaptation to Climate Change Conference

University of East Anglia – Norwich, UK

September 6-8, 2003

What is the probability of dangerous climate change?

This elicits three fundamental questions:

- What is “dangerous” climate change?
- What sorts of climate change scenarios are out there, and how do we assign probabilities to them?
- What “solutions” have been proposed, and how are they affected by projected probabilities and consequences (or lack thereof)?

The Problem: Schneider ≠ Nostradamus

NOSTRADAMUS PREDICTS HOTTEST SUMMER IN HISTORY

FAMOUS seer Nostradamus wrote a clear and specific poem that reveals the horrors of our upcoming weather.

What do we know?

- **IPCC Second Assessment Report** (SAR – 1996): Human activities are indeed having a "discernible" impact on the Earth's climate.
- **IPCC Third Assessment Report** (TAR – 2001): The IPCC estimates that by 2100, the planet will warm by between 1.4° and 5.8°C, up from the range of 1.0° to 3.5°C that had been estimated in the SAR.
- **Effects of such warming** will likely include more frequent heat waves (and less frequent cold spells); more intense storms and a surge in weather-related damage; increased intensity of floods and droughts; warmer surface temperatures; more rapid spread of disease; loss of farming productivity; movement of farming to other regions, most at higher latitudes; rising sea levels; and species extinction and loss of biodiversity. **CATASTROPHE?**

Climate Change Impacts

Reasons for Concern About Climate Change Impacts.

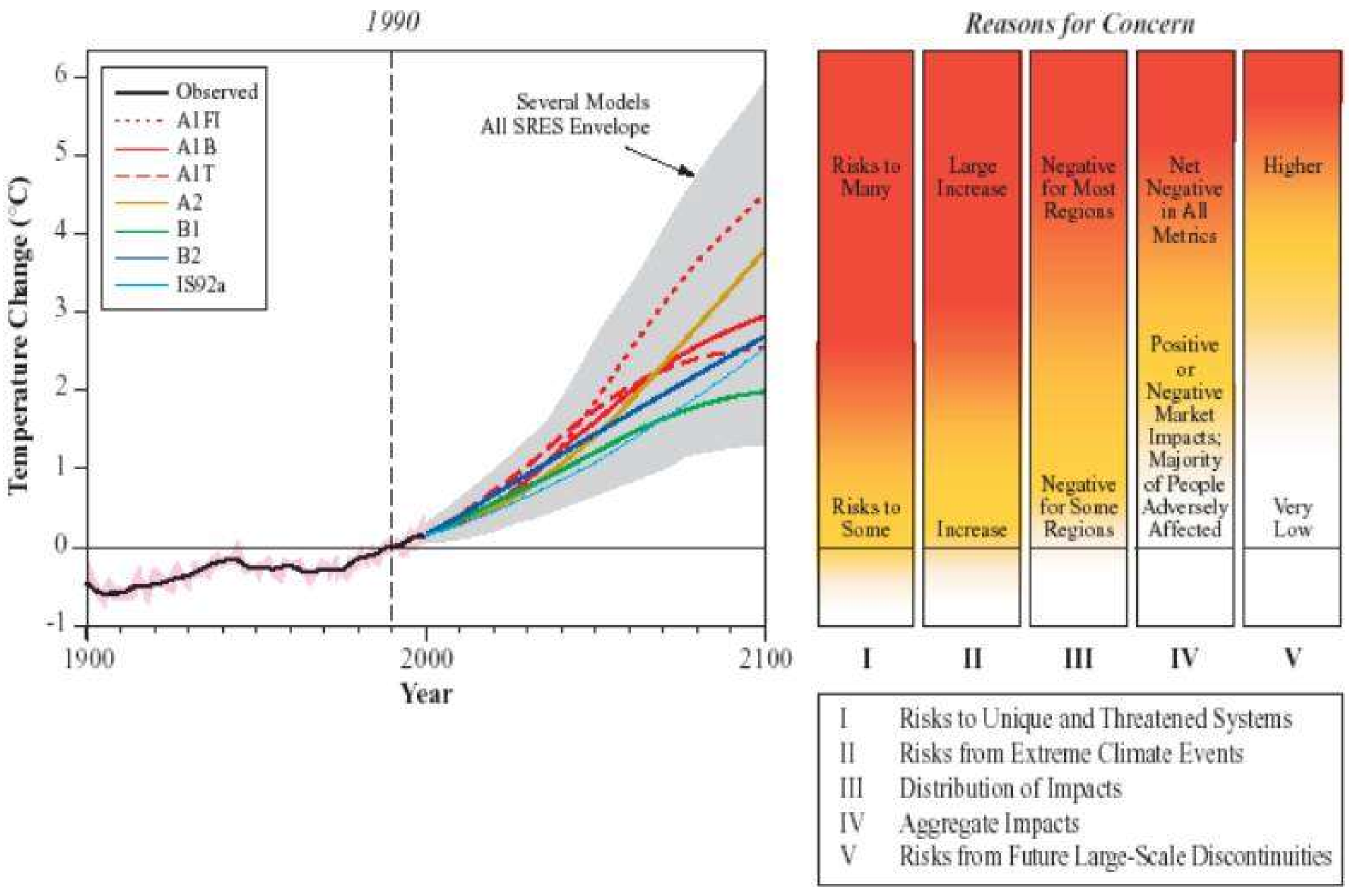

Figure — Reasons for Concern About Climate Change Impacts (source: Climate Change 2001b). This figure shows that the most potentially dangerous impacts (the red colors on the figure) typically occur after only a few degrees Celsius of warming. As indicated, the risks of adverse impacts from climate change increase with the magnitude of the climate change itself. The left part of the figure displays the observed temperature increase from 1900 to 1990 and the range of possible increase after 1990, as projected by Working Group I (WG I) of the *IPCC (Climate Change, 2001a)* for scenarios from the Special Report of Emission Scenarios (IPCC 2001 – See the SRES emissions scenarios). The right panel displays conceptualizations of five reasons for concern regarding climate change risks evolving through 2100. White indicates neutral or minimal negative or positive impacts/risks, yellow indicates negative impacts for some systems, and, as noted, red represents widespread adverse impacts.

"Mediarology"
What should policymakers believe?

Large Vehicles Are the Solution, Not the Problem

By SAM KAZMAN

If you listen to journalists, you'd think sport-utility vehicles were more dangerous than Saddam Hussein. SUVs supposedly deplete the Earth's resources, poison its atmosphere and encourage rude driving. Worst of all, because of their size they allegedly pose a grave collision threat to just about anyone who ventures outdoors. According to a recent New York Times report, the worst safety hazard is yet to come—once these "expensive toys" depreciate and are sold by the "responsible family people" who now drive them, they'll be bought by teenagers who'll handle them even more recklessly.

These threats have been wildly overstated. And the solution proposed by many SUV critics, raising the federal fuel economy standards, would mean expanding a regulatory program that has already caused thousands of traffic deaths.

The federal Corporate Average Fuel Economy standards, enacted in the wake of the mid-1970s oil shocks, require each auto maker's annual output of new cars to meet a set fuel economy level. The current passenger-car CAFE standard is 27.5 miles per gallon; for light trucks, the standard is a more lenient 20.7 mpg.

The easiest way for car makers to meet ever-rising CAFE standards has been through continued car downsizing. As the National Highway Traffic Safety Administration itself noted, "weight reduction is probably the most powerful technique for improving fuel economy. . . . Each 10 percent reduction in weight improves the fuel economy of a new vehicle design by approximately 8 percent." The result was a CAFE-driven downsizing of approximately 500 pounds per car.

Smaller cars, however, are less crashworthy than similarly equipped large cars in practically every type of accident. According to a 1989 Harvard-Brookings study, CAFE-induced downsizing has increased car occupant fatalities by between 14% and 27%; that translates to between 2,000 and 4,000 extra deaths a year.

You'd think that NHTSA, an agency whose middle name is safety, would have brought this issue to the forefront of public attention. But instead NHTSA has repeatedly claimed that CAFE has no safety effect. In a 1992 court case brought by the Competitive Enterprise Institute and Consumer Alert, a panel of federal appeals judges blasted NHTSA's position as "fudged analysis," "statistical legerdemain" and "bureaucratic mumbo-jumbo."

If CAFE had been a privately produced product, it would long ago have been recalled as defective and its producer, NHTSA, jailed for the coverup. But because CAFE is a product of Washington rather than Detroit, it remains in place; worse yet, it threatens to expand in the face of the SUV "threat."

The overblown nature of that threat is demonstrated by a study issued last month by the Insurance Institute for Highway Safety. Journalists widely reported the study as re-emphasizing the need for action against SUVs, but its findings indicate otherwise. What the institute found was that collisions between cars and SUVs account for only 4% of car occupant fatalities.

Cars are most vulnerable in side impact collisions. According to the institute, in fatal collisions involving cars that are hit on the side by SUVs, the relative risk that the death will be in the car rather than the SUV is an apparently lopsided 27-to-1. But when this relative risk is broken down by car weight categories, it turns out that car-SUV mismatches are frequently outweighed by other common collision disparities. For example, the occupants of a light car struck in the side by a heavy car face a greater relative risk of death than when a heavy car is side-impacted by an SUV. That is, there is a greater mismatch between light cars and heavy cars than there is between heavy cars and SUVs.

What this means is that upsizing the car fleet may well be the most important step we could take toward improving safety. But upsizing, of course, is what CAFE currently restricts.

You're safer in a sport utility vehicle.

The same conclusion emerges from a 1997 NHTSA study, which was similarly characterized as indicting SUVs but which turns out, on closer analysis, to indict CAFE. A NHTSA press release touted the study's finding that a 100-pound decrease in SUV weight would prevent 40 fatalities per year, most of them in cars colliding with SUVs. But according to the study itself, this conclusion was not statistically significant; there might even be a net loss of life from such downsizing, and on balance the overall effect would be "negligible." More important, those minimal effects paled in comparison to the effects of a 100-pound *increase* in passenger car weight—a saving of over 300 lives a year. And the effect of this passenger car upsizing was found to be statistically significant, unlike the SUV downsizing.

Upsizing, however, would entail relaxing CAFE rather than tightening it—a move that would be totally alien to this administration and to its environmentalist supporters. The Sierra Club, for example, claims that higher CAFE standards would be "the biggest single step to curbing global warming." In their 1992 campaign book, Bill Clinton and Al Gore recommended raising CAFE to 40 mpg by 2000—a level whose potential safety consequences add more than a little irony to the book's title, "Putting People First."

SUV critics argue, to use Consumer Reports' words, that "most people who buy ... he bought it for safety, to distinguish himself from "some teenager" trying "to b[e] cool." Too bad his regulatory approac[h] doesn't do much for other people's safety.

In fact, much of the SUVs' recent popularity stems from CAFE itself. CAFE's restrictions took their greatest toll on larg[e] cars and station wagons. As economis[t] Paul Godek pointed out in a study pub[-]lished last fall, light trucks were the onl[y] real alternative for consumers concerne[d] about safety and seating capacity. In e[f]fect, he concludes, most of the weigh[t] forced off the passenger car fleet by CAF[E] has reappeared in the light truck fleet.

So the real problem is CAFE, not SUV[s]. The next time you hear the term SUV, re[-]member: The "S" might as well stand fo[r] scapegoat.

Mr. Kazman is general counsel of th[e] Competitive Enterprise Institute in Wash[-]ington.

March 17, 1998

THE WALL STREET JOURNAL.

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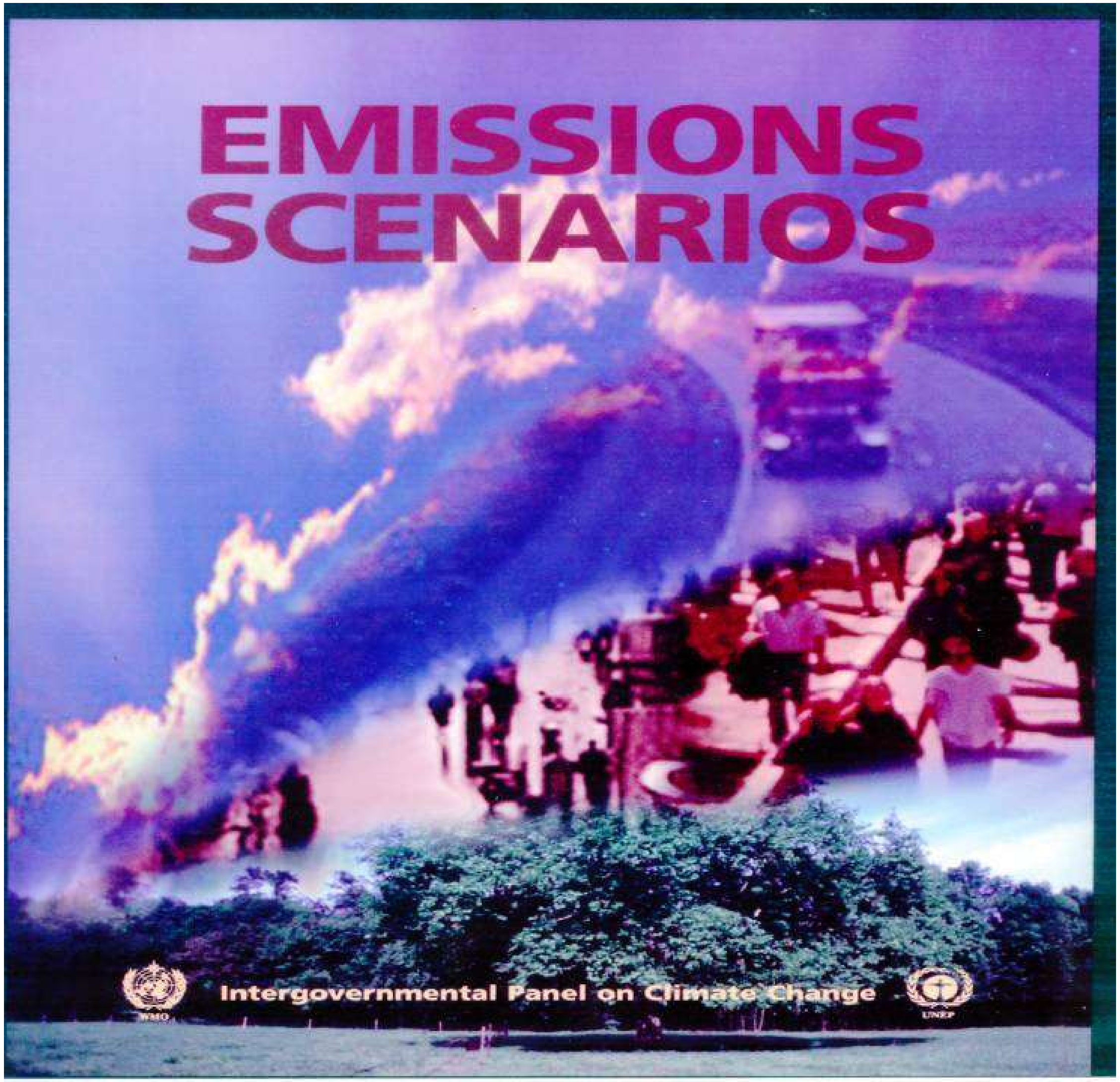
The role of the scientific community
#1: Provide climate change scenarios



The IPCC's Special Report on Emissions Scenarios (SRES) - 2000

A1 storyline/scenario family

The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence between regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income.

② ② ② ② ② ②

The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system:

- **Fossil intensive (A1FI)**
- **Non–fossil energy sources (A1T)**
- **A balance across all sources (A1B), where balance is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies.**

A2 storyline/scenario family

The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented, and per capita economic growth and technological change are more fragmented and slower than in other storylines.

B1 storyline/scenario family

The B1 storyline and scenario family describes a convergent world with the same global population (which peaks in mid-century and declines thereafter) as in the A1 storyline but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity but without additional climate initiatives.

B2 storyline/scenario family

B2: The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population (at a rate lower than in A2), intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. Although the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

Projected CO_2 concentrations using IPCC storylines

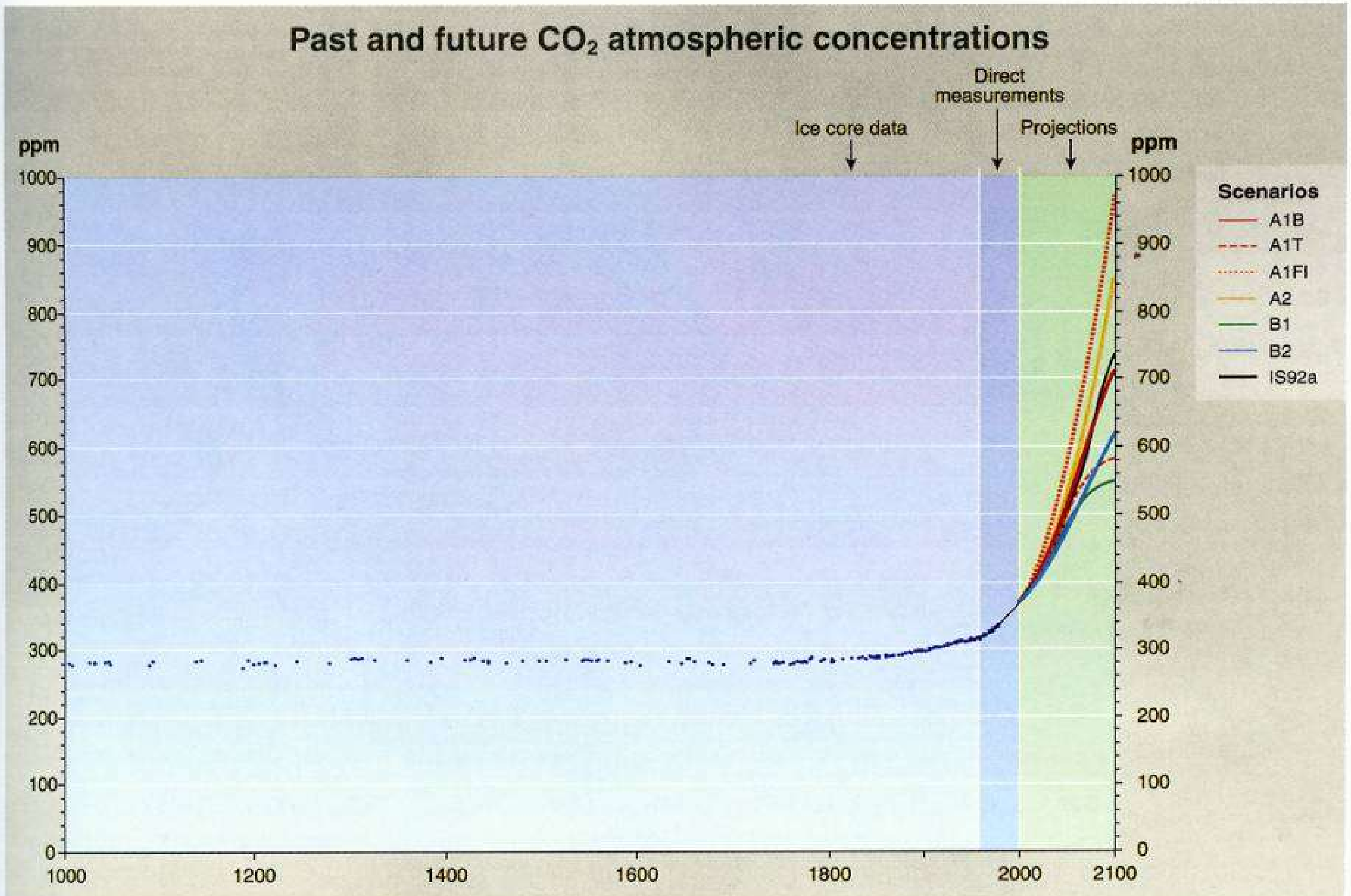
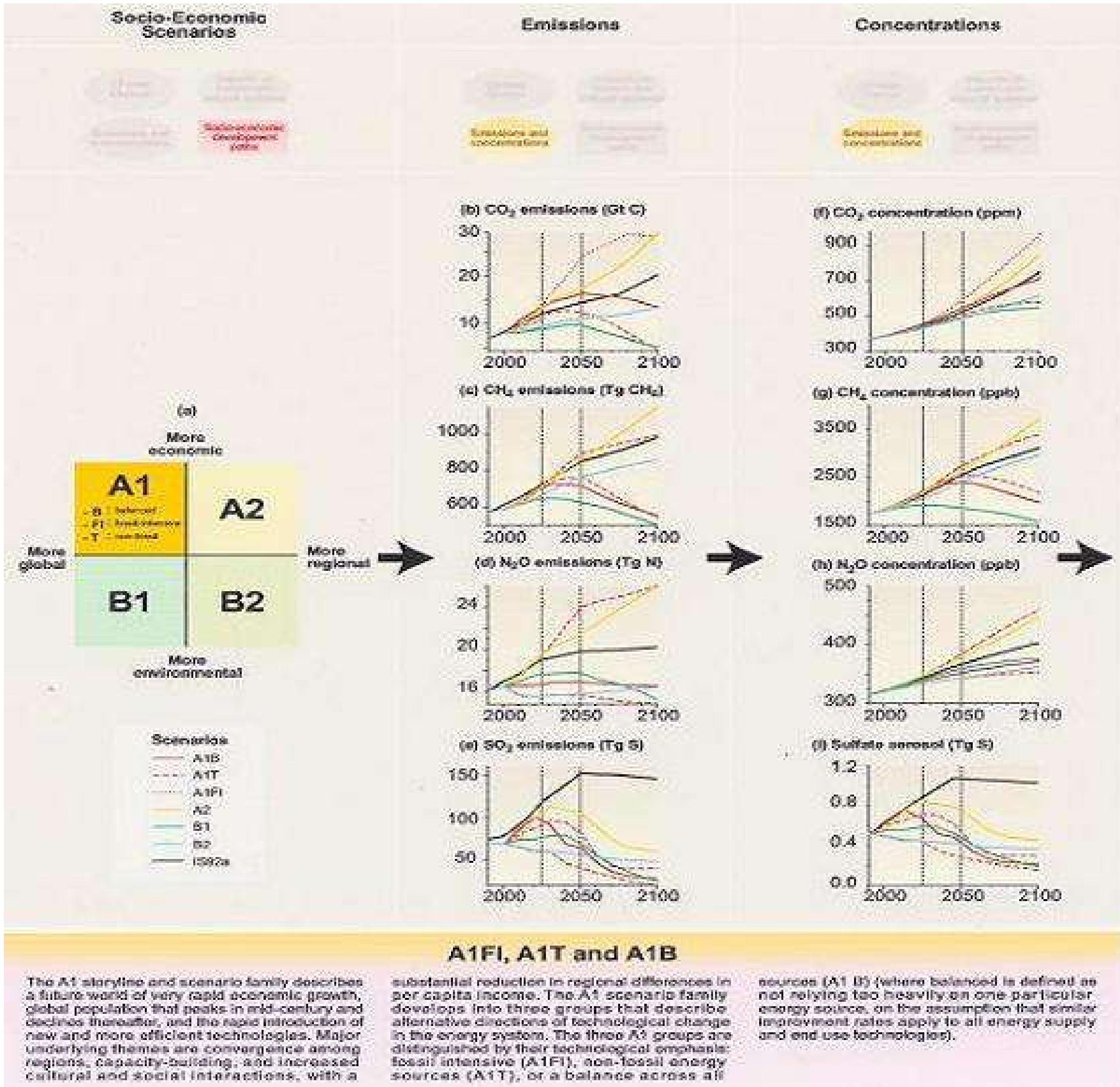


Figure SPM-10a: Atmospheric CO_2 concentration from year 1000 to year 2000 from ice core data and from direct atmospheric measurements over the past few decades. Projections of CO_2 concentrations for the period 2000 to 2100 are based on the six illustrative SRES scenarios and IS92a (for comparison with the SAR).

Q9 Figure 9-1a

IPCC scenarios – Breakdown of emissions and concentrations



The role of the scientific community
#2: Complete the risk equation

Some IPCC authors consider the scenarios “equally sound,” which offers no guidance on which storylines are more or less likely. A subjective probability assessment of the likelihood of the sets of scenarios would offer policymakers a useful characterization of which scenarios may entail “dangerous” outcomes.

Basically, scientists have outlined the possible consequences of climate change, but have not assigned probabilities to those consequences. They must do so to complete the risk equation:

Risk = Probability x consequence

Uncertainty and probability assessment

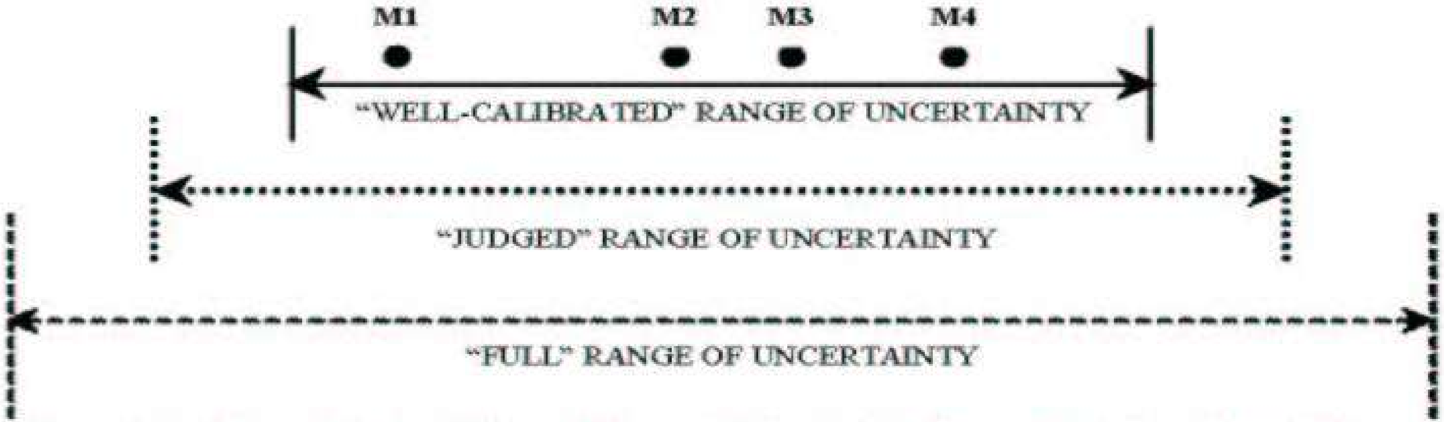
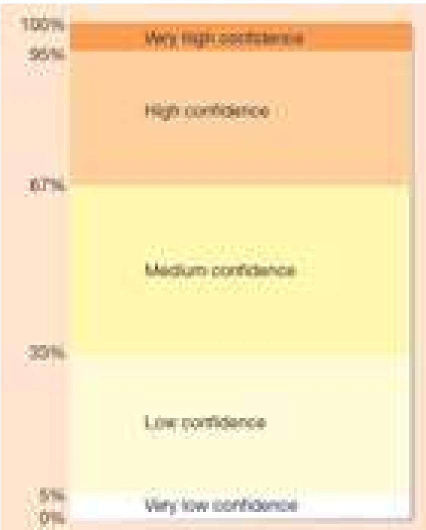


Figure 2. Schematic depiction of the relationship between "well-calibrated" scenarios, the wider range of "judged" uncertainty that might be elicited through decision analytic survey techniques, and the "full" range of uncertainty, which is drawn wider to represent overconfidence in human judgments. M1 to M4 represent scenarios produced by four models (e.g., globally averaged temperature increases from an equilibrium response to doubled CO_2 concentrations). This lies within a "full" range of uncertainty that is not fully identified, much less directly quantified by existing theoretical or empirical evidence[i]. (from Schneider and Kuntz-Duriseti, 2002).

[i] Jones, R.N., 2000: Managing uncertainty in climate change projections: Issues for impact assessment. An editorial comment. Climatic Change 45(3-4): 403-419.

Tools for probability assessment
Confidence bands



Source: Giles (2002)

While it is difficult enough to forecast the future state of the world (e.g., the extent of use of alternative energy, kinds of new technologies available, standards of living, types of economies, energy intensity, access to new technologies, etc.) for use in building scenarios, assigning probabilities to those scenarios is perhaps even more daunting. For this reason, Schneider and Moss (2000), in a guidance paper on the formal treatment of uncertainties written for the IPCC TAR lead authors, recommended the use of consistently-defined confidence bands. When scientists describe their results, Schneider and Moss argue that they should assign one of five confidence ratings, ranging from “very low confidence” to “very high confidence.”

Tools for probability assessment
Bayesian updating

When lack of direct observations (since there cannot be, even in principle, any frequency data on the temperatures of 2100 before the fact!) prevents probabilities from being calculated using standard "frequentist" statistical techniques based on objective data, Schneider and Moss (2000) suggest that authors assign subjective probabilities to important conclusions by taking into account their knowledge of the models and data behind them. Although confidence levels for future events are necessarily subjective, they can be updated as more data about a system—its performance against known variations, its consistency with known constraining laws, and/or the quality of its various sub-systems—become available. This process is known as "Bayesian updating" and is common in decision-analytic efforts in fields as diverse as medicine, security planning, investment banking, and environmental assessment.

The role of the scientific community
#3: Account for surprise

For a climate change assessment to be truly useful to policymakers, it must be able to warn of "surprises." Most scientists have found it problematic to incorporate non-linear, catastrophic, unpredictable, and perhaps irreversible "surprises" into their IAMs and probability projections, both for "imaginable surprises" and for *true* surprises, events not yet currently envisioned. This may be even more detrimental to policymakers than not having probabilities assigned to non-surprise events, as societies will have greater capacities to adapt to smooth, relatively predictable climate change, whereas abrupt, unanticipated events will likely cause most of the damage.

Progress on surprise

- Imaginable surprises include collapse of the North Atlantic thermohaline circulation (THC) system, which would cause significant cooling in Northern Europe;and deglaciation of polar ice sheets, which would cause significant sea level rise.
- Systems may exhibit multiple equilibria. Once a certain threshold is surpassed, a system may shift to a new equilibrium. This could constitute a surprise occurrence.
- DICE and E-DICE models connect the non-linearity of potential "surprise" occurrences to the integrated assessment of climate change policy, but they do not assign probabilities to surprise events.
- Many climate change assessments eliminate the best and worst damage scenarios, as they are the least likely. This is unwise, as it could be ruling out a very risky event that could very well occur.

The role of the scientific community
#4: (In)Equity Considerations

- How do we value natural ecosystems?
- What discount rate should be applied to IAMs (or, how do we value future generations?)?
- Is there a way to account for inequality across nations?

The Science/Policy Crossroads

The definition of "dangerous" and what to do when faced with such danger is ultimately the subjective, normative choice of the decision-maker (be it an individual farmer, private enterprise, politician, or international governing body). However, it is still largely useful and more objective for scientists to complete the risk equation by assigning probabilities to the various consequences their analyses suggest, thereby enhancing policymakers' understanding of the trade-offs involved in various climate strategies such as adaptation, mitigation, or both.

Citizens Get:
[FROM EXPERTS]

- WHAT CAN HAPPEN?
- WHAT ARE THE ODDS
- (HOW DO YOU KNOW?)

Citizens Give:

- VALUE JUDGEMENTS ON HOW TO TAKE RISKS, DECIDE WHO PAYS, ETC.
- CERTIFY OPENNESS OF EXPERT ASSESSMENT PROCESS
- AGENDA FOR EXPERT ASSESSMENT

It takes two…

Both scientists and politicians must play their parts.

Scientists must deal with:

RISK: PROBABILITY times CONSEQUENCES

DESCRIPTIVE SCIENCE:
- **WHAT CAN HAPPEN**
- **WHAT ARE THE ODDS**

(But what probabilities? and from whom?)

Decision-makers must deal with:

NORMATIVE JUDGEMENTS:
- **WHAT IS SAFE**
- **WHAT IS DANGEROUS**
- **WHAT IS FAIR**
- **WHO SHOULD PAY?**

The Policy Challenge
#1: To hedge or not to hedge?

Unlike science, within the policy arena, Type 2 errors are often less forgivable. In order to avoid being remembered in history as modern-day Neros, decision-makers typically prefer to hedge against uncertain but potentially damaging events rather than wait for them to possibly occur under their leadership. Unfortunately, this usual adversity to all levels of Type 2 errors that seems to be prevalent elsewhere in the policy world has not yet been seriously applied to the climate change problem.

Type 1 versus Type 2 errors and their consequences

Decision	Forecast proves false	Forecast proves true
Accept forecast—policy response follows	**Type I error**	Correct decision
Reject or ignore forecast—no policy response	Correct Decision	**Type 2 error**

Competing paradigms between science and policy communities.

It is common in policy analysis to refer to an incorrect forecast that was taken to be true as a "type 1 error" and a decision to ignore an uncertain forecast that turns out to be true as a "type 2 error". The prime paradigm within the scientific community is to view the type 1 error as the more egregious mistake, whereas within the policy arena, the type 2 error is often more concerning. Decision-makers often prefer to hedge against a potentially damaging event rather than wait for it to possibly happen.

The Bush Administration's attitude towards climate policy

Keystone policies

startribune.com

Steve Sack
Star

Published

The Policy Challenge
#2: Determining a course of action

- Hedging?

Or, as proposed by the U.S. Department of Energy (1977):

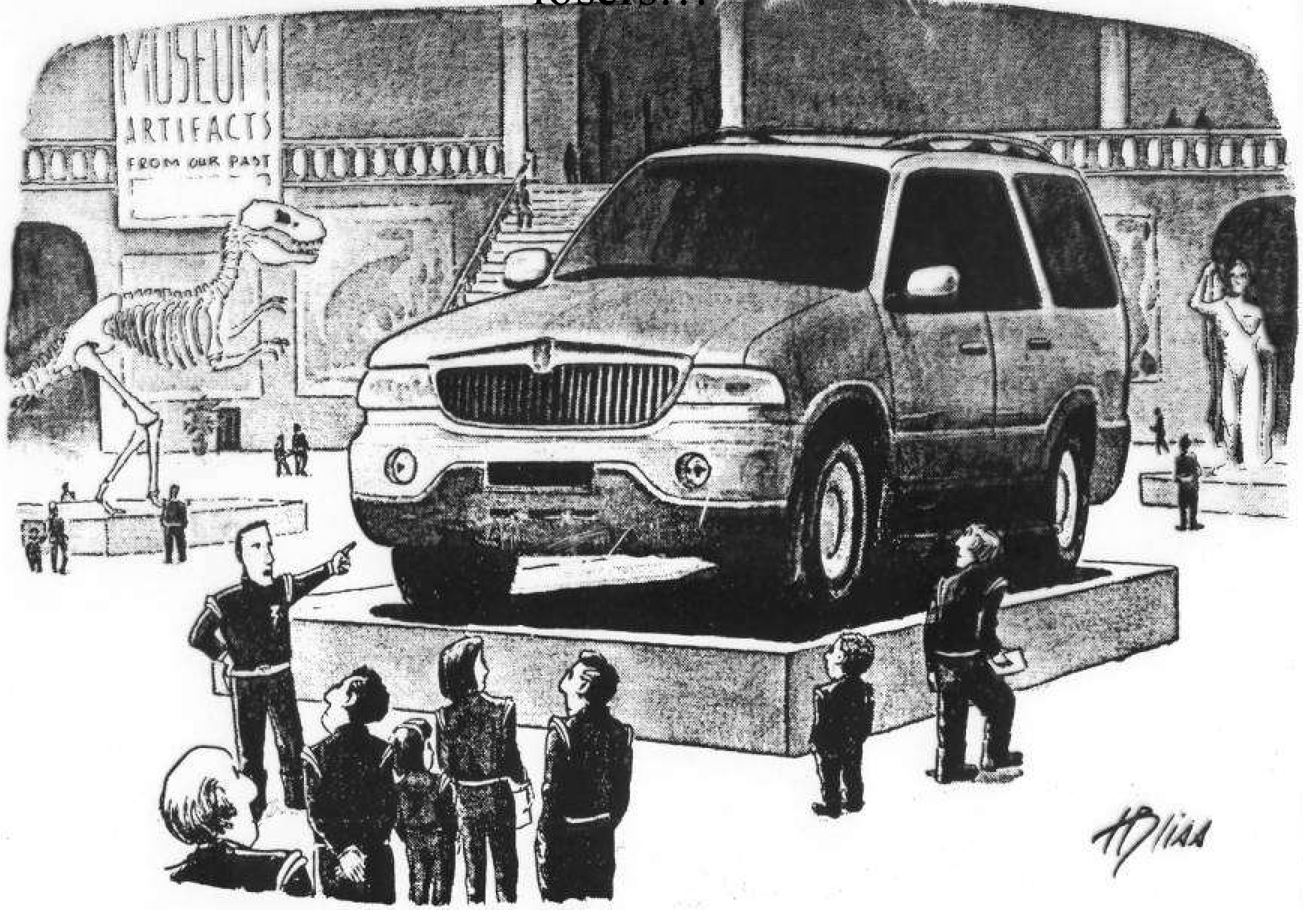
- Mitigation (abatement)
- Adaptation
- Prevention (geoengineering)

The Case for Abatement

All three IPCC Assessment Reports have noted the need for 50 percent or greater cuts below most business-as-usual scenarios (e.g., those of the A1 family) by the mid- to late- 21st century in order to stabilize atmospheric CO_2 concentrations below a doubling of pre-industrial levels, and the TAR has clearly noted that eventually *all net carbon emissions must go to near zero* to prevent continuous buildup of CO_2 concentrations in the 22nd century and beyond.

The losers (Part 1)

If the IPCC's advice on phasing out CO_2 emissions is heeded, these will be the losers…

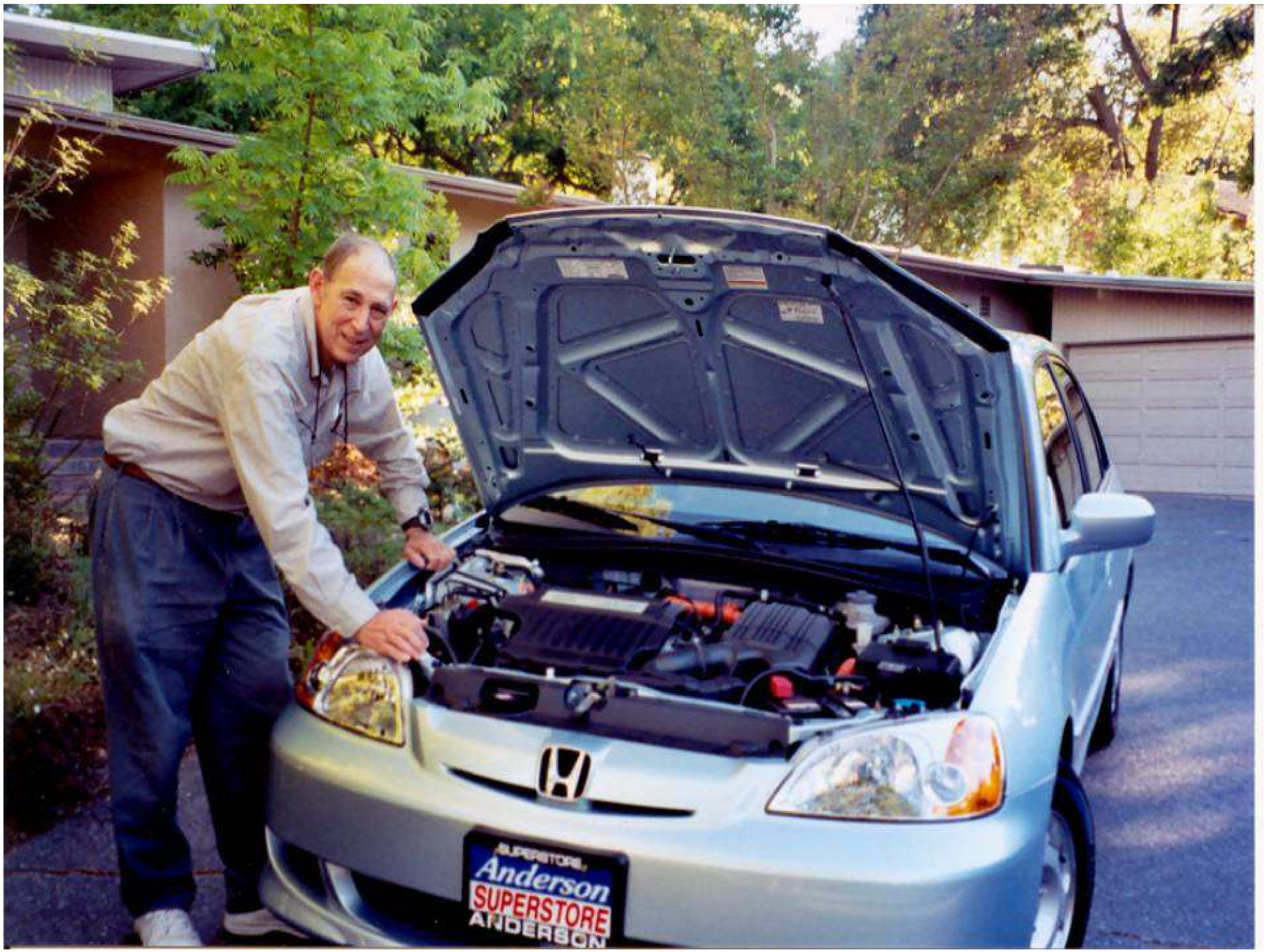


"We're not certain why they disappeared, but archeologists speculate that it may have had something to do with their size."

The losers (Part 2)

The winners (Part 1)

…and these will be the winners…



The winners (Part 2)

Setting abatement targets using Decision Analytic Frameworks

- **Cost-benefit analysis** - Aggregates all damages into a single dollar value so that policymakers can grasp the gravity of the situation, but such aggregation often conceals rather than highlights some of the critical issues and value-laden assumptions that are at stake (Bangladesh example).
- **Sustainability approach** - Does not rely on a one-dimensional measure (or numeraire) according to which all impacts are measured. Instead, proponents of the sustainability approach believe that there are five numeraires of concern that should be expressed in their appropriate physical or biological units (see following slide).

The Five Numeraires

The Five Numeraires*

{Vulnerabilities to Climate Changes}

• Market Impacts	{$ per ton C}
• Human Lives Lost	{persons per ton C}
• Biodiversity Loss	{species per ton C}
• Distributional Impacts	{Income redistribution per ton C}
• Quality of Life	{loss of heritage sites; forced migration; disturbed cultural amenities, etc. per ton C}

*Disaggregate by value differences—provide traceable account of re-aggregations to make value differences transparent

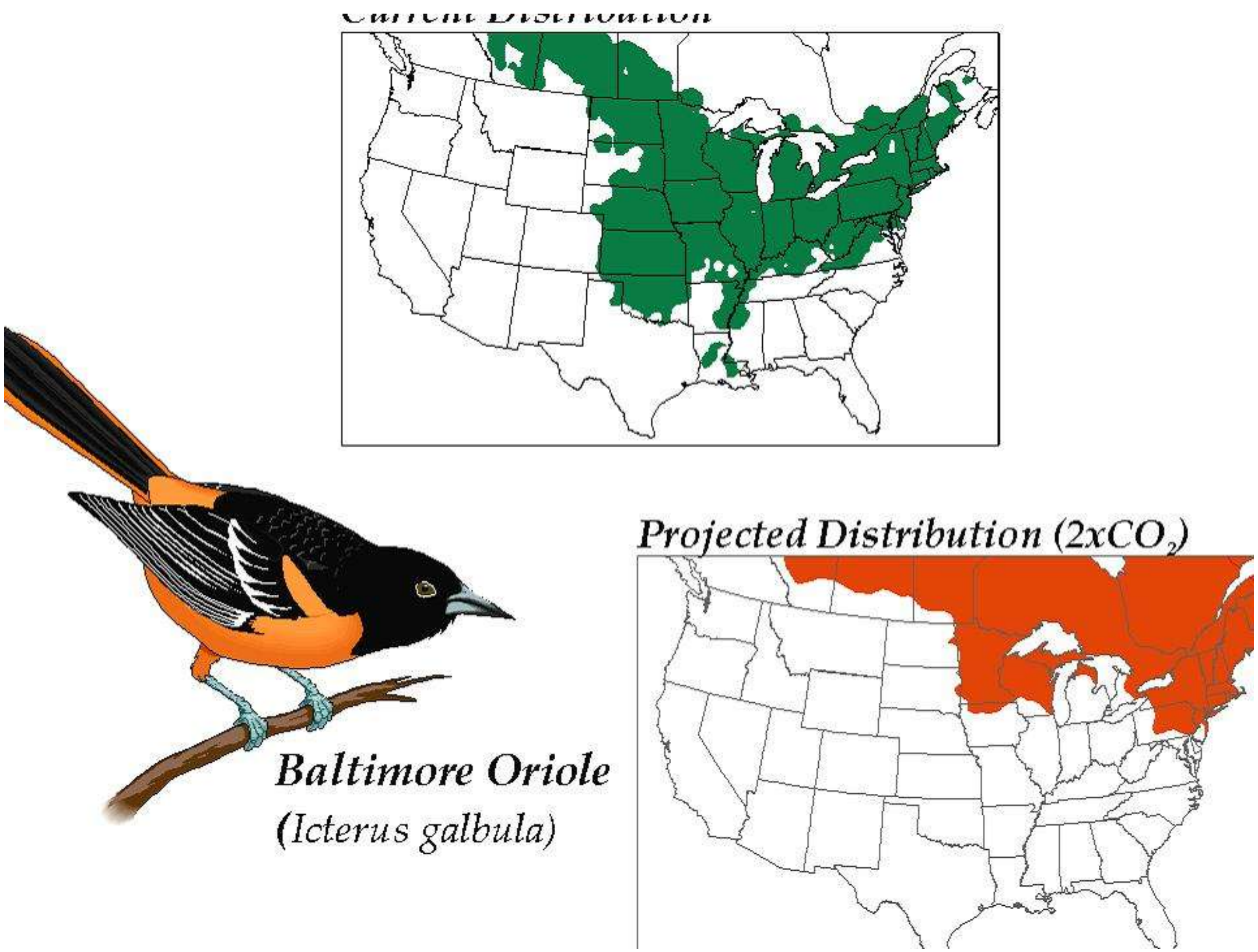
The sustainability approach allows for more equitable treatment of entities affected by climate change

- Ethical arguments for the sustainability approach include: How can we justify that the richest countries of the world emit greenhouse gases that are expected to cause the most severe damage in the poorest countries of the world?

- The sustainability approach is also more capable of valuing low-probability but catastrophic events, whereas these “surprises” are downplayed in cost-benefit analyses because of discounting.

- The creation of a sole numeraire dealing with biodiversity is a key innovation in the sustainability approach.

The vulnerability of natural systems will be given more weight in the sustainability approach



Abatement should not be rejected on cost grounds

If conventional economic models are remotely accurate in their 2% per year growth rate projection, then even if we were to spend those trillions of dollars on CO_2 stabilization, global income levels would be delayed less than a decade, and probably only a couple years, behind the no-abatement-spending scenario. The more complex question is not *whether* to spend but how to share the costs fairly among nations and groups within nations, not all of which contribute equally as groups, let alone per capita, to the dumping of gaseous wastes into the atmosphere or share equally in their adaptive capacities and vulnerabilities to climatic changes.

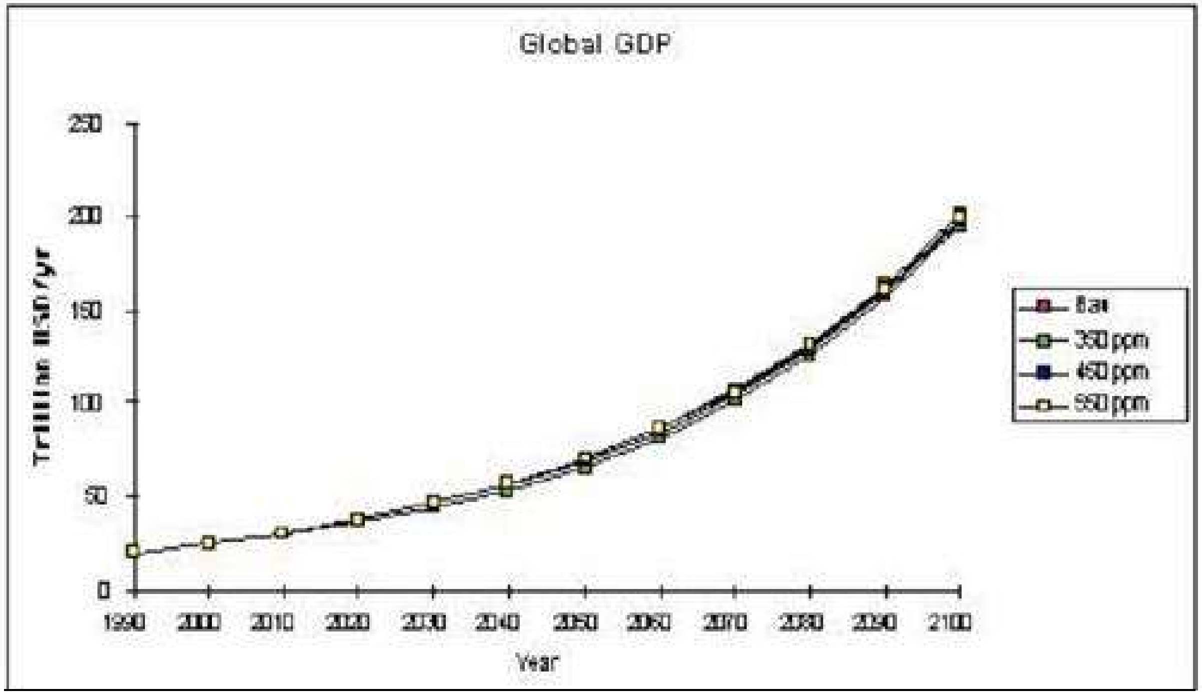
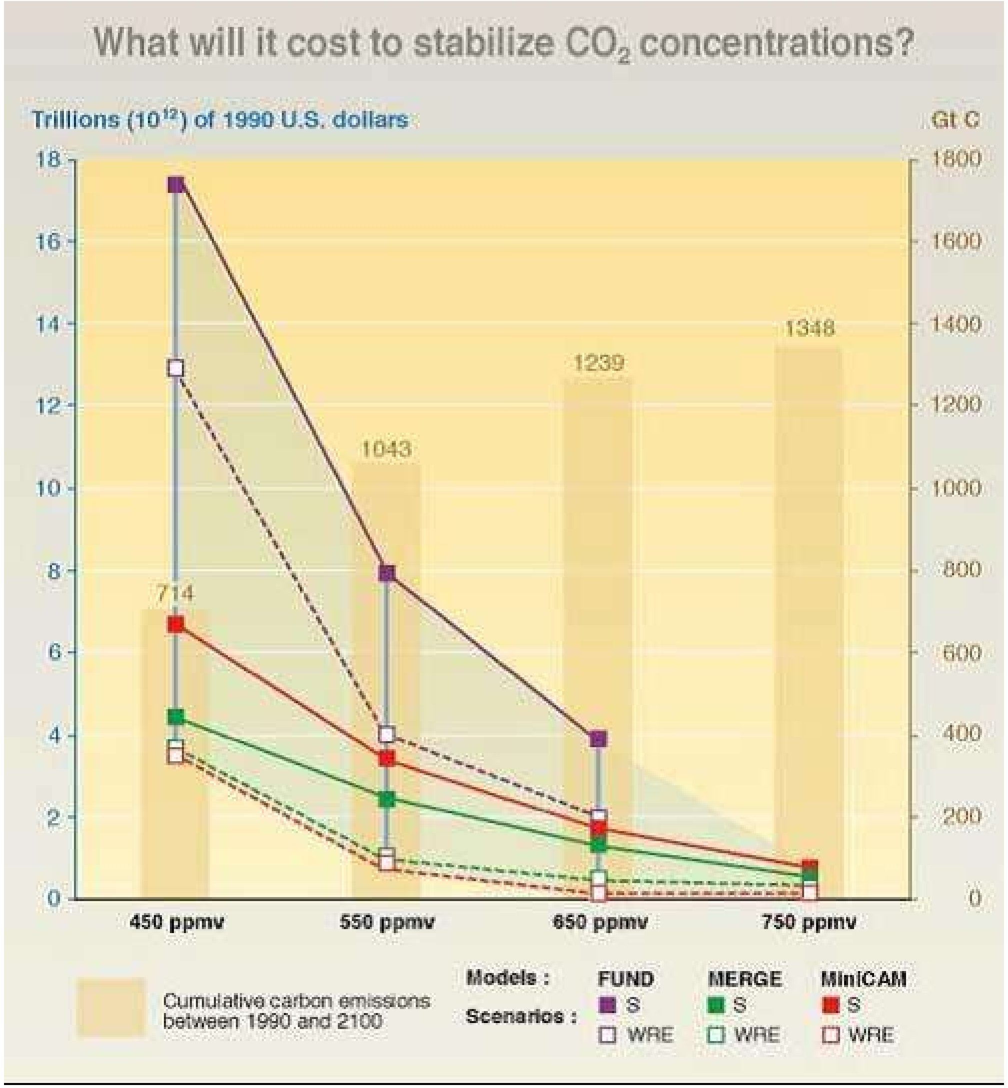


Figure – Global income trajectories under Business as Usual (BAU) and in the case of stabilizing the atmosphere at 350ppm, 450ppm, and 550ppm (source: Azar and Schneider, 2002

The IPCC supports this stance on cost



Can adaptation be traded off against abatement?

Global warming and its effects are already being observed, and there is a good chance that they will become more pronounced in the future, even if strict abatement laws are passed, which makes adaptation efforts prudent. There are two basic types of adaptation:

- **Autonomous adaptation** - Non-policy-driven reactive response to a climatic stimulus that occurs after the initial impacts of climate change are felt
- **Planned adaptation**
  - **Passive -** Essentially reactive in nature. Could involve an action like buying additional water rights to offset impacts of a drying climate.
  - **Anticipatory -** Proactive adaptation. Could include such actions as the purchasing of more efficient irrigation equipment, the building of higher bridges and dams, the engineering of seeds to make them cope better with altered climates.

(In)Equity issues in the adaptation versus abatement debate

Suppose it were cheaper for a rich, high-emitting nation in the North to adapt than to mitigate. If the rich nation chose only to adapt and therefore continued to emit, it would be detrimental to a poorer, less adaptible country in the South because the poorer country would have greater loss potential from the North’s continued emissions, a problem it had little to do with creating. Simply comparing mitigation and adaptation costs and aggregating the values across all nations is a “one dollar, one vote” prescription, and it clearly has serious (in)equity implications.

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Solution = Abatement + anticipatory adaptation (?)

The adaptation debate is also difficult to frame without having probabilities attached to climate change consequences

Decision-makers need expert scientific assessment of the probabilities and consequences of global warming, as these are the two determinants of risk. As previously mentioned, in order for decision-makers to enact cogent climate change policy and avoid disaster, it is imperative that they are well-informed of the likelihoods of various outcomes. Lacking probabilistic advice on climate change risks, how can policymakers judge what is "dangerous" and how important action on climate change is compared to a host of other important problems from clean water to health policy to security investments to education, all of which must be tackled with a limited pool of resources? Indisputably, this issue warrants additional scientific attention.

Our actions today will have long-term effects

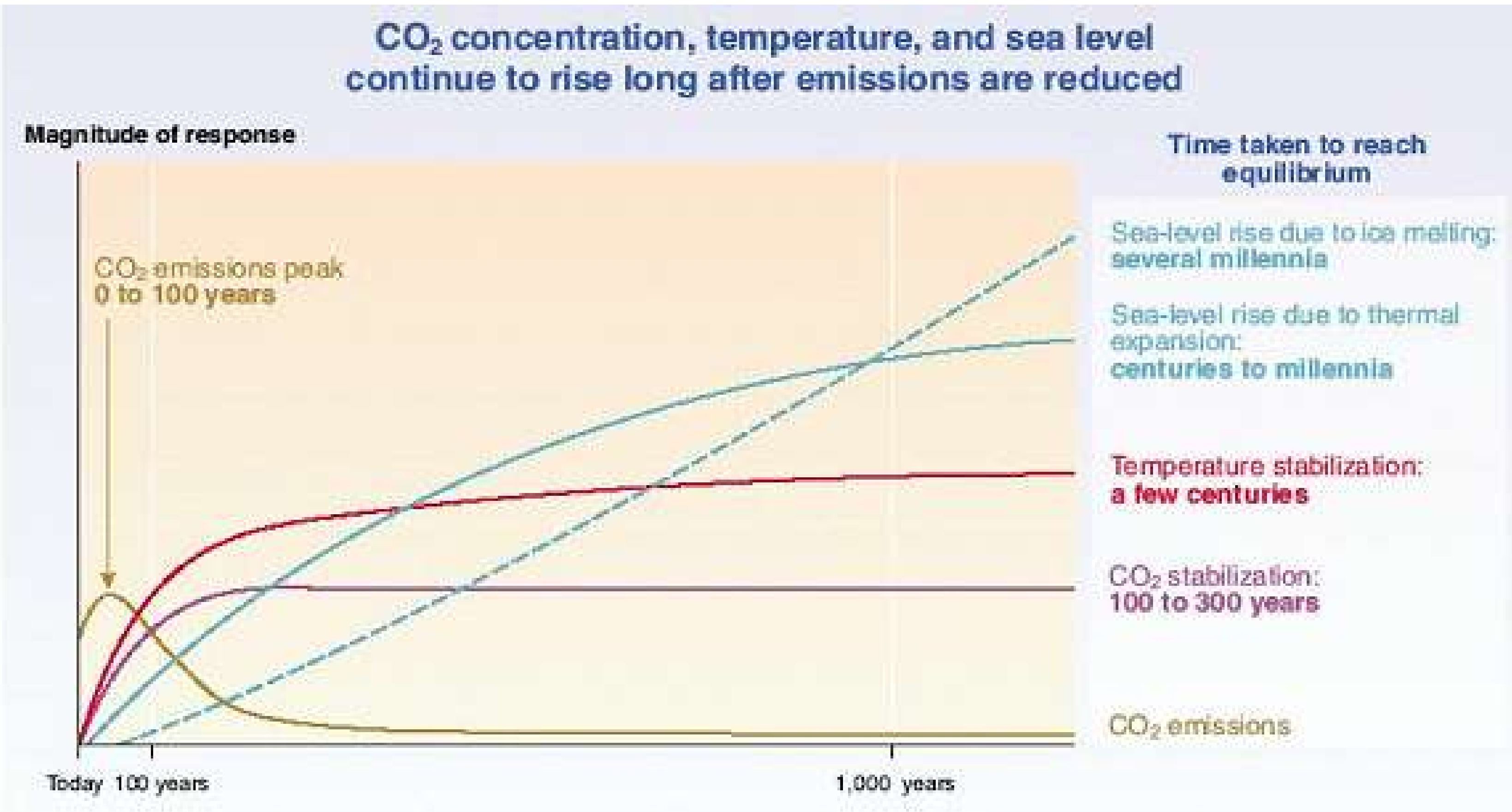

Figure – CO_2 concentration, temperature, and sea level continue to rise long after emissions are reduced (Source: Climate Change 2001d). After CO_2 emissions are reduced and atmospheric concentrations stabilize, surface air temperature continues to rise slowly for a century or more. Thermal expansion of the ocean continues long after CO_2 emissions have been reduced, and melting of ice sheets continues to contribute to sea-level rise for many centuries. This figure is a generic illustration for stabilization at any level between 450 and 1,000 ppm and therefore has no units on the response axis. Responses to stabilization trajectories in this range show broadly similar time courses, but the impacts become progressively larger at higher concentrations of CO_2.