

## **Eugene Linden**

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There's this idea that the Earth has gotten more populated and that we used to have vast amounts of open land, a surplus. As Adam Smith put it, and as I've looked into it, it looks clearer and clearer that at any given point, we've had as much population on the planet as the climate and the technologies of the people could support. If you look back through the record, when climate is good and when times are good, people expand to fill every available space. And if you look in the 12<sup>th</sup>, the 13<sup>th</sup> century in England, population tripled during that century. Then the little ice age hit and population stagnated for the next 400 years. Same thing happened in Iceland. It reached a population, went from zero in about 974 A.D. to, 50- to 80,000 towards the end of the tenth, the eleventh century. Never got back to that number again until the beginning of the eighteenth century.

So, when times are good, and when climate is benign and clement, population expands. And then when climate turns bad, populations stagnate or diminish. And in that respect, you know, we're no different than fruit flies. We tend to expand to the limit of our capacity, or the capacity of the biosphere to absorb our numbers. And the interesting thing, and the dangerous thing about that is that, at any given point it contains an implicit assumption that things are going to continue to be good. And we've been proven wrong as a species many times in our past. The danger, of course, is today that once again we've had about 150 years of good weather and human numbers have expanded enormously during that period. And we've made a massive global bet that climate will continue to allow us to produce the food that we need for the future. In the past, that has turned against humanity, The question is whether it will this time as well.

If we're going to have another two and half billion people in the next 30 to 50 years, climate had better be good. If it's not, it is going to be a Herculean job trying to feed those people and provide them with access to fresh water. We use about 54% of the available fresh water in the world right now as a species and 70% of that goes to irrigation. The amount of irrigated land is not going to be increasing dramatically, barring some unforeseen technological breakthrough. And within the next 30 to 50 years, we're going to have to feed another two and half billion people on an existing amount of arable land and with diminishing supplies of fresh water. It's a hefty chore no matter what the circumstances, but if climate turns bad, it's going to be almost impossible. That's the conundrum we face.

Water is very heavy. It's very expensive to make. It's mostly available in the places that need it the least. Iceland is probably the most waterless rich nation on Earth. Canada is enormously water rich. It doesn't have many people. The places where most of the people have the greatest water stress and the fastest population growth rates would be places such as the Middle East where there's a great deal of water stress. There are about 400 million people who are suffering water stress at the moment. That could rise into the billions in just the next 15 years or so. And with water comes conflict if you have people competing over access to water.

The one thing that is a requirement for life and for agriculture and for nature is water. And, we're not making any more of it and it's very difficult to move. You sort of have to play the hand you're dealt and make the best of it. Now, there is a bit of slack in the system because estimates of the amount of water wasted rises up to about 70%. So you could increase water supplies just by reducing waste but that might be overstated. Various people, like Mark Rosegrant, have pointed out that even if water is wasted, it's captured downstream. The system might be more efficient than we think it is, which is bad news in a way. It means we have fewer options for capturing some of that waste. Water is a limit. And, already in parts of the world like China, you have industry, agriculture, and people competing for finite and diminishing amounts of water and increasingly polluted water. Nature gets squeezed out.

We basically mine water, to the degree that withdrawals from aquifers around the world are, in many cases, exceeding the recharge rate. So you have water tables dropping dramatically and then you have a number of consequences from that. It gets more expensive to pull the water to the surface on the one hand. Then, on the other hand, you have collapses, sinkholes and things like that. That's a minor irritant compared to the major problem of where you are going to get the water when that mining operation is complete.

Another aspect, in islands like the Philippines and in coastal areas, when the aquifer gets drawn down too much the salt water can intrude. And once salt water intrudes, the aquifer is useless for human use. It's a worldwide problem but it's part and parcel of this bigger problem, which is that as human numbers increase by about 80 million people a year at the moment, you're going to have to feed more people with less water. Diminishing supplies, diminishing capacity to produce it and increasing competition for those supplies are what's left. And it's again an assumption predicated that climate will continue to provide bountiful rainfall in the places that we need it.

If climate changes at the same time we have all these pressures on water, you have an extremely volatile and dangerous situation set up. In fact, some of the climate models show that Mexico, which already has severe water stress in many parts of the country, may have its water supplies cut drastically, even in some of the most benign climate change scenarios. And there was recently a study in California that showed, in the most moderate best-case scenario for climate change, the Los Angeles area could lose 50% of its available water. This was done by Tim Barnett and a number of other people at Scripps and other places. What they found was that the snow pack in the Sierra Nevada is essentially a water meter and so it meters out the water. And if you have a diminishing snow pack and a shorter winter, you have a longer time during the summer where you don't have the capacity to store water. You don't have the available supplies and absolute availability of water decreases. That's a best-case scenario for climate change in the richest country on Earth. We could probably do something about it in California because so much water goes for agriculture that you can divert a bit and still have water for agriculture and have adequate supplies for urban areas. A lot of other places on Earth don't have that choice.

The Ogallala aquifer has been mined for years and it caused sufficient alarm in parts of Texas and in the four corners, where it crosses the border. People have begun to use very stringent water conservation measures. Again, if climate change affects the recharge of the Ogallala aquifer, the U.S., which is absolutely critical to the world food surplus, will have less water. One point that seems to have gone beneath the radar in recent years is that world food stocks, the surplus, in essence, that we draw down when there's a shortfall in production, is at its lowest point in the 45 years since it's been measured and has been steadily declining. You've got, roughly 80 or 90 food importing nations on Earth and then you've got just a few that are major exporters, the U.S. being the largest of the exporters. Then where do you make up the slack? Already we've seen that production has been falling short of consumption for a number of years. The only reason there hasn't been a crisis, of course, is that there has been this surplus but that surplus is disappearing rapidly. And, mammoth consumers like China have been moving from exporters, where they were in the late '90s, close to the point where they've drawn down their stocks and may soon become importers of corn and other grains.

An interesting story has been emerging in China. In 2004, its surplus has all but disappeared. China will soon become a net importer unless things change. And that has enormous implications for the rest of the world. On the one hand, it's probably good for farmers because as these stocks get drawn down, the farmers have increased pricing power and increasing pricing power, at least under our economic theory, should bring more land into production and enable the farmers to improve their yields. Maybe it'll make up some of this difference. We don't know. I mean, that's the theory and that's the hope. But you have a lot of food importing nations that really can't compete with China. If China wants grain, it has the billions and billions of dollars in foreign reserves to buy it. And the question is, who gets crowded out and what happens to them?

Well, you can take your pick of the 80 or 90 food importing nations. Egypt imports some amazing percentage of the food that it consumes, upwards of 50%. And you know, it would be one of the competitors in the marketplace as will a number of other food importing nations that are poor. The U.S. is the richest nation, the E.U. are rich nations. They're all food exporters. Where are the farmers going to sell their food? And who is going to supply the food to these food-importing nations if China becomes a colossus in the world grain markets?

Well, Haiti, I think, is one of the few sort of Malthusian case studies on the planet today, where you can see the intersection of environmental degradation and population pressures and political instability. Let's hope it's not a model for the future. During the rainy season you can see Haiti has a type of brown girdle around it, as eroded land flows into the lagoons and into the Caribbean. The question is what does Haiti mean? Well, one thing it means is it shows how you get this nexus of forces, this interplay of forces, of environmental degradation, population pressures, and political instability and you have huge out-migration. That out-migration poses a problem for all the bordering nations in the Caribbean and the United States, which has had its own issues with Haitian migration. But Haiti's just one of these countries where you have migration as a result of land degradation. Mexico is another.

Estimates from a couple of years ago were that a million people a year were forced off the land in Mexico by desertification. Where do they go? Well, they go to Mexico's swollen cities, which don't have the capacity to absorb them and then they eventually try to make their way to the United States. That pressure for migration, which is a push pressure rather than a pull pressure, is a relatively new thing. Economists always loved international migration in the past because it redistributes labor from where it's in surplus to where it's needed and redistributes people from an area they're in surplus to where they're needed. But, when there's a push factor it's a little harder to deal with because there are only so many places that can absorb these people and many of them have put up no vacancy signs. It works into a larger issue as well, which is that through much of the world, we have a population implosion rather than explosion.

Russia, despite the fact that it is encouraging childbirths has a declining population and also a shortening of life spans. Europe, by the way, has a declining population too. On the other hand, 99% of the world's population growth comes from the poorest countries in the developing world, 80 million a year. Where are they going to go? Well, the developed world, including the United States, needs a workforce just for its economic vitality. And it needs young people because it has an aging and shrinking population. But on the other hand, there are fears of loss of cultural identity and xenophobia and all these factors that come into play that cause nations to resist. Is that a tenable situation? I doubt it.

Cities are interesting phenomena, both in terms of population and as a force for instability in the future. Most of the world's mega-cities are in the developing world, places like Karachi, upwards of 12 million people or more, growing at fantastic rates and drawing in people from all the surrounding areas. Many of them come from tribes that have been in conflict or come into conflict once they move into enclaves in the city with an infrastructure that was built for a city of a fifth or a tenth its size.

What happens as these cities grow? One is a positive thing. On the one hand, people have access to jobs, markets and things like that. Karachi is responsible for an astonishing percentage of Pakistan's economy. A second thing is that the migration to cities in and of itself dampens population growth because children, seen as an asset in rural areas as a workforce, become a liability in cities where space is expensive. So in one generation you'll see birthrates drop astonishingly. And I think that one reason that population growth going forward is going to be at the low end of, and even below the low end of predictions from 30 years ago, is that no one foresaw the impact of this vast movement from the countryside into the cities. The price, though, may be instability because in order for these cities to work as they continue to grow, people have to behave better than they've ever behaved in the past. And I think it's unsustainable to assume that a new human being will emerge that behaves better as people are crowded cheek by jowl. You need a type of common outlook and it becomes harder and harder, with the butting heads of different ethnic groups and with people who elsewhere might have been in conflict. It becomes a combustible brew.

I have to say, having written a couple of articles about mega-cities, and seeing them as unsustainable, I am somewhat surprised that we haven't seen the kind of breakdown that has happened in the past. Throughout history cities have grown to certain sizes and then broken down. We can't expect to overrule the patterns of history but we see that many of these cities like Mexico City, somehow hold together. It might be that we're not seeing support systems that help people, that don't show up in the ordinary screens we apply when we look at the life of cities. In a way, it's kind of hopeful that it hasn't happened yet. On the other hand, you have to worry because as these cities grow, and outgrow the ability of their governments to provide infrastructure and support, the potential for calamity rises.

It was only in the last couple of hundred years that cities were able to grow past a million people because prior to that, the lack of sanitation made cities a breeding ground for infectious disease and whenever they grew past a certain point, infectious disease would rise up and knock down the population of the city.

Paris might have been the first city to reach a million people, but I'm not sure. In any event, with the discovery in the late 19<sup>th</sup> century of the microbial theory of disease, you have the first installation of sanitation infrastructure. We created a system by which cities could grow far larger than any had in prior history. But now we have cities outgrowing that same infrastructure. Karachi is a, a good example. Mexico City is another example. And what that means is with a stressed population, stressed by many, many types of infectious disease and weakened immune systems, they in essence become incubators for infectious disease. In Kinshasa in Zaire, where you have a fairly high HIV infection rate that weakens the immune system, TB has a chance to have a resurgence as a result. And then, because of the interconnection of the global economy and the transportation system, no microbe is ever more than a plane flight away from the United States. Even though these are far away cities, they are connected and that is one reason why there is such concern in the United States about outbreaks of avian flu in Asia. Just 24 hours later, a new microbe or a new infectious disease incubated in one of these mega-cities, could make it to the United States and we might not be prepared.

We're entering this century, the 21<sup>st</sup> century, with far fewer frontier forests than we had before and a commensurate reduction in options. A good case in point is India. In the early '70s, the Ford Foundation did a study called "The Second India", in which they tried to predict what would happen over the next 20 years or so. And then they looked back in '94 to that study, or '93, I can't remember the exact date, of what happened against what they thought would happen. Well, what happened is India's population doubled, of course. I think it may have surpassed a billion. But they're facing another astonishing period of growth where who knows where their population will level off. I've seen estimates of over 1.6 billion. But with most of their arable land under plow, with most of that land using green technology techniques, it's not likely there are enormous gains to be made in India's crop production. And with most of their forests cut, there's just a very small percentage of their forests left. Yet millions and hundreds of millions of people in India use firewood for cooking and other things.

So there's enormous pressure on their remaining forests. And no one looking at that situation would say this is the situation where I'd like to enter a new century and a growth of another 600 million people, which was the population of India in the 1970s. And that is another conundrum that we face, which is that population pressures around the world have put enormous stress on the world's remaining wild lands, principally forests.

Tropical deforestation rates are just astonishingly high. When I first flew over Indonesia in 1971, Borneo was mostly pristine forests. Much of Borneo has been cut. There are virtually no forests outside of national parks in much of Indonesia now and there's even enormous cutting in these parks because people still have need for wood. This story is being played out around the world. Mexico has lost most of its forests, the Congo basin, etc. When China decided that it did not want to cut its own forests because of the dangers that followed from floods and loss of watershed, they began buying wood from Russia and Africa. So now they're a force for deforestation in Gabon and other countries in Africa. The Congo basin, the second largest rainforest on Earth, is under extreme threat.

The Amazon is also under threat. While there's been some good news in the Amazon and there have been massive efforts to try and protect the core of the system and its most precious parts, the jury is out on whether those efforts will be successful and, whether enough of the Amazon will remain in 20 or 30 years to preserve the hydrology of the system. You can get a self-perpetuating cycle of decline as you cut forests around the edge of a big system where you reduce the amount of local rainfall and that further reduces a wet, tropical forest. That can lead to a runaway collapse of a forest and of course we don't want to see that happen. The results would not just affect the residents of the forest and the animals and the biota, they would affect, for instance, Brazil's soybean growers. They're one of the largest producers of soybeans on Earth, but a significant portion of the moisture that nourishes the soybean fields to the south of the Amazon in Brazil is moisture that has been recycled by the Amazon, bounces off the Andes and comes south. And indeed, some of that moisture in turn makes it back through the trade winds to South Africa and affects the corn crop in South Africa. So deforesting the Amazon, for instance, is not just a local problem. It would have effect on food production in Latin America and in other continents.

Well, when you look at it a little more closely, ecosystems produce a great deal right up to the point at which they collapse. In fact, you can make the argument that that is what indeed is causing the collapse, the overshooting of the capacity of the ecosystem to produce. The Georges Bank had some of its biggest harvests of cod just before the fishery collapsed. And so taking as an indicator, the present ability to produce goods, is a dangerous game. And those tipping points are in all of the indicators that we look at. You could have your maximum production of wood in Indonesia just before the ability to supply its sawmills collapses because you have the most people cutting the wood and a diminishing amount of wood. It all happens very rapidly and almost in a nonlinear way. You'll go from steady increases in production and then all of a sudden you'll see a drop-off dramatically.

But, there is a lot of good news. One is that it turns out that family size is shrinking, and it's shrinking independent, in many cases, of what governments are doing. People on their own are making their own judgments about how many children they want and seeing their well-being and their family's well-being enhanced by smaller families. And it's happening in places where it never was expected. I think that what we see is that people are smart. They're intelligent. They have the ability to say when, particularly when they're given information, what is in their own interests and might coincide with the interests of society and the world.

And a second piece of good news is that more and more, poor people are seeing their well-being associated with the environment, with clean water, with adequate supplies of rainfall. They see themselves as net losers from environmental degradation and that is happening in places where incomes are not rising dramatically as well.

I think one other piece of good news is that when attitudes begin to change they can change very rapidly. The attitude towards family size that's part and parcel of urban migration is one example. We might think back to the Earth Summit of 1992, when the Governor of Amazonia showed up with a chain saw at the Earth Summit and he, actually at that point ran on a campaign, I think, of handing out chain saws to cut the Amazon. The state of Amazonia is the largest state in the Amazon. This got a lot of news coverage back then. Well, flash forward ten years and what you see is Amazonia probably has more forest now than it had back then. And a couple of things have happened. One is it's not good land for conversion to agriculture. A lot of the worst-case scenarios didn't come to pass. But another thing that's happened is that there's been a local constituency that has risen up and is interested in preserving the Amazon in Brazil. And that constituency is a counter force to and a balancing force against those who would cut it and exploit it.

And you can go around the world and you can find examples of this, where local people have actually begun to equate a healthy environment and maintaining the ecosystems upon which they depend as essential to their own well-being and not just something they're doing for the rich nations or for other people, and not just simply resenting outsiders telling them they have to conserve their natural resources. You know, I think one of the things that has become clear in the last 20 or 30 years has been this convergence of environmental, economic and even security issues and political issues so that when somebody's damaging the environment now, or cutting wild lands or abusing or exploiting or polluting resources, the losers, the net losers, are making their voices heard. And more and more, on this increasingly crowded planet, people immediately see themselves as losers when this happens. Salmon fishermen in the Pacific Northwest see themselves as losers when logging operations damage their streams. Cutting coastal mangroves hurts the fisheries off Ecuador. You can go around the world and you can see this playing out. I think the dynamic has changed and we see that attitudes change, can change very rapidly. That, I think, is an extremely hopeful sign because if bad ideas can spread rapidly around the world, maybe good ideas can as well.

Well, I think grassroots is the answer, you know, that's where the rubber meets the road. It's very hard to get any action on any environmental or population issue without a

champion, *in situ*, on site, who is going to take up the cause. Look at the Orangi Pilot Project, which installed sanitation in parts of Karachi, for example. That was totally grassroots. It bubbled up from beneath. You see that in small atolls in the Pacific, people realizing that their lagoons are really associated with their well-being. And one of the best examples of this, I think, is what happened in Rwanda with the mountain gorillas in Karisoke. Here was a place that underwent one of the worst genocides of the last 20 years. Several hundred thousand people were killed, a guerilla war, with refugees roaming throughout. The gorilla population actually increased during that period. Both sides realized that this was a large earner of foreign exchange through people coming to see these wonderful creatures and that killing the gorillas in any postwar Rwanda would deprive them of their best sources of foreign exchange. It shows that even amid political turmoil, people, in this case Tutsi army leaders, can realize that they have to protect resources. And they did. And it was respected to some degree. Now, outside Rwanda a lot of the gorillas, I think, were killed where there wasn't that recognition of self-interest. More and more as self-interest and as the economics of the cost of environment and of the liabilities of unbridled population growth become apparent, you'll find local people who will make that connection and will be willing to act. And I think that is a cause for some hope around the world as well.

Technology does move the goal posts. There's no question about that. It's moved them throughout history, which is why the planet can support six billion people right now where as you could have periods of starvation 6,000 years ago, 5,000 years ago with 250 million people. So clearly, technology can change and thwart these Malthusian projections that we see. On the other hand how many times can you pull the rabbit out of the hat? And that's why I mentioned the difference between the start of the 19<sup>th</sup>, 20<sup>th</sup> century and the start of the 21<sup>st</sup> century. We started the 19<sup>th</sup>, 20<sup>th</sup> century with a great deal of wild lands around the world. Population increased by what, a factor of five or so in that century.

Now, we start the 21<sup>st</sup> century with five times the population and a fraction of the wild lands. It has almost become a religion to say technology will save us. Well, you look at the details. We are going to have to produce something like 70% more rice to feed the two billion people who will be added to the world's population in the next 30 to 50 years. We've already had green revolution techniques increase the production enormously in rice and nobody really knows where more is going to come from because rice is the food of the world's poor. If you earn under \$2 a day, chances are rice is a large part of your diet. So somebody's got to produce that food. We have this religious belief that it will be produced but we face a situation where world food stocks are at their lowest point in 45 years, where most arable land is under plow, where irrigation is stagnated. So where is it going to come from? I submit that you need something more than a religious belief that technology will save us to give me confidence that we can deal with this problem.

Well, putting all these factors together, which is growth in population, environmental degradation, the trends we saw in the 21<sup>st</sup> century, in the 20<sup>th</sup> century, I began to wonder where is this all leading. I was well aware that, you know, futurism, or predicting the future is God's way of making fools out of experts. And Cicero, I think, said that no

soothsayer should be able to look at another soothsayer without laughing. And the same holds for those who would predict the future. So, I began to think about how do you predict the future and how do you think about the future knowing that experts are always proved wrong and predictions are always proved wrong.

And it occurred to me that, let's say a Genie popped out of a bottle and said if you had one question about the future, what would it be? And I thought about that and then I remembered hearing a study, or seeing a study from the Max Planck Institute that said that waves were getting larger in the North Atlantic and it occurred to me that, gee, why would waves be getting bigger? And you'd say, well, something's changing in the way the Earth distributes heat. Well, what would that mean? We've predicated a lot of our economy and our future on thinking "business as usual" continuing. In other words, we've made a global bet based on stability. And stability is fundamental. In stable times societies grow, economies grow, people innovate. In unstable times societies stagnate or shrink. You have less innovation and people turn inwards and you have more intolerance and more xenophobia.

Well, maybe the way to think about the future is not in terms of what will actually happen, but whether it is likely to be more or less stable than the present. If we could make an informed guess about whether it would be more or less stable, we'd know a lot, because we know how societies and peoples react in unstable times. And I began to think how can you know what are the factors that are going to affect stability? Well, I began thinking about that and I discarded anything that I thought that we could do something about. In other words, international crime is a big problem around the world, but with enough societal will, we can do something about that. Toxic chemicals are a huge problem around the planet. But again, with enough political will we can solve that problem.

What are the long wavelength phenomena that we can't do something about? And I was left with these nine clues. And several of them are indirect results of population pressures and others are indirect results of environmental degradation. But a couple of them have to do with economic factors. For instance, the wage gap has grown even as we've gone through the greatest period of economic growth since World War II that we've ever seen. Migration, a derivative effect of population pressures to some degree, is ultimately destabilizing and is very hard to do something about, particularly when you have declining populations in the developed world and exploding populations in the developing world. Changing climate, regardless of how climate changes and who's causing it, the fact that it's changing undercuts the basic assumptions of our economy going forward because climate is the context for all human activity. So that's a big one. The rise of infectious disease, which is both a symptom of instability and a cause of instability, also increases. It is also to some degree, a derivative effect of population pressures and the growth of world mega-cities and migration. And mega-cities themselves, as I've noted, any system predicated on people behaving better than they've ever behaved in the past is not a good bet. Then one of my clues was the rise of religious fundamentalism. And I wrote this book long before 9/11.

The book, I wrote in 1998 was meant to be a look forward 50 years, testing this hypothesis about whether we faced a more or less stable future than we have in the present. Subsequently, a lot of events happened and I did an afterword to the book, just after 9/11. And, net what I discovered was that what was meant to look at 50 years forward into the future was more and more becoming a picture of the present. The kinds of instabilities associated with the rise of religious fundamentalism, we saw in Technicolor, of course, in 9/11, in the destruction of the World Trade Center. The effects in change in climate-- the 1997, 1998 El Nino-- contributed to the fall of the Suharto regime in Indonesia and misery around the world. This dramatically underscored the vulnerability of the global economy to weather events. Keep in mind an El Nino is a very mild form of climate change, one which we see every seven years or so, and yet that El Nino caused about \$100 billion of damage around the world.

Baby boomers like myself grew up in perhaps the most stable period in modern history. We've had over 50 years without a great power war. We've had over 70 years since a great depression, worldwide depression. We've had over 80 years since a great killing epidemic like the flu of 1918 although AIDS, of course, is making itself known. And the weather has been good for 150 years. And then of course the whole sweep of civilization has occurred in the Holocene, where it's the best weather of the last couple of hundred thousand years. Baby boomers like myself have grown up in stability, nested in stability. And we think this is going to continue forever. The question is, will it? We've bet the ranch that it will.

There's this assumption that we shouldn't really worry about climate change. That sure, climate changes, but the winners will balance the losers. Yes, somebody will lose and yes, somebody will win. It depends on how climate changes. It's absolutely true that during the little ice age, for instance, it knocked off the Norse colonies in Greenland and if it weren't for the little ice age we'd probably be speaking Norwegian in parts of the United States. On the other hand, the Inuit loved the little ice age because as sea ice expanded, they could hunt ring seals in a wider expanse of the ocean. And so, yes, there are winners and losers but what may be happening with climate is that there is this new paradigm of this notion of rapid climate, change that has just arisen really in the last ten years or so.

The policy makers of the world are still negotiating about a climate change of moderate and incremental change where it's becoming more and more clear that in the past when climate does change it does so very rapidly and tends toward the extreme rather than the moderate. None of the scenarios that were discussed for negotiating the Kyoto Treaty took this into account. So, we have essentially a treaty that's based on looking for the keys under the street lamp because that's where the light is, whereas climate might be doing something else.

The new paradigm of climate change that has emerged in just the last ten is that in the past, when climate has changed it has changed rapidly and in extremes, particularly during the glacial era and possibly during our modern era as well. And in that scenario of climate change, there is a period of transition when the climate flickers. Richard Alley, a

glaciologist at the University of Pennsylvania put it, most people like to think of climate as a dial. You turn it up or you turn it down. But it may be a switch. But when you've changed the switch, it's like a neon light. It flickers before it assumes a new state. And in that case, it's hard to imagine that anyone could be a winner because you are constantly adjusting between warm and cold, dry and wet. And those are the very circumstances that are ideal for unleashing new disease for instance, on the planet. Because microbes and pests tend to reproduce rapidly when climate changes or when an ecosystem changes, it might create an opportunity for them and they can react faster than the creatures that prey upon them.

Well, as a society we've made a bet that climate is going to continue as it has in the past. And in making that bet we've assumed a massive risk. Now, as climate changes, that risk is going to become material and real. We already see increased storm activity, more intense storms; and insurers are beginning to react. They're beginning to try and pull back from areas vulnerable to climate change because they are beginning to realize that just as they've assumed the risk for terrorism for free, before 9/11, they've assumed the risk of climate change for free now. And as they begin to react to the risk of climate change they will pass on that risk. They'll pass it on to property owners and they'll pass it on to businesses. There's an estimated \$2.7 trillion of the ten trillion dollar economy in the United States that is vulnerable to disruption by climate change according to the former head of the Department of Meteorology at Penn State University. That's an enormous amount of the economy, twenty seven percent.

It's unlikely that insurers will continue to accept that risk, for free. So they'll charge for it and they'll try and figure out ways to charge for it and so the cost of business will rise. So, pretending that climate is okay and going to continue doesn't make it so. And it doesn't mean that the costs of climate change won't come back to bite us anyway. Insurers are probably a first line, a first responder, so to speak, because they will see it and feel it first. But they'll pass on the risk to us and they'll pass it on to banks and certain properties will become uninsurable and certain ways of doing business will become more expensive. Ultimately it will have its effect on the world economy. Now, we can either let this happen, let the markets decide what the risk of climate change is, as they eventually will, and particularly since climate is changing quite rapidly at the moment, or we can do something about it, attempt to take action, to at least make sure that if climate is changing, it isn't our fault. Or, if it is our fault, we're going to have to minimize what happens in the future. We're not doing that. There's certainly an enormous amount we could do.

We can reduce our use of Carbon Dioxide. Everybody cries wolf on this thing and says that, well, you'll wreck the American economy. We've made these transitions before in the past, a simpler one was the fear about the destruction of the ozone layer by CFCs in the 1970s and 1980s. The same arguments were brought up when scientists and policy makers first said we have to take action to protect the ozone layer, which was that it would throw thousands of people out of work and put us at a competitive disadvantage to other nations, etc. The transition was seamless. It was too late, in a way. It was about ten years too late and so we're still stuck with some of the consequences of a thinning ozone

layer and ozone holes. But, we took action. The world took action. And these technological transitions can happen. It would be better if they would happen voluntarily, and, not mandated, but they can happen.

I think that the Earth has been sending us distress signals and the distress signals have to do with the pressures of human population and the pressures of the human economy on the ecosystems. And these distress signals are surfacing as ugly surprises. What we've seen is a proliferation of dead zones and algal blooms, for instance, around the world. And these are things that were unanticipated but they can kill fish and they can become breeding grounds for disease. But they're also a by product. They're telling us something about the systems in the planet not being able to absorb our impacts and reacting almost like a blemish on the planet. These algal blooms could be looked at as a type of rash on the oceans and it's a symptom that something is wrong and we need to pay heed to these symptoms. The disappearance of frogs around the world, why is that happening? We need to pay heed to these signs.

The planet is sending us these distress signals and we need to understand what it is saying, what we are doing, and how we can stop what we are doing before we reach one of those tipping points, by which time it will be too late. That's the lesson that we can learn from what happens, like with the Georges Bank and the collapse of the cod fishery. The point at which you see change may be too late. The point at which the system has already started to change, you may not be able to stop those changes. The time to do it is beforehand. It's very difficult to muster political will when everything is going fine and the economy is going fine. And that's why we have to pay heed to these ugly surprises and these distress signals from the planet.