

Stephen H. Schneider Lecture, Gallagher Auditorium, University of Arizona, March 27, 2008. Global Warming: Is the Science Settled Enough for Policy?

Introduction: Huge number of sponsors who donated money. The Dept of geosciences; ecology and evolutionary biology; atmospheric sciences; soil, water, and environmental science.... Without their financial support, this event would not be possible. Southern Arizona Geographers Association. Bridges gaps between and within disciplines, especially between the physical and the social sciences.

Schneider:

Thank you very much for that invitation I have to confess that when the students invited me, I negotiated a date; if the faculty had invited me I might have negotiated a year, but it is always fun to meet with students, and we had a very productive, I might say epistemological argument. What is sustainability, good stuff like that.

So these issues are all...very, very interdisciplinary. But before one can be interdisciplinary, one has to be multidisciplinary. You can't just bring the technology and economics, which drives the social structure, which produces the emission, by itself because then you have to feed that information into a carbon-cycle model which is ecology, ocean chemistry, then you feed that concentration into a climate model, which is mostly physics and oceanography and some chemistry, and then you feed that into agronomic, hydrologic, ecological, and so forth. Sea-level rise,.... Then you feed that into the governance models, and by the time you finally get down to the bottom of the food chain where it is really important what you do about it, the guys upstream have changed the scenario. You have to get a lot of guys in the room who know a lot about various topics.... That's not a trivial thing. Nobody is born interdisciplinary....

So in order to answer the question that is up there, it involves science, it involves policy and other things. You have to have some background. So I apologize if late in the afternoon there are a few scientific slides and physical and biological social sciences. Let's get right onto it so we can get onto the good stuff. The first one [chuckles]. [The slide shows Santa Claus and a kid on an ice floe, reindeer in the water. Conveys uncertainty and urgency. Caption: "The jury's still out on climate change."]

When you're communicating complexity, you automatically know that you've gotta use metaphor. If you're very lucky and get on the evening news, you get two five-second soundbites in between somebody else who has got five-second soundbites saying you were all wrong. You gotta be the one [getting the last word] and hey don't get a rebuttal. Sometimes you end up the other way and that is all up to the journalist. But in any case, you gotta use metaphor because there's no other way you can convey both the urgency and the uncertainty of the problem.

So I am not showing this for the reason you think I am, yeah, well this is laughable. What's the metaphor up there? A jury. If it's a jury, it implies a trial. So if you're on a jury, for those of you who have been on a jury at some stage or if not you watch TV programs, and if there's a jury the

judge gives an instruction. If it's a criminal trial, the standard of evidence is beyond a reasonable doubt. And we're scientists, we're aware that people have to make judgments, but what's the probability of a reasonable doubt? Hmm... Not defined. This makes scientists very uncomfortable because we tend to be, even when we're being subjective, we like to be explicit about what we mean by words. The Intergovernmental Panel on Climate Change, which was mentioned in the introduction, had a guidance on uncertainty. I coauthored it with Richard Moss, and we were very, very anal about it. You can't use words like "likely" or "highly confident" in a vacuum. Because many social science studies have shown that people have a factor in their minds of what the probability is of a "likely." So we define this as two-thirds to nine out of ten and "very likely" is above nine out of ten. So anyhow, many are uncomfortable with the notion that the jury is out. So what is the probability that the jury is out? How do you know. So I asked my lawyer friends about the probability that a court made a mistake.... Well they didn't like that framing, but in fact that is exactly the question, what is the probability of a reasonable doubt, and they said, well, say something like one in ten if we're very lucky, one in a thousand. So basically the guilt beyond a reasonable doubt is somewhere between 90% and 99.9%, their subjective reading of their own profession. So all right, just to be clear. Now we know who we are. I wouldn't want it to be a capital offense if we are going to make that many errors, but the point is that that is the definition.

When we're talking about climate we're talking about a very complex system. And that complex system is going to have elements that are well-established. It's going to have elements where there are arguments, areas where there are competing explanations, and it's going to have aspects of the speculative.

So let's keep the metaphor going about the jury.... Keep the jury and go to the other kind of trial, a civil trial, when the standard of proof is preponderance of the evidence: more than half. In some courts, that's a lot. Other courts, not. If we're talking about climate science, when we have a preponderance of evidence that the earth is warming at a rate which is statistically significant, in my view that was 20 years ago. If it's 50%, why do they say, hey now, it's unequivocal? I don't actually like that word because I don't know how to attach a probability other than no probability that it's wrong, and there's nothing that has no probability that it's wrong. But in any case we already crossed that threshold. But if we had asked 20 years ago, what's the likelihood that we are going to get to deglaciation of Greenland and western Antarctica, I think we would have said it was speculative. Now we've moved it into competing explanations. Because you do learn over time. So in essence, you have to watch out. Because out there is a very nasty, ugly debate. Those of us who live in it can attest to it.

People come along and they live in the ghost of Karl Popper. Anyone remember Karl Popper? Falsification. Right. Falsification. And therefore the way scientists work is they do a contrary experiment and if the experiment does not support the hypothesis, throw out the hypothesis. False. That works, say if here I have my tea. And if I make a hypothesis that tea is acidic, I can, mmmm... No, my taste isn't good enough. No. I can get a piece of litmus paper and I can stick it in there and I can falsify my hypothesis. So it does work.

But in systems analysis, how do you falsify the hypothesis which for 20 years was that the reconstruction of the emissions of microwaves from oxygen atoms measured by satellites was

overpowering the 40 years of surface thermometers, rising oceans and melting glaciers, but which people claimed the satellite showed no warming, therefore they falsified the other. Nonsense! Because data is not information. Right away. It takes a long time for a community to analyze data and make sure it was collected right, analyzed right, and this is not a simple process. It is not amenable like the litmus paper.

So what we do in systems science is we look for preponderance of evidence. And it's a community judgment made over time by study after study, and any individual study that comes along neither proves it or disproves it. It just moves your confidence up a little or down a little, and then you study like mad to try to figure out what was going on. In the case of the satellite, the reason [it seemed to show a mild cooling trend] was that they neglected the fact that they fly in a soup of protons, it bangs into the satellite and it slows down a little bit just enough over time and the orbit drops and it changes the angle of the sensor that which gave a false cooling trend, and it was corrected by three groups. And now we actually find out that they agree. So it is supported but for a while it wasn't. A few people ran off and said, aha, they falsified it. Don't believe it. Not true. Because in systems plan, it's preponderance.

Remember James Carville and his famous advice to Clinton in the presidential campaign? ... "Well, it's the preponderance."

I had to go on a ... program and talk about west Antarctica. I said, "Come on guys, it's one event. One event doesn't prove this. On the other hand, there's a systematic pattern in both hemispheres of deglaciation. That gets us to significant reasons for concern. So what you have to do is remember that global climate is never about short-term trends in one place. It's about accumulated evidence over time, which is about as opposite to media attention as any problem you could name.

So therefore, they are searching for some new incremental result that goes in one direction to validate, or in the other direction to invalidate it, whereas it hardly pushes the opinion of the knowledge community around very much at all. Because you don't have any idea whether it's any good. It takes a while. So what I like to tell people is, don't listen to the National Geographic Society, wonderful video on Nova, I really love these documentaries, but they really give you a little bit of a false impression about how these things work.

There's this winsome young graduate student out in the [volcano?] ... with these special boots not to burn up her feet. Scoops something out of the lava, takes it back into the lab, has a eureka moment ... and that's not how it works. The way it works is the first twelve times the boots don't work, it's a near catastrophe, you bring it back, don't analyze it right, and when you do, don't know what it means. Then you go to the second-rate hotels where we meet, and we get together in the bar, and a bunch of people actually work it out. So we're in essence a community effort. So we should celebrate individuals who go out and get this data, but very rarely would any of us claim that in the context of a complex system that we're in a position to interpret it all by ourselves. That's why we have IPCCs and National Research Councils, and the Brits have the Hadley Center, and the Australians the CIRES [?] It's because it's a community enterprise in which no one of us should be trusted. And that doesn't map very well into the political advocacy

world, from which positions and policy come. So when you start asking the questions of whether the science is settled enough for policy, we're getting into a whole different set of questions than what scientists tend to do, where we have the patience to argue this stuff out, and it's not only the patience, but it's required by our professional standards.

So just a few more cartoons.... The question is, is the polar bear truly endangered? How many think the polar bear is endangered? [few hands] How many think not endangered? [possibly a few more hands] And you're not sure, right? I'll give you my frank opinion. I do not believe the polar bear itself is in danger of extinction. First of all, they're really smart. And they can live in the garbage dumps in Churchill? Second of all, you know that there is going to be a bunch of rich people and guilty countries that are going to set up boutique preserves... So I don't see the polar bears going extinct. However, what does the polar bear do for a living? It lives on a block of ice. It's very sloppy. It's not a nice guy. Anybody ever see a polar bear upfront? Close? Yeah. You already know that your best friend at that moment is a well-sealed vehicle or a high-powered rifle. Because if you go over to say, "Hi, nice bear," you're going to be in the Darwin category. You know what I mean?

We care about them because they belong there. They are the product of millions of years of coevolution of climate and life. The polar bear gets on the ice, grabs a ... seal, But there's a whole ecosystem. Arctic fox, ross gull, ivory gull ? That's the key. As the sea ice is going out, I think the polar bear ecosystem ... is functionally extinct already. It's not the bear itself. I'm more worried about the ross (russ?) gull than about the bear. The other thing is the knowledge in the head of the bear about [how to get along]. Is it innate, or learned? So supposing 200 yrs from now we restore the system, and the ice comes back, could we put the bear back out there, will it know how to do it? We don't know how to answer that question.

So I think when we get into these very easy media soundbites, it's very easy to say polar bears are going extinct, but I don't believe that. I think it's very easy to say that polar bear ecosystems are functionally extinct, and whether that is irreversible, stay tuned. I don't know. This kind of complexity brings us back to the issue about preponderance, and why I'm spending so much time on it, is this really a fundamental question that under undergirds all this, and the real question to me is can democracy survive complexity, because if you tell the truth, you can't leave out these complexities, but you can't put them in the evening news broadcast. So you have to have your hierarchy. You have to have your soundbites; otherwise you don't get on the air. You could write an oped piece, or soundbites. You can do a *Scientific American* article, okay that's getting a little bit of depth. You can write full-length books and websites, where you can tell the factor of 10,000 or smaller fraction of population that wants to know what you really believe. But it's a real challenge. Because in a democracy, you want people to send value-judgment signals to their leaders so that they can make decisions about how to take risks.

Do we fear more investing present resources that we would like to use for other social goods on a problem that may not be as bad as some people think? Or do we fear more not investing it and risking really serious outcomes without having slowed it down? Those are not scientific judgments. That becomes... type I, type II error, false positive vs. false negative. Those are value judgments about how you want to take risks. So you need to send those value signals to your

representatives, but if we are so disconnected from the reality of problems, then what happens is special interests send value signals off in campaign contribution checks, and then we end up disconnecting the democracy of its original purpose, which was to get values adjudicated through elections. So climate change is a fundamental challenge when you look at it in its entirety to the functioning of the society when you have to deal with the preponderance and complexity.

All right, let's go back to the polar bears for a second. So here's the seasonal cycle of sea ice. This has nothing to do with global warming. In the middle and late in the summer there is less of it than there is in the early spring because it gets warmer due to the solar energy, but this probably does have something to do with global warming. I don't remember exactly what you guys said, whether it was likely, or very likely, that the decrease in sea ice in 2005—here's the 20 years before that and that is the 2007 numbers when this graph was plotted. So this trend is what has people concerned, and this trend is very rapid relative to the extent that we can tell with respect to previous events. It is definitely difficult to reconstruct it, however we were measuring it. So there are always going to be elements of uncertainty in there.

So let's get to more sophisticated here. It's the kind of graph I promised you we'd have some; I didn't lie. So here's less than one-year-old ice, the new stuff. Here's middle ice, two to five years, that's this color, and here's old ice. This is a much more sophisticated question; this is more important in my opinion than asking just how much. Because when we start shifting from having a much larger amount of young ice relative to the past and much less old ice, that not only affects the polar bear ecosystem but this very young ice is very hard for the Inuits and the bears. You start to see a real structural change related to the climate and that, averaged everywhere.

And what I'm doing is giving you a hierarchy of information through data, and so here's the average from February 2000; here's February 2008. Remember one year doesn't prove anything, as I said. But it's still pretty interesting to look at where the heavy thick ice was. Not only is it not enough to look at the average thickness or even the average age of the ice, you sometimes also have to look at the location. And as a result of that, like everything else in systems science, there is a hierarchy from global averages to very sophisticated questions.

What makes this debate so unpleasant in the public arena is that somebody will come along, and I could name names but I won't, and say, "Hey, look. It's really thick over here. What are you talking about?" and then not mention, but look it decreases substantially. So you gotta watch out for this plucking out of the bell curve of information the end-of-the-world outcomes that the deep environmentalists want, plus the good-feel outcomes that the fossil-fuel industry opponents of collective action always point to. Therefore, this issue of policy getting stuck on how people can interpret the relative merits of these arguments. This is why we need an IPCC that helps sort out the, shall we say, the north end of the southbound horse from legitimate science.

Well, the polar bear has been iconic, so they're going to get lots of cartoons, this was one of my favorites because I like the symbol of the polar bear being a book. The reason is not because he's a nice guy, but it's like being a volume in Nature's Library at Alexandria. It is there. It belongs there. And the barbarians in this case happen to be you-know-who, emitting our tailpipe and smokestack emissions into the system. It's amazing that these creatures are so symbolic. If you

show this in Chile or in Australia or in South Africa where they don't have too many of them, they are really very sympathetic. But if you're an icon you've gotta take a few hits. [laughter]

If you find this on the web these guys are bouncing to the music, but I'm really lousy at getting this done. I want to know how this guy from the Southern Hemisphere gets into the ...ocean to make it... This is what I call the victims as villains. This is my favorite. This is the retribution slide. The bad news is the ice cap is melting and it is going to be almost impossible to catch seals, and the good news is we keep moving south and there's tons of fat animals called humans ... [laughter] You'll also notice that this is both racially and gender appropriate. Okay. So. Enough with this serious stuff.

Okay. Anybody know what I'm on here other than the fact that this person over there was very young, very thin, and had hair. This was a long, long, long time ago. This was right before my Ph.D. defense in 1971, and my guide, and yeah that's a termite mound, and that's Kilamajaro, another iconic symbol of global warming which we're going to deconstruct. So why a termite mound, aside from the fact that it is whopping interesting-looking thing, because in the guts of termites cellulose is converted by microbiota into the energy the bug needs, and the byproduct is methane, which is a very potent greenhouse gas. So nature is in the greenhouse business. In CO₂, methane, in nitrous oxide, and water vapor. Not in chlorofluorocarbons, sodium sulfur hexafluoride. We manufacture some real goodies, but most of it is due to gases that already are there. So we're not in the issue of "Oh, humans have come along and now invented this new stuff." We've got to be quantitative. How much is due to Mother Nature, how much is due to us, which is another reason where the complexity comes along and why you have to have a mixture of observations and theories. You can pluck out a trend by just observing what's out there. But you can't attribute a trend to cause without having a theory and then having alternatives in that theory. Now you falsify in a system sense, then you go test alternative projections, retrodictions actually, and then you test it on the data and you see which goes along better and then you start to decide if you believe one more than the other. That's how the community works.

So let's go back to Thompson's picture of the decreasing ice in Kilamajaro, that's the iconic thing. I think it would even begin to be a tree. So I put me on it to where I was then, just to remind you that I tend to think of myself when I first got in and thought climate was something that happened in centuries to millennia, and, my god, 35% of this has disappeared in my professional lifetime. So that is really in a way kind of emotionally sobering but then that red line...also happens to correspond roughly to where the freeze line is. Above that it is still below freezing, below that it's above. So a number of climate scientists said, wait a minute, if it's below freezing, then it's melting for some reason other than global warming. Is that true? How many think that falsifies the hypothesis? That's true—that it is below freezing. Well, I would argue it doesn't. Because what happens to melt is back to complexity, sorry about this. Suppose you take your ice cube tray with just liquid water in it, and it's a cold day and you live in a climate where it's below freezing, in say 26°F, you put it outside and it is going to freeze if it stays out overnight. Supposing the temperature is now 30°F, and you and put it out overnight, it is still going to freeze. It's going to take a little longer to get there. Supposing now the sun comes up, what's going to happen? Even though it's still below freezing and it never gets over 30, it will melt! Because what happens with melting is not the temperature. That's one component of the

energy balance. There's the Q , the energy from the sun, times $1 -$ the reflectivity of ice, the amount that's absorbed in there, and that gives you a positive term in the heating equation. And then there's a term that's the temperature difference between the ice and the air, and some coefficient of turbulence, and we don't need to go through details, that's a negative term. But it depends on the balance of the two. So you can't automatically argue that because it's below freezing above that red line, therefore global warming didn't cause of the reduction. It could be. Because if you warmed up from 4 degrees below to 2° below, it means that you have now got a net positive in the energy balance.

So I give you that just to remind you that even though the iconic image is not yet in the solved category, it's certainly in the competing explanations. It's not speculative. That's why you have to think of preponderance.

Now you don't use glaciers to make this conclusion by looking at one or two glaciers, you go globally. And I forgot the number, 95%? roughly of glaciers are shrinking in the last 50 years. The probability of that being a random event and not connected to global warming trends is pretty darn low. So there's a Patagonian ice sheet in '28. That of course is the 2004, and that's pretty dramatic. And you do it because you never trust one. You have to look at the preponderance. Some of you know where that is. That's flying over the eastern shore of Greenland and there's one of those breaking-up ice shelves. The shelf is what flows out, and it's land ice, when it breaks up it doesn't constrain the flow so the sea-level rise doesn't come from this, because that has already displaced its weight in water, it comes from that back there and if that gets out quicker then you start influencing sea level by melting at the margins. The other thing that's in the forecast is that the center of Greenland is way below freezing. So in warming it up just a few degrees, you're actually going to increase the snowfall, and that's the prediction because you're going to be holding more moisture in the atmosphere when it is warmer, that's thermodynamics, and therefore you'd expect more snow on the top. So who wins? The melting on the sides or increasing on the top? We'll talk about that in a minute, but the satellites can help you answer the question.

And you can probably guess the answer. But if I got by and run something from September last year, you don't learn anything from the snapshot because you have no baseline to judge something against. It's a guess. Remember just like showing you the sea ice. You have to have a lot of it. So here's the United [Airlines] video screen. That's where it was. Then we fly over the center here, not really the center, but it's enough above the freeze line and...that's what it looks like. It doesn't look like anything. You know what that is? That's the contrail of the airplane. I wasn't even sure the camera was in focus until I could get the contrail on it here. So again. Who's winning? So when you sit there and you listen to those famous climate professors, the scientists, the ones that have published so many papers in the refereed journals telling you that this is a fraud because the ice sheets are building up, by talking about the top while neglecting the sides. You know the two, Professors Crichton and Limbaugh. [laughter] And then we go to the other side and there it is breaking up front again. You don't learn anything from this, you've got to have long-term trends, and that's exactly what this is and I think this is from the IPCC, so there's '92 and the melt is not new, it happens every year and then re-freezes. Here's a very large increase in melt. Is this just the natural fluctuation? It's very hard to know the answer to this question

because ice sheets change on century timescales. There are these moulons, these rivers, they flow down in the bottom. They lubricate the ice sheet, big debate. Does lubricating the ice sheet cause it to slip? If it starts to slip, that's going to generate amazing friction. Take your hands and rub them fast like that, you feel the heat. If that causes further melting it accelerates the deglaciation. Or is it not going to do that?

This is another one of those competing-explanations fights where we don't have enough information to really pin it down. Working group 1 says we don't have enough understanding. Working group 2 says the government has told us to do risk management. We can't leave out meters of sea-level rise and centuries because that is relevant to risk management and that would be the consequence if the outcome of this debate is that it causes a positive, that is an amplifying feedback. Well, we don't know, but you certainly can't rule it out with a coin flip. So you get into what is really paradigmatic fights over whether you're a believer in type I or type II error aversions. That is, do you believe that scientists should be so circumspect that if we don't have really highly confident outcomes we don't say anything? Or do you believe that if there is a really high consequence that we just pointed out that we can honestly say that we don't have high confidence in it but we are not ruling it out, so Working Group 2 said there's a one-third to two-thirds chance that four to six meters of sea-level rise in centuries or millennium. Work group I said for warming of one to four to five degrees warming there is 10 meters of sea-level rise in thousands of years. And I kept saying, nobody cares about thousands of years. What can we say about two centuries? That's still in the timeframe of human imagination [?].

Well, we don't have enough information. That was not scientific debate. That was a value judgment debate about whether you feared more making a type I error, that is a false positive, or a type II false negative; let's wait until we're sure and by that time, if it turns out on the bad side, you are going to have to live with the consequences.

So we talk later on about how much science does it take to have policy. It's not a scientific question. It's a value judgment about risk-taking. And that's the difference between what we do as scientists, and decision making [?].... Risk is, what could happen, what are the odds, probability times consequences. Decision-making is risk management. Therefore what do you do, which is how you want to deploy resources... Do you want to wait? And remember, there are other good reasons to use resources. Housing, health, security, there are a lot of good things, infrastructure, even National Parks or reserves as an adaptation to climate change to protect species? You can pick environmental goals [?].

Therefore climate has to take its place with all the other calls on the treasury for our limited resources. So we can't duck that question of trade-offs. But at the same time, they're not in commensurate units. How do you trade off the gains of the shipping industry in melting the Arctic sea ice versus the destruction of an ecosystem? They're not monetizable. Well, some people do it but by methods that, pardon me, are the south end of a northbound horse. But in any case the debate is over whether this is going to cause a cancer—got an answer? I don't have an answer. Not going to take the bait.

So Konrad Steffen showed this just recently in a conference that I was at in Australia and the

word he used was “spooky.” This was the 2005 result in Greenland; notice it’s even more melting than the previous ones. The spooky part was the red dots. First recorded melt. In other words, they sank cores in there, and you can go down through the record and look at the annual layers and what he said was they couldn’t find any evidence of melt before that year. That starts to tip me over toward preponderance that this is not just a random fluctuation. Now I’m not tipped over into 99%, I’m not at the beyond-any-doubt level, but I’m sure moving toward preponderance in my own head, more than I was five years ago. We lowered the threshold of “potentially dangerous” climate change because of information like that.

What other kinds or lines of evidence? Well, this is a map, or graph, rather, of the annual sea surface temperature in the North Atlantic and the power dissipation index (PDI). Basically, it’s how big the storm and what’s the maximal wind speed; it’s the cube of the wind speed. And he picked that because that’s the proportional to the damage. ... And it’s highly correlated, there’s no doubt about it. The question is, is this a natural internal dynamic of the system or are we in the game? There’s also no doubt the ocean temperatures are up something like half a degree and there is very little doubt according to the IPCC that we are responsible for a good part of that in the last 30 years. The other thing is that Kerry [?] [Emanuel?] also found a similar relationship not as good put in the Pacific. Well, does that prove anything? No, because there are multiple explanations. This is another competing explanation. So what did IPCC say? I thought it was rather conservative, the assessment is that it is more likely than not that recently observed increases in intensity are connected to warming and they went beyond that and that future intensities are likely to increase more with further warming. So it’s again, looking at preponderance and framing it in terms of probability.

So now I ask a question after all this. Is the science of global warming settled? How may say yes? How many say no? How many say, don’t ask us stupid questions? Right? [laughter] Remember what we said: well-established, competing explanations, speculative. And the speculative does not overthrow or falsify the well-established. Not for a long, long time. And right now the preponderance is on the well-established and competing explanation being the conventional argument. [?] But there’s still plenty we gotta learn. Especially about how to adapt and how to mitigate that cost.

So what is in the well-established? I’m not going to go over that in detail because you already know these hockey sticks. This is not *your* hockey stick, Malcolm. No this is not temperature. This is 10,000 yrs and these are the three principal greenhouse gases that humans affect [CO₂, methane, nitrous oxide from slide], and every one of them has the Industrial Revolution. We know, established beyond a doubt, this is unequivocal, and we did it, no doubt, you can tell that from isotopic composition and other things.

However, how much of that was responsible for the warming? That’s another question. So IPCC said warming was unequivocal from evidence and observations and so forth, but IPCC got a Nobel Peace Prize so it must be true, right? After all, even a few lead authors from Stanford happened to be in town when he gave a press conference [showed photo of Al Gore with Schneider and others apparently in Stockholm], but that doesn’t do it, one of these things about this picture that I really like,... one of the reasons why we crashed the party, although they invited

us right before we got there, I got a call from somebody saying, “Oh, would you come down to the press conference?” We already knew because several reporters had called us at home and said “Hey, are you going to the press conference?” and we said, “What press conference?” And they said, “Well, there’s a press conference.” “I don’t know what you’re talking about.” “And congratulations, didn’t they call you? And I said, “For what?” “You guys are in the IPCC, and they won the Nobel Peace Prize.” There are 4,000 at IPCC, how can they call us! In any case, we crashed, and what I like about it and one of the main reasons I am really proud of it is that prizes and glamour are so linked to the cult of personality. It’s such a disease in this country. And finally, by awarding 4,000 people, including many in this room, this prize, even though we all are two-tenths of one percent of it, what it says is the culture of community is what really matters. And the reason that is so important is how are we going to solve this problem? Individual actions are necessary, moral, and helpful. But if everybody doesn’t do it or at least a large number do their share, we don’t get there. Therefore, it’s critical that that community be part of it.

What are you going to do when countries like China and India, which tell you rightly that they have one-tenth per capita the emissions that we do, now you tell them that they’ve gotta take targets like the U.S. Senate said in 1997, in the Byrd-Hagel Amendment, it’s not fair to American industry and workers. Well, maybe, but the level playing field that they want hasn’t been level for a hundred years. So you’re going to play a little catch up before you can do that. So you go to an international meeting and you hear someone from China or India tell you that we’ll take a target when we catch up with you, and then we say, yeah, but you’ve got four times the population of us and you’re not entitled to that much emissions, you end up with all kinds of fingers pointing at each other and I gotta tell you that is not always a happy finger. It’s really pretty nasty. And what one side says is, well we’re going to hold the sustainability of this planet to our notion of equity. And other side says, we’re going to hold the sustainability of this planet hostage to our notion of consumption. And that is a planet sustainability train wreck. And that’s the track we’re on. And we’re not going to solve this without community.. So that’s why I like this symbol.

Anyhow, this is the unequivocal thing. There is the seven and a half tenths [0.75 °C?], 1.4 Fahrenheit of warming and ... This is a very important graph because what was unequivocal is how much is warming, not how much is Mother Nature and how much of it is us. So I apologize for the complexity of this. What it is, is the six continents and total global land and global ocean. The black line is where the yellow line was before. So that’s the warming of the last hundred years. The blue, that’s this, is the [...] of computer climate modeling. Remember I said you can’t determine attribution by data alone, that you have to have a theory. The theory in this case is that the warming of the last hundred years was caused by natural causes. So they put in volcanic eruptions, which throw dust in the stratosphere, they put in sun spots and connect that to energy changes, and when you do that you get the blue. It’s not bad up to the middle of the century and then the whole thing on all continents does not work after that. What’s the pink? The pink is driving the computer model with the sum of natural and anthropogenic, which is dust that cools, mostly cools, not all of it, and greenhouse gases that warm. However, when you do that, this is still circumstantial evidence which leads to a preponderance, but it leads to a much better fit. What’s the probability all independent continents will do that? Not very high that it’s by accident. So therefore IPCC says it is very likely, more than nine in 10.

By the way, it is not just this figure... That is the signature of ozone depletion. The middle of continents warming up more than the middle of oceans, that's a sign that it's forced and not natural variability. Low latitudes warming up more than high latitudes... There are other fingerprints. So that's not a judgment derived on the basis of some quick, thoughtless process as asserted by the famous professors I mentioned before.

So is the science settled? Some, but others not even close. Standard criticism, I'm sure you've all heard it. How many times have you had a phone call from the media saying, "Oh, it's happened before. Okay, isn't that relative?" My answer is always the same. Of course it's relative. Because what has happened before is the background against which you calibrate ... Otherwise how do we know whether our tools are any good? But as soon as they cross over and say, "Therefore, this is a natural event," now they are logically off this, and how do you explain that?

Well, this is a classic. This is an old picture. I am not going to go through it in detail. It is a half a million years, ice ages about every hundred thousand years in the last half million, interglacials warm periods about 6 degrees C, 10 degrees Fahrenheit the differences, so that is the peak to peak. If you look really carefully, notice this one is one or so degrees, what do you say? Three and half warmer than that. Hard to know the exact number. On that order, and therefore it's asserted that you can't see there is this little upward blip at the end, it's kind of smoothed out in this kind of record. These are ocean... they're kind of smeared. See that? Now when you do that, the statement that therefore recent warming is natural because it's been warm before it isn't even logical. [?]

So I have a metaphor for that that I like to use when asked that in Congress or on TV. And that's the norovirus. Anybody here ever have the norovirus? It is awful. It's like cholera for three days. It's really terrible. I had 102°F for three days, running stream, you don't wanna know. In any case, the bottom line is, if the logic is that it's been warmer before, therefore this warming is natural is proof, then the logic is if I have 102° from the norovirus, the next time I have 102 it must be the norovirus. It couldn't be kidney, it couldn't be respiratory, it couldn't be malaria.

So what do we do in science? We look for cause. In this case, we know that there were orbital element changes, and in the tilt of the axis and that helps to explain it. So the fact that the very same model that we use to predict global warming from greenhouse gases [can] actually reproduce, but not perfectly, but actually reproducing major aspects of paleoclimate, that is reinforcing, not damning. But that's very difficult to jam that into a sound bite. And the other thing is when somebody tells you it was warmer before so I drew a horizontal line here to show you that it really was, did they also tell you that sea level was five meters higher?... So if you're going to use the...analogy, you can't use it asymmetrically one unless of course your object is not to do science.

So let's move toward ending by going to some impact issues. This is the snow cover going down. I gave this talk in Boulder last year when they were having horrible snowstorms. I remember the airport was closed for days and... Boulder is a pretty environmentally-oriented town, and there were people saying, "Do you mean the snow pack is going down after what we've been through? Maybe that's not such a bad thing." I found out the reason they were complaining is that they all

had school-aged kids who they were stuck with at home. [laughter] But that's another story. Of course they didn't phrase it quite like that. And then of course other people in the room said, What are you talking about, we need it for the ski industry and the water and the ecology, so immediately once you get a change there are two sets of stakeholders in the room, opposite belief as to whether it is good or bad. Remember, is science settled enough for policy, even though some science is settled and some isn't. Whether it's enough is a value judgment about what's an improvement and what's a risk. And that has to also be done explicitly.

The other thing is, and this drives me crazy, when people sit there and say "I falsified climate change," you know Congressman Rohrabacher, is telling us since 1998, have you seen this nonsense about the [?] satellite, it's in the paper and all over the media now? Satellite doesn't show warming from 2002 until now. Well, what does that prove? Absolutely nothing. It is five years. I could've picked a period in here and shown that we were heading for the next ice age. And then I could've picked a period over here and said we're going to hell in a handbasket. These are false terms. Climate is global long-term. This is all weather noise. Again, that all has to be understood.

But are impacts good or bad? Oh that, that's supposed to remind me to ask you that question. Oh, well. As long as it's up there. [Cartoon] The good news is at the current rate of global warming we'll [big fish? sharks?] be able to swim over there and eat them in 105 years. This is reminding you that not everybody loses. First of all it will probably take a century to get a 1 meter sea-level rise, and second it doesn't need a century because any good storm surge will get them anyway. Third, as [?] told us, if you collapse the resource base, it's not very good. And fourth, ninety percent of big fish are gone, and these guys are much more in danger of being fished out than eaten. But those remind us that not everybody loses.

And this is the part that I want to close with, which is supposing we're talking about a cost-benefit analysis, which is the way the Office of Management and Budget tries to frame it. So they're doing a cost-benefit analysis and they're saying well climate change has some good. I mean, after all, if we're going to melt the Arctic sea ice, the shipping industry is going to have a northwest passage. So we're going to save xxx dollars, put that in as a positive. But what about, you don't need to read all this, this is just about the Inuits suing the energy companies and the U.S. government for dereliction of responsibility under common law because their culture is being driven to extinction.... But how much is a culture worth relative to a shipping industry? Or an ecosystem? Those are the kinds of choices that have to be made when you're going to talk about policies. Those are not monetizable cost-benefit analysis friendly... They are political negotiations. Lead to radically different world views about what's important.

Where economics come along is once we reach a decision on how much we want to cut and how much risk we want to take, now we want to bring economics in hammer and tong to do cost effectiveness so that we reduce the emissions as cheaply as possible. And we have an additional component that we have to deal with. If you believe that it's fair that polluters should pay, that there are real costs from dumping your waste in atmosphere, from sending kids to the hospital with asthma, seniors with emphysema being threatened. In the West ... will tell you how much increase in wildfires. Part of that is climate change, part is inappropriate development, ... it's

competing explanations, but nonetheless it's real. It's there, climate is a piece of it, and it's certainly going to get worse. I have a high confidence that fire and pests will increase with warming based on the literature. That's a real cost. You cannot hold smokestack emissions costless and expect the market to produce a reasonable reaction. So therefore it appears to have the ... principle to have the polluter pay.

But what about people who manufacture Hummers and SUVs and mine coal. They don't do it to screw up the climate. They do it because it's all they know. So again are you going to hold the sustainability of the climate and the country hostage to his grandfather's line of work, or are you going to say, wait a minute, you can't do this indefinitely. We are going to help you through the transition.

So when you have climate policy that increases the conventional cost of energy, not only does that affect some industries. By the way, it creates probably more jobs in other industries, but those jobs or for people who don't know and who aren't organized. It also hurts poor people. Because what would an increase in energy costs do to me? Probable lower my grade of drinking pinot noir. What would it do to some poor person. It might lower their grade of protein for their family. But again, you can't say, no we're going to risk it. Don't subsidize poverty with artificially low prices of commodities. Or energy. Subsidize it with the real stuff. With a voucher to buy an efficient car.

So what that calls for is two good acts of government. First you protect the commons as a fiduciary and stewardship responsibility. And second you have to do it in a way that is fair. And fairness cuts two ways. Number one it is a distribution of impactees. They're not all losers, like the shipping industry, but there are other losers and we have no funds now that are funded to anywhere near the extent needed for adaptation, which is critical for those people who are going to be hurt by the climate change already in the pipeline. And the second thing, you have to help people who are going to be differentially hurt...[?] by climate policy. Through at least a transition period of say a generation to get them out of doing what they're doing. You can't let them block progress, and at the same time you just can't cast them loose.

And two good acts of government, my god, you couldn't get one, but I'm optimistic and I think from here on out that that is going to change. I have had three or four appearances in Congress since the changeover a year and a half ago. It is not just the Democrats. The behavior of the Republicans has been spectacularly different than it was before. In fact, it reminds me of the way it used to be back in the 1970s when it was bipartisan, cordial; I don't know how many of you remember back then; it was informational. But after '81 it got confrontational and stayed that way up until one John McCain hearing in 2001 and then since then has still been confrontational until this year. Not any more. So this almost extinct I thought, at least endangered species has been rediscovered in Washington: the moderate Republican [laughter]. There's no solution without them. Therefore, I'm actually optimistic that we will see that any of the three leading candidates will probably have a climate policy..., and it will be passed. Will we have a filibuster because we know Inhofe is going to do it in the Senate? That remains to be seen, but I think we'll get enough crossover Republicans, and we probably will. So remember ...

So the last thing I'll say is I was there in the Ways and Means Committee, the Tax Committee; it

was a Republican who asked a very fair question. He said you guys in California you've got a Republican governor and a Democratic legislature, on the same page, how'd you do that? So I quoted California's Mediterranean climate if in the summer you crank up the heat, you're going to increase forest fires. You're going to go have snow melt earlier and less water in a state that's critical for water that has 50% of our storage in the snow pack and not in reservoirs. And there's no such thing as a Democratic wildfire or a Republican drought. And we have a common enemy, so we're kind of working on it. And if you look at the emissions in California, they're about two and a half times on the world average in terms of CO₂ per capita, they are a little less than 40% on the U.S. average, and they're half of the Texas emissions per capita. Which is the worst state except for Wyoming. But you can't count Wyoming because per capita it's not fair to Wyoming because if you divide by zero you get a big number.

So why is that? Is that because you have ... and that's addicting? Yeah, that's a bit of it but that's not the whole story. It's because we live in a radically different community culture. California has long had a community culture of social protection. We constantly have passed bond issues. We've had very strong laws on energy efficiency. So when you look at states you're going to find this heterogeneous patchwork quilt of all these rules, and therefore what really takes is to get to the federal scale to solve the problem. When moving in that direction, and I'm optimistic that the U.S. will find that the world's largest economy and largest [?] ...will be back in the leadership role a year from now, and that's a prediction you can test me on. Thank you very much.

Questions and Answers

Q: How do you deal with the equity question in India and China?

And believe me, India and China are not the worst egregious cases. There's the big five of developing countries: India and China, Indonesia, Brazil, and Mexico and there's a significant chunk of world emissions, and then the OEC countries, and if you include the former Soviet Union you've got 80%. But there's still 30% of the world's population, the poorest of the poor, are left out of the whole thing, who are a factor of 20 per person less emitting than we are, and a factor of three less than China or India. And them we have completely excluded. So let's just do the intermediate countries like India and China. They say, and they have a legitimate right to say, that we can't have our development goals blocked by policies that could stop us from using coal and developing our economy around it, because after all, isn't that what you rich guys did in the Victorian Industrial Revolution somewhere from about 1880 to 1910, with sweat shops, coal burning, and the internal combustion engine? And we still are powered by internal combustion engines and coal burning, and the sweat shops are globalization, are imported. And it's still going on. So you have a pretty good point. On the other hand, if you multiply the total number of people in those places by the total U.S., European, or California, which is about the same as Europe, emissions per capita, we're talking about tripling CO₂ by the end of the century and probably quintupling it in the next one.

That to me is a very highly dangerous outcome. That's warming, if we're incredibly lucky, 5 Fahrenheit and if we're unlucky 15. I mean, that's really big stuff. Larger changes in the ... cycles in 150 years I don't think anybody, even the famous professors, would believe that that's a good

idea.

So how do you stop it? What you have to do is you have to is to leapfrog the Industrial Revolution into high technology. Let me give you an optimistic—give me just one second, let me finish my thought here. So here's Exhibit C.: cell phone and I remember when I was in ..., China a couple years ago and I went out in the countryside and things were developing. There was a merchant class, there were shops, and everybody was walking around talking on cell phones. There were no copper wires. How did we communicate? We used materials, stringing copper wires all over our continents. They've leapfrogged right over it to high technology to cell phones, much less energy use. The object is not to reduce the economy. You want to have as much growth in economy as you can because that's part of alleviating poverty. The object is to do it with a minimum amount of energy and materials. So that is the key where inventing your way out of the problem becomes critical.

So I would argue that the way you approach this is to say to China and India and places like that, don't repeat the coal boom. First let's leapfrog, first through gas to solar thermal to district fuel cells to appropriate biomass, which is not corn ethanol subsidies. And variety of other things that we can do, and they'll come back and tell you, okay we don't have the patents on all that stuff, we only have a little bit of the knowledge, how are we going to do that? The only way we're going to do it is back to culture and community through an international program where there would have to be national incentives to invite the corporations to enter into literally legal agreements with China and India for patent sharing and learning-by-doing experiments. Because a lot of this technology, we know the basic principles. Our problem is not R&D, that's research and development. Our problem is R, D, and D² which is demonstration and deployment. Because what we need is literally a feeding frenzy in learning by doing.

How can we do it socially effectively, cost effectively and escape? It's not clear whether it's going to be solar, thermal, safe nuclear, battery cars, DC transmission lines, biomass that doesn't cause more harm than good—there are examples of that that you could use to do it. I think it's a little early.

So why not do a lot of experimentation in countries like China and India? But they're not going to agree to that without getting help. So what we're really talking about is making sustainable development and the climate is our number one priority, rather than competition as the number one priority, and that we do that through cooperative ventures, and what does it cost? Well people have costed it. Somewhere between starting at tens of billions a year going up to 100 to 200 billion a year to do it. Well, that sounds outrageous, but let me remind you that when I was told that I didn't mention carbon capture and sequestration that's gotta be part of it too, we take CO₂ out of the flue gas from coal burning and natural gas burning and put it underground in a hopefully safe form of storage. That's another thing that needs to be experimented with at scale—and we have a lot of experience with small scale; we don't have experience with the large scale.

The U.S. government went to Bali, remember, and said that the U.S. was going to invent its way out of the problem by subsidizing technology and we should do that rather than the so-called market mechanisms that hurt industry and all that. Fine. They were booed, by the way,

unprecedented because they weren't believed, and I guess the boos were appropriate because what just happened was they said that we are going to come up with clean coal. It was a project in Washington that was funded in Washington called which is [?], which is GE and a couple of private corporations, with the Department of Energy [making a contribution?].... And then they just decided not to fund it, after Bali. How could they do that with a straight face?

And when somebody said, half a billion dollars is too much money in a recession. A half a billion dollars if you'll pardon me is 1.5 DIW, days of the Iraq war. Where in hell are their priorities? [applause] So how do you make these investments? You can't invest \$200 billion the day after tomorrow. It's going to take a ramp up. It's going to take 20 years. But just to give you some numbers on that, I can show you a graph but I won't.

I'll end with this. This is such an important question. I apologize for five minutes on it. But the economy is about 50 trillion of the world right now. U.S. ten, round numbers. So it's growing at about two percent per year. So every year the world economy adds into its GDP about a trillion dollars. So if it's a hundred billion to deal with this kind of sustainable development and end up with 450 ppm rather than 950, the cost is not the GDP. The cost is the growth rate in the GDP. One-tenth. It is a tithe of the growth rate. If you calculate that out over a hundred years, and I have done it, you can go to my website climatechange.net, there's an article in the very back of the site where it references Azar in *Ecological Economics*, where we use neoclassical economics to cost this out. And we have \$100, \$200, \$400 a ton carbon tax. And \$400 brings you to around 350 ppm and \$100 around 556. And that's a lot of money. It's trillions of dollars over a century. It reduces the economy by about two percent a hundred years from now. So the economy of the world is currently 150 trillion and has gone up two percent every year, 30 years is the doubling time in round numbers, that means it doubles three times in a hundred years, round numbers factor of eight, eight times five, \$400 trillion, two percent loss of the economy a hundred years from now. It's a lot of money, \$8 trillion dollars. That's almost the current value of the U.S. economy. Can you believe that there are people who said that Kyoto and climate policy would bankrupt the American economy because they're comparing \$8 trillion 100 years from now with the present size of the economy? There's only one word for that: a lie. You can't compute a future number and then compare it to the present. You have to compare it to the size of the future economy. And when you do that, and you look at the growth rate of the future economy which is two percent, that means the two percent loss in economy then is made up in one year. So the cost of insurance, to be at 450 ppm versus 950 ppm, is one year loss in being 500% per capita richer. This is not too expensive to afford.

But it is real money. There will be real displacement of people in certain industries. We have got to be able to deal with that transition, and we are not going to get cooperation from the developing world if we don't start setting up transfer mechanisms to help them achieve that. So that's why I appreciated the question so much because it's not again amenable to an easy soundbite answer. The soundbite is we have to have cooperative strategies to spend real money to try to achieve real goals to bring us to sustainability. It's a soundbite. I just gave you these numbers. Everything I said is not controversial. It's also in the recent IPCC Working Group 3. They show that complying with Kyoto is being about 80% richer in 2025 in April [rather] than in January. So this story about bankrupting the economy is a fraud.

Q: Given that the momentum in policy ... we need to develop a consensus around safe climate policy.... Latest IPCC report. Hansen and Lovelock have something to say about sustainability emergency and time frame.... [much inaudible] Should we come to scientific consensus on what is a safe target before we go on to amplifying unprecedented climate...?

A. Okay. That's another great question and you may not love the answer because I'm going to complexify it first, then I'll bring it back because I have been, I've allowed myself to be advertised by the Sierra Club with my son, some of you may have seen it in a number of environmental magazines, on the Schwarzenegger so-called 2% solution. Two percent is the California target; it's not only a governor's declaration but also passed by the assembly and the ... Senate and signed by the governor. It calls for an 80% reduction over, I think it's current levels, I've forgotten, maybe it's 2000 levels, by 2050, which is two percent per year, right? Times forty years. No I guess it's 2010. Whatever it is, it's now two percent per year of the current emissions. Let me first of all say, that's impossible. We're going up for at least 10 years because there's inertia in the system. But if we really do the investments right, solar, thermal, and transmission lines, buses, plug-in cars, and this kind of stuff, we can come down even faster than two percent per year cost-effectively in the out years. We've got to do that R&D.

So I am with you on wanting to do that but I've got to warn that you have to be careful. I didn't talk much about the projected future, but that's Working Group 1 [?]. That basically gives the band of uncertainties with another 1.1 degrees C top of what we already have, .75 C, so the lowest outcome scenario is not a thrilling scenario, and the top one, 6.4 Omigod, an Ice Age, interglacial cycle difference in a century. I can't imagine that being anything other than catastrophic.

But this is the problem. When you try to set dangerous level—I'm the coordinating lead author of chapter 19, Working Group 2, the title of it is Key Vulnerabilities and the Risks of Climate Change. What it's about is the U.N. Framework Convention at the 1992 Rio meeting, which has the famous article II which says it is the obligation of all parties, and by the way the U.S. signed that treaty, George Herbert Walker Bush signed it, and the U.S. Senate ratified it as the law of the land, even if the current Bush chooses not to do it. Apparently the Congress does not view that in violation of law to be impeachable. So what does it say? It commits us and the other 189 countries that signed it, an unbelievably mega-signed treaty, to stabilize greenhouse gases in the atmosphere at the level that would prevent dangerous anthropogenic interference with climate system.

It does not define dangerous levels. It just basically says that ecosystems adapt naturally, we're already past that in some of them, others yes we could do it. Food production nonthreatened. Some systems already past that, others have plenty of time, and allow sustainable development to proceed. Coastal growers and people in hurricane alley are probably already passed that, and the rest of the world still time. So how are you going to define dangerous?

How do you even define it to the Great Barrier Reef? If you want to go to the north end, well the number 28 C I can never remember when you start bleaching, and whether the reef goes extinct is

not just a bleaching temperature but how frequently it occurs. So the more you warm up, the shorter the distance between bleaching events, and if it gets too short it goes extinct. The northern end is probably almost functionally ready to be in deep trouble. It's hot. The southern end probably has three degrees to go. I don't even know how to come up with a number for the Great Barrier Reef.

So you've got to deal with the fact that there are so many systems which have thresholds that any one of them we could transgress but while we know there's a threshold, we don't know where they are. And we know if we start aggregating them, they don't look like everything is fine. The reason I so dislike this frame that we have to go to two degrees and then we must stop. I bought into it because we have to pick a number, but I have to tell you if I don't like it, because at 1.8 degrees of warming the world is not fine at all. At 2.2 it is not a climatic pumpkin. There's still many systems not yet out. So we have to do as much as we can as fast as we can as fairly as we can. Which is why I don't get too caught up in those numbers, the reason I don't like this we-have-10-years-left-to-do-it frame is what happens in 10 years if we haven't really done it? Which is pretty probable, Are we now going to say you know the *On the Beach* syndrome of 30 years ago: the radioactive cloud is coming to Australia, so they all race cars and kill each others because it doesn't matter because you're going to die of horrible radiation poisoning anyway? I mean, we can't get in that mentality. What we have to say is one degree is not great, 1.4 is worse, 2.0 is even worse, and 4.0 is almost unimaginable, and 6.0 is Oh my God.

And so let's not get there. Let's get on with doing as much as we can as fast as we can. Because if you get over hung up in the numbers, you have a problem because somebody's going to come along and tell you that it could be only 1.1. So we're not going to exceed the two degrees threshold even if we double the—remember that 1.1 is the low end of the climate sensitivity range multiplied times the CO₂ doubling in the lowest IPCC scenario. So you could say therefore we're not sure, and that's exploited by exactly the kind of people I mentioned before who said, "We're not sure."

I believe it is probably already too late to avoid a 3-degree warming, because if you go to the middle of the bell curve, what of it, it's going to be very difficult to stop. Well, I'm not going to give up because we can prevent 4 degrees. Let's do as much as we can, run an overshoot scenario and then come back. If my answer is wrong, and I apologize for that but there's a lot of complexity in it, yet I bought onto the soundbite, I bought onto the 2-percent solution, which is essentially saying we're going to try to stay under 2, but remember it has no meaning to say stay under 2 because there are two bands of uncertainty: human behavior... and the internal dynamics of the climate system, which controls climate sensitivity. We can control this one; we're clueless on that one. That's an error [?] in the system that we don't yet get. So it could be too late or not.

Q. [mostly inaudible] Methane accelerates, Antarctica, greater need for Precautionary Principle even further...

A. I of course agree with you. As you know I've been screaming this in Congress starting in 1979 when I went there to the first hearing with Roger Revelle and was there with Suki Manabe [?] and who's the other one, Gordon MacDonald, where we opposed Carter's—I was on the Carter-

Mondale science policy task force and I went there to oppose his oil shale initiative because of CO₂. So we've been yelling for a long time. Don't put us in a box where we're stuck with that picture. And nobody listened. So now we're in a situation where we have to take more drastic action to have lower levels of risk. So let's get on with it. I completely agree that there are all these risks. But I also have to tell it straight, which is I can't absolutely assure you that all the things are going to happen. Well, what idiot is going to take a 50% chance of dramatic nonsustainability with a life-support system? That's how I view it, but that's my value judgment.

Q. ... Where do we start to examine the assumption that economic growth is necessary to alleviate poverty?...The economy is based on waste, throw-away products, and war...

A. Okay. I have to confess I'm sympathetic with your viewpoint, but I'm also a realist. Remember there are a couple of clichés about politics: all politics is local and short-term, and politics is the art of the possible. I don't know of anybody running with any conceivable chance of more than a percentage point of the electorate who is running on reducing economic growth. So I admit I have given up at the moment dealing with that, and what I'm trying to do is be certain that we build our growth on much cleaner and on alternative ways. At the same time, I didn't do it because this is not a talk on that. I love to show slides and say, how do we do this and my first set of slides, as I show this cartoon, it's very cute, I don't have it in here, it has this giant SUV that is towering over people that's in a museum where there are dinosaur bones and it says we don't know why this species went extinct, some people think it had to do with their size. A cute cartoon. And then what do we do? The U.S. Congress gives a \$25,000 tax deduction to cars over 6,000 pounds in one of the most disgusting interferences in the so-called free market for a long time. I think that is about over.

So we've been on the wrong side of this for a long time. So what I'm trying to do is get started on the two percent solution, at least get the U.S. to do some things, but as I've said many times, we've got to deal with the transition strategy for helping people to develop. Some of that has to involve economic growth. But remember economic growth does not have to be consumption of SUVs. People do not need energy. They need energy servants [?]. They need transportation, heating, refrigeration, clean food, water that's healthy. Those will not be done without some energy and some economic growth. But it doesn't have to be repeated in the Victorian industrial model. That would be my opinion really bad, and that's why I keep talking leapfrogging.

You're right, but you have an incredibly long way to go. I've spent enough time over in Congress that I have trouble convincing them that we should have a federally mandated efficiency agenda. That's called, "Oh, but my home is my castle, don't tell me how many panes of windows to have in there." And I said, no, they're not going to tell you how many panes. We're going to give you the performance standard. How much heat goes through? You figure out how to solve it. You go on the market. You love the market. You go in the market, and you buy what's available, which is going to be a 3-pane window [?]. [laughter] But in any case, right now somebody might invent a real cool one. But nobody's going to invent anything without incentive.

So I don't think we can abandon some market principles during the transition because you're not going to change the politics instantaneously, and my view is to [sigh], I'd love to turn the tanker,

to put it in reverse, in my view it's heading onto the rocks, but I would at least like to get it out of all ahead full steam, and start the wheel turning, so I admit I'm a defeatist, so I'm going to give up and go for a lower strategy to at least get us started, but I am not unsympathetic to you ... and others who point out that the fundamental paradigm cannot go on indefinitely unless we depopulate. That's true, but that's not going to happen any time in my lifetime or many of yours, so let's get the most we can, allow consciousness to evolve.

Q. I'm trying to think of other examples where we've dealt with a public policy issue with denial. Can you think of ways they have succeeded...?

A. Well the tobacco case is a very depressingly legitimate analogy. For 30 years the American Tobacco Institute used the standard strategy of the false god of falsification. They would always have three studies which were inconclusive or showed the opposite to the 300 studies and claimed that until these three studies were refuted that we should not have any policy. They also argued, and it was correct, that the actual biology which connects smoking to cancer is not deeply understood. It is speculative. Competing explanations, many of them still is, my cancer friends tell me, cancer doc friends tell me, and therefore, until that is resolved we do nothing and eventually, the epidemiology, that is the data, was so overwhelming that it overpowered this campaign of frankly disingenuous misapplication of how science works.

But we have some positive examples. There's the Nuclear Nonproliferation Treaty. Not perfect, not everybody signed it, but most of the countries that have signed it are more or less adhering to it. We have an international agreement on air travel and air safety that most countries are agreeing to. We have the U.N. Framework Convention, and we're doing an absolutely miserable job, but through the COP process and Kyoto we're starting to get there.

I'll give you an optimistic example. You have the Montreal Protocol and the London extension to ban ozone-depleting substances. After the ozone hole opened up, very quickly, within a year or two, the Montreal protocol was ratified, and in fact even signed by the U.S. By the Reagan Administration. To ban about half of the ozone-depleting emissions. And when Susan Solomon, same person who worked on ozone [?], I've picked on a little bit, but Susan has done a lot of fabulous stuff. She led an expedition to Antarctica that showed that the ozone hole was not a weird event of nature but directly a smoking gun, she said at the press conference, we have a smoking gun, we know who pulled the trigger and we know at whose head it was aimed, great line Susan, I keep trying to remind her and to encourage her to do it again in climate, but in any case we got an extension from 50% to 90%. So the glass is half full. We could act. But I could make the glass half empty again by saying that we knew for 15 years that dumping wastes that affect ozone was going to lead to ozone depletion, we just knew it was going to be a depletion, and why did we have to be kicked in the teeth to act. So I think that there's precedent for some good, but it usually takes a kick [?], and how many Katrinas, heat waves, factor-of-seven increase in wildfires, and how much does it take to jumpstart this process and make it politically possible?

I think it's an accumulation, and if you add up those events with the transformation in the Senate and the House with that endangered species reasserting itself and with thousands now, it used to be dozens, then hundreds, now it's thousands of corporations on various scales saying, you know,

we've got to have climate policies because we're saving more money by cutting emissions, then it's costing us less through reduced energy than it's costing us to fix it up, and it's making our employees feel good and it's giving us good greenwashing. Well, what's wrong with that? I'm into doing well by doing good. You know, that's all right. So there are positive signs out there. And we shouldn't entirely despair that as long as we're in growth maniac phase as he pointed out it's going to be very hard to stay under CO₂ doubling. But I think we can stay at doubling and then get off it.

The real problem is how many irreversibilities are being triggered while we go through that transition to being a mature planet. That's what scares me, I won't be around to watch it, but I feel some sense of responsibility to my children and grandchildren and Nature, their children, and I hope all the rest of you do too. Thank you very much. [thunderous applause]