And I just wanted to mention a few more things about community ecology before I move onto the final lecture which I've forecasted to you where I'm going to try to tie everything together through a research story that I want to tell you about. But before we go to that, I just want to present one very famous ecological experiment from your textbook. Because what we're trying to do here in this lecture is bring together the first set of lectures where we talked about biogeochemical cycles and productivity which we think of as the function of ecosystems with the last set of lectures where we talked about population biology, community structure where we actually talk about different species and how they interact. And the structure of the community effects productivity in biogeochemistry. And these processes in turn feed back and affect the structure of the community. And this is something ecologists have known, but it's not easy to demonstrate this experimentally. So one of the famous experiments was done by David Tillman of the University of Minnesota because these are very long-term experiments. And, of course, it's easier to do these kinds of experiments with plants because they actually stay put. So he asked the question is the species diversity of plants in a living community related to the productivity of that community, and also the resistance and the resilience of that community to stress? So what he did is he set up plots. And he went through generations of graduate students monitoring these over many years. This would be a plot that would have a single species in the plot. And here's a plot that has 24 different species in the plot. If we mixed them together they were all indigenous species that would grow there. And he showed first that the total plant cover here as a percent was a function of the number of species per plot. So establishing that indeed productivity, the amount of plant biomass produced was a function of species diversity. And when you think about this it makes sense because the more diverse species you have the more likely they're able to exploit the full suite of resources in the soil and are probably more resistant to predation. So the more diverse the plot it has a greater biomass. The next thing he looked at, and this is in your textbook, was the effect of the biomass to the resistance to disturbance. So this is a change in biomass one year before a drought and then to the peak of the drought showing that this ratio increased with the number of species. And finally the resilience, that is how long it takes for the community to recover after it's been stressed, he was also able to show increase as the number of species increased. So there is a relationship between community structure, and indeed productivity, resistance and resilience increase if there is more diversity, which is, of course, one of the motivators for preserving species diversity on the planet globally. OK. Now we're going to try to tie all this together through this story. Now, going back, many of the slides that I'm going to show you you've already seen. Parts of this story you've already learned from my previous lectures, so I'm trying to tie this together and remind what you know and help you to think about how you can apply what you know to current issues in global ecology. So you remember this, our global carbon cycle showing the photosynthesis of the plants balanced by the respiration of the plants and the animals. You learned this. And superimposed on that is our burning of fossil fuels and land use changes, i.e., cutting down trees increasing CO2 in the atmosphere. And as we showed last time, I mean in the first set of lectures that this sudden excavation of this fossil photosynthate is causing a dramatic increase in CO2 in the atmosphere relative to historical concentrations of CO2. This is thousands of years before present. And we're worried about that. This is all reminding you, getting you in the train of thought here. We're worried about that because there's good evidence that these increases in CO2 are already increasing the temperature of the planet. This is average temperature over the last thousand years. And if it isn't already there is certainty that it will in the very near future. So let's look here in the ocean, my favorite ecosystem, where the phytoplankton, that you know all about now, play a critical role in drawing CO2 out of the atmosphere. And this draw down is referred to as the Ã¬biological pumpÃ® of the oceans. And we talked about this very briefly. Here's the phytoplankton community photosynthesizing, drawing CO2 into the surface ocean. And then because of the food web, that you've learned all about, most of this phytoplankton productivity is eaten by zooplankton and by fish going through the marine food web. As it's eaten they are respiring and CO2 is released and it goes right out of the system. So CO2 in, CO2 out. But some of that carbon, some of that photosynthetic product finds its way to the deep ocean through fecal pellets of zooplankton, through aggregates of dead cells, through just basic mucus that fluffs off of jellyfish. It's all carbon that came from photosynthesis, but some of it settles down to the deep ocean where it's chewed upon. Now, here is where all those deep consumers that I showed you in the DVDs last time are. There are fish and squid and jellyfish in the deep oceans that feed on this carbon that rains down, because there is no photosynthesis down there, and bacteria that then regenerates that organic carbon into CO2. So this functions as a pump. And the concentration of carbon dioxide in the deep ocean is very high if you look at a depth profile of CO2. This is depth and this is CO2. And at the surface, of course, it's in equilibrium with the atmosphere. And it's very high in the deep ocean because at low temperatures and pressures it can hold. So this is a huge reservoir of CO2, so much that if you did a thought experiment and you killed all the life in the oceans and just shut off this biological pump and then you let the oceans mix all the way to the bottom, which they won't do, but this is just a thought experiment. And you let that all equilibrate with the atmosphere, all of that CO2, the concentration in the atmosphere would double to triple what it is today. That's how much CO2 is in the deep ocean. And so this is a natural function of the ocean ecosystem, is to maintain this pump and maintain this gradient of CO2. So this you also learned, remember? That the oceans are not this homogeneous soup of phytoplankton, but there are areas of very high phytoplankton biomass and productivity and low biomass and medium in the green here. And we talked about nutrient limitation of that primary production, which is the availability of nutrients. And what I told you was that the sort of standard understanding of this system was that nitrogen and phosphorus were the primary limiting nutrients, this is all review for your final exam, in aquatic ecosystems. But I told you that I was going to tell you in the last lecture that there was more to it than that. And there is indeed much more to it than that. So for years we thought that nitrogen and phosphorus were the nutrients that were regulating this differential productivity, but we knew that something was wrong with our understanding. Because these satellite images, which I just showed you, of the distribution of productivity showed this distribution. But if you took a simulation model and modeled the global productivity based on the availability of nitrogen and phosphorus to the phytoplankton this is what the model showed. They said this is what the ocean should look like, not that. There should be much more productivity here in the equator and down here in the Southern Ocean than there actually is. And, in fact, people wrote papers why isn't the equator greener? And they had all these different hypothesis for why that might be, a lot of them having to do with grazing with the food web. Well, it turns out that iron is a really important limiting factor in the ocean. And this is a story that has just unfolded in the last 15 years. And I'm not telling you in exactly the order that it unfolded, but more or less in the order that it unfolded. A fellow named John Martin who is an oceanographer out at Moss Landing Marine Labs had been studying iron for quite a long time in the ocean. And he had a hypothesis that iron was limiting. But most people wouldn't believe him because most people, when they went out to measure iron in the oceans, got very high concentrations. So they said how could that be limiting? Well, it turned out that most people were measuring contamination in their iron samples. And if any of you have ever been on a marine ship, if you look around the deck you notice there is always rust. They are constantly painting marine ships, right, because the seawater is very corrosive. And so there is rust everywhere. And it turns out that you have to be heroically clean in order to measure the concentration of iron in seawater. And John Martin and his group realized this and went out and developed these techniques to collect the sample and to have it never see air before it went into the sample bottle. And they acid washed the sample bottles through this process which takes weeks and weeks and weeks. I mean you had to really believe that iron was limiting in order to go through all this agony to measure the level. So his group was able to measure really low levels of iron in seawater, but still they weren't able to convince people because this was such a totally different way of thinking about the oceans. So there was a lot of pushback. He also argued that iron is introduced to the oceans through atmospheric dust. Those people did believe. And that if you looked at the atmospheric dust flux, which is proportional to the iron flux, you'd see that in the Atlantic it is relatively high because you have wind patterns coming off these deserts in Africa. And also over here in the Western Pacific it's relatively high. It's low down here around the Antarctic because there's no land source there. So these patterns of dust delivery map on pretty well to this discrepancy to what we see and what we model if nitrogen was the limiting nutrient. So what John Martin argued was that there was lots of nitrogen and phosphorus in these regions but there's not enough iron for the phytoplanktons to actually utilize that. Remember the Redfield ratio we talked about, how it's the availability of nutrients relative to what's required by the plant that determines what's limiting? So he did some experiments where he went out in the boat and took samples. In the control sample he would add nothing and another sample he would phosphorus and nitrogen and another sample would add iron. And he was able to show that the addition of iron caused phytoplankton to bloom. He said iron is limiting in these regions of the ocean, but everybody said bah, bah, bah, no it's not, we don't believe you. They made up reasons why these experiments couldn't be true. There are not zooplankton in the bottle so this and that and the other thing. And so he persevered. And he said OK. If you don't believe my bottle experiment, I'm going to go out and I'm going to add iron to the ocean, then you'll believe me. So he said we're going to go out with a boat. And what they did was, and my lab was involved in these experiments. We had a small role, that's the boat, in measuring a certain component of the phytoplankton. But they pumped iron into the propeller wash of the boat and made a zigzag path in the ocean where there is about ten kilometers by ten kilometers. And the natural mixing in the surface ocean in about a day would mix that iron through that patch. And, of course, meanwhile the patch is moving. The oceans are moving, the patch is moving, they've got these location buoys, the captain of the ship is going crazy trying to navigate relative to these buoys rather than relative to the solid earth. But we were able to actually follow the patch. And, oh, here's John Martin who was also a friend of mine. And sadly enough he died of cancer before the first experiment showed unequivocally that iron is limiting. But he knew it was so that was good. Anyway, he threw out this line. Â¬Give me a half a tanker of iron and I'll give you the next Ice Age. This was before the experiment because he was trying to drum up enthusiasm for the experiment because he wanted to do the science. But you see the connection here. So what's the connection between a tanker of iron and an Ice Age? Exactly. If you fertilize with iron, the phytoplankton photosynthesized more. It could be argued that they draw more CO2 out of the air and will cool the planet. OK, so he got a lot of attention because of that, even though this was a scientific experiment. So now I'm going to, and we'll come back to that, of course, later. I'm going to take you on an oceanographic cruise so you know what it's like. And this is one that my post-doc went on. This was not the first iron fertilization experiment. There have been about five of them now, but this was one of the actually one of the more recent ones that was done in the Southern Ocean. They've been done in the subArctic Pacific, in the Equatorial Pacific. I went on the one in the Equatorial Pacific because I'm a cruising light-weight, but my post-doc went on the one in the Southern Ocean and that's where these slides come from. But just to show you what goes into doing this. These are the vats where they mixed the iron which they mixed with an acid solution. And they also put in sulfur hexafluoride which is an inert tracer so they can use that to trace the patch. Here's the oceanographic ship. What you do when you launch a cruise is you patch things in these vans. And sometimes you have your whole lab in your van. And, in fact, for this trace metal clean work they have special trace metal clean vans where they're all Teflon lined and positive air pressure and all of that. So you ship this out to the Antarctic, and it gets loaded onto the ship, the van, and then gets tied down. This is what the lab looks like before the scientists arrive. It's just a bunch of tables that are tied. And these labs get broken down and rebuilt for each cruise because different types of scientists have different needs. And this is what it looks like when everybody is settled in. It's a very crude makeshift thing very crowded with equipment and wires and is all set up temporarily for a month's worth of work. So here's the shift leaving port. They're going out of New Zealand which is where most of these cruises leave from for the Antarctic. Here it is in the rough seas of the Southern Ocean. You cannot see this very well. But that's an iceberg which is a big problem down there, because that's just the tip of the iceberg. So navigation is very tricky. So here's a radar showing these icebergs scattered around that they have to look out for. Here's another one. Here's how the samples are taken. These little plastic PVC pipes are all electronically wired.

And this ball, when they're open, is drawn into it. So when these are lowered in the water they fill up with water, and then you trigger it and the ball shuts it and then you bring it up. So you can set it, say this one goes off at 5 meters, that one 20, that one 50, that one 100, whatever. Wherever you want them you set them, and then it comes up and you have your water sample. Working in the Antarctic is particularly difficult. In this case this person is out there taking the snow off of these incubators that have sample water in bottles trying to make the phytoplankton think that they are still in the ocean, but they are in controlled experiments here. And they're taking the ice off so that the light intensity stays the same. And this is to summarize the results of the iron fertilization experiment just in a picture. This is the water without iron added and this is the water with iron added. The addition of iron to these waters causes major algal blooms. And here is just some of the data. We can just look at chlorophyll Ã¬aÃ®, which you know is a measure of phytoplankton biomass in the patch versus outside of the patch. And this is actually a satellite image taken off of the NASA satellite of this iron-enriched patch. So there is no question now that the availability of iron limits primary productivity over vast regions of the ocean. I didn't think I was going to use the board but I will use the board. And because the Redfield ratio, which you guys now know, of carbon, some nitrogen, some phosphorus. Remember? We talked about this, 106:16:1. If we add iron to this, iron is about 0.005. Anyway, tiny amounts of iron are required relative to nitrogen and phosphorus in order for a phytoplankton cell to grow. So you can leverage, if there's abundance of nitrogen and phosphorus, it just takes a little bit of iron to get this big bloom. And that was very appealing to people. Any time it takes a little bit of something to get a lot of something, I think people get interested. And I think what motivated this whole interest in ocean fertilization, I think, is motivated subconsciously a lot by man's ability to manipulate a system so large with so little effort. But that's sort of a [subset? . So the success of these scientific experiments, were really just to go out there and understand what regulated productivity in the oceans, were picked up very rapidly by entrepreneurs. And the proposal that was put forward was to develop a commercial ocean fertilization industry where you'd fertilize the surface oceans with iron. And I'm kind of joking here that money comes out the bottom, but I'll show you how this works in a minute. And turn this into a business. And there are a lot of unknown questions here. First the experiment showed that you could increase the phytoplankton growth here, but they didn't show that you could increase this export because the timescale of this is much longer than you can stay out on a ship to follow it. So it could be that this is increased and then this arrow is increased and you have no net flux. There is a little data on this flux now, but it's not compelling yet. Then the next question is if this was an industry, could you actually verify how much carbon was exported, if it could be exported? And then the collateral effects, which we're going to talk about in a minute, could it be made profitable? And the biggest question is what would the unintended consequences be of such an intentional fertilization? And this is where you guys come in because you have learned in this class a lot of things that could help you assess what the unintended consequences are, and we're going to talk about that. But how could you make money doing this? And it depends on a lot of things. Right now you couldn't, but there are people depending on a future in which you could, and this is the way it works. There is an emerging market in carbon trading credits, especially for countries that did sign the Kyoto Accord where there's a commitment to reducing CO2 emissions. And so these carbon offset credits are worth money. So the way this would work is, if it works, was you'd have this industry, you'd fertilize with iron, you'd be able to claim that you buried X amount of carbon in the deep ocean. And with that claim that would give you these carbon offset credits that are worth money. Utilities companies could then buy those, and if there was a cap on how much carbon emissions they could have this would increase their cap. So it's just like, you've probably heard about tree plantations generating carbon offset credits. And that's a going industry now. So that's how it would work. And there are companies, these are some websites. Planktos.com, they have patents filed on this process. How they're able to do that is beyond me since it's published in the open literature, in the scientific literature, but they do. Their mission is to develop formulations to [manage? phytoplankton productivity in carbon export. There's another one that you don't have in your slides. I just slipped this in this morning. But here's the website, Green Sea Venture, if you're interested. But it's another company that is marketing this idea. And here's another. I just saw this ad last month in [EOS?] which is a publication of the American Geophysical Union. And it seeks professionals to work on an ocean nourishment demonstration. This is a new word. The oceans need to be Ã¬nourishedÃ®. So there's a psychology here. They'll talk about ocean deserts that are nutrient poor, need to be nourished. And this is not only for sequestering CO2, but the claim is to increase wild fish stocks by fertilization. And so some of these outfits are really on the edge of credibility, and I will let you figure that out yourselves. If you did enough research you could find out. That's not part of your assignment for the class. But some of them are actually really rational-thinking scientists and engineers behind them. So there's a whole spectrum of people interested in this. So why am I concerned about it? In fact, one of my good friends, who is a very good scientist, really thinks we should explore the idea of fertilizing the Southern Oceans to bring the whales back. Because he thinks that the whales are gone because the krill are gone, the krill are gone because the phytoplankton are gone and the phytoplankton are gone because the whales aren't there to recycle the iron. And we don't know any of that, but that's the hypothesis. He thinks the ecosystem needs to be Ã¬jumpstartedÃ® by an iron fertilization. So just to give you an idea the way people are starting to think about ecosystems and our ability to manipulate them. So why am I worried about this? And why should you be worried? Because you know now from taking this class that it's not that simple, that ecosystems are complex. And you know that if you fertilize with iron and you create a lot of organic carbon, phytoplankton, and some of that settles, a lot of that settles down to the deep ocean where there is no productivity, if it's consumed and digested by bacteria oxygen is going to be consumed, right? And respiration, heterotrophic bacteria, that's what you learned in the first set of lectures, oxygen will be consumed and CO2 will be regenerated. But if you have enough of this it will actually, the oxygen in the deep ocean waters will decrease and can even go anoxic if you do it long enough. And when you change -- That's the function of the system, the oxygen concentration. You change the community structure of the system and you'll have a different assemblage of microbes there than you had before. And one of the things that could happen, for example, is that you would increase the ammonia concentration by this remineralization, you could stimulate nitrification and denitrification, which you learned about in my second lecture, I think. And you remember that a byproduct of that is nitrous oxide. And nitrous oxide is also a greenhouse gas that is 300 times more effective molecule per molecule than CO_2. In terms of its greenhouse capability, in terms of its absorption of heat. So you're doing this whole thing to suck CO_2 out of the atmosphere, but if a side effect is creating nitrous oxide, the amounts of which are impossible to predict at this point, you could be worse off than you started. And none of these proposals takes this downstream effect into account. The other thing that can happen in low oxygen waters is the stimulation of methanogenic bacteria which produce methane that is 22 times more effective molecule per molecule CO_2 as a greenhouse gas. So there are ecosystem consequences to this. You cannot just say I'm going to add this and make carbon and that's the end of it, because you make carbon and things happen to that carbon. The other thing that is overlooked that you guys know about, remember this diagram of global ocean circulation? If you fertilize the Southern Ocean with iron and utilize the nitrogen and phosphorus here, when those waters upwell over here along the equation that nitrogen and phosphorus isn't in them. Now, that nitrogen and phosphorus is fueling the productivity of these ecosystems upon which fisheries are based. People are fishing the fish from those systems. So those people should be able to say to these people, hey, you took my nitrogen and phosphorus. That has to be factored into your balance sheet. My loss of fish, my loss of income from the fish needs to be factored into your balance sheet for your carbon credit. And if you do that the profitability is really marginal. Finally, there are models from a group at Princeton that show if you do this in a sustained way that after many, many years, this is 1500 which is the extreme, but even after 100 years you create, this is latitude. Here's the equator 40 degrees, 40 degrees south. So this is a broad swath of the ocean and this is depth, OK? So this shows a huge, huge anoxic zone in the oceans that would be causes by sustained fertilization in this way. Not surprising, you're making a lot of organic carbon. It's going to be consumed by bacteria. So that is all a story, a scenario to get you thinking about your future and your relationship with the earth's ecosystems in the future. Because our relationship with these systems is changing dramatically. We are now in charge. We've been in charge for a while, but we haven't taken the responsibility of being in charge for a while of these systems. And your generation is going to be making these kinds of decisions. As we move forward and we experience the aftermath of some of the manipulations we've done in the past like burning fossil fuels and increasing CO_2 in the atmosphere there will be choices to make. Do we just adapt to this global warming or do we know enough about how the earth works to try to counteract it in ways like fertilizing the oceans. And then you'll have to decide are the risks of fertilizing the oceans much greater than the risks of adapting to climate change? And a new trend in thinking about the earth is thinking about nature and ecosystems as not simply as something that we value because they're part of our world and we should set up reserves so that we can enjoy them and see nature and so generations in the future will know what natural ecosystems look like, but starting to think of ecosystems as things that provide services for humans and actually have a monetary value that is not part of our economy, it's not part of our economic system but they provide functions to our world for free. And so as we destroy them we're losing those functions. And this is a very well known paper. There's a journal called Ecological Economics that tries to talk about factoring in ecosystems into our economy. And this is a very well known paper on the value of the world's ecosystem services and natural capital. And course this is impossible to do but you've got to try. So they evaluated the ecosystem services as worth $33 trillion. And this is just a brief list of some of the services that they analyze in this. One that's pretty easy to wrap your brain around is the pollination of crops by insects. We rely on insects to pollinate crops. They do it for free and we rely on that. And just this is estimated to be worth $6 billion. That if you had to hire somebody to manually pollinate your crops if there were no bees and all of the things that are doing it, it would cost $6 billion globally. There is decomposition of waste, recycling nutrients, dispersion of seeds, control of pests, purification of the air and water, ecosystems to do this. And this is compared to the GNP of $18 trillion per year, the global gross national product. So this is sort of a shift in our thinking about how we think about ecosystems. And just in the last -- This slide was in one of your handouts about, I don't know, five lectures ago, but I didn't get to it so I thought I would bring it in now. Just in the last, well, April 14th was announced this Millennium Ecosystem Assessment Report, which was over a thousand scientists worldwide assessing the state of the earth's global ecosystems and from the point of view of strengthening capacity to manage ecosystem's sustainability for human well-being. So the focus is on how do we manage these things for ourselves and the future generation? And you can go to the website if you want to get depressed. Well, you can get depressed about what we've done. But you can be optimistic that we're really facing up to this challenge in a very systematic way. But the bottom line is that two-thirds of the natural machinery of the earth has already been degraded by humans. And water use is dramatic. Major rivers are dry before they reach the oceans. We are mining groundwater basically. We're taking water out of the ground much faster than it's being recharged. One-quarter of all fish stocks are already over-harvested. I mean we're in a non-sustainable mode. I don't need to tell you. You read the newspaper and you know this, and so I'll skip over this. Oh, just this last part I think is the most important. The argument is that more and more people are going to be living in the cities in the future, so less and less in touch with nature. So nature is going to be more and more of an abstraction to us. And people are really worried about this because conservation of natural spaces is not just a luxury. This is a dangerous illusion that ignores our dependency on these systems. And we have to really strengthen that understanding. OK, so now I want to lead you, this slide several students have told me is the only thing they remember from this class and my other ecology class. And that makes me very happy. If this is the only thing you remember that's great because this is really the take-home message for you and your generation. And this is how we have changed our relationship to the earth and this is where we are right now. So you learned in the first lecture about the biosphere, autotrophs producing organic carbon, heterotrophs consuming organic carbon and with a little bit of input from the earth's crust, nitrogen and phosphorus, and this system running pretty well before humans. And before the Industrial Revolution societies fit into this system of tight recycling taking a little bit off of the autotrophic productivity and putting a little bit of waste into the system. But then we had the Industrial Revolution. We've cut down massive amounts of trees. we've changed the very landscape of the autotrophic system, and we've dramatically increased the waste stream. And we're mining the lithosphere in a huge way, elements, mining for metals and things used in manufacturing, etc., which is, of course, increasing this waste stream. So this is where we are now. And we know that this is not sustainable the way we're operating. So this is your generation's decision. Are you going to go this way or are you going to go that way? Very simple. You've got to point your compass in the right direction. So this way just increases these streams, the waste stream and the erosion of the natural ecosystems and the mining from the lithosphere. This stream works toward recycling within the societies that we've already built, restoring natural ecosystems so they can do their functions properly for cleaning air and water, and leaving enough productivity for the rest of the heterotrophs on land. You know we're not the only heterotrophs. There are all these other species that rely on this primary productivity, the birds and, well, all the species. So we need to leave some of that for them so the ecosystems can sustain themselves. And so this is where we should be. And we just need to find the will to get there. So easily said, not easily done. And there's an organization called The Natural Step. I put this website, which you might want to write down because I don't think this was on your slide, if you're interested you can write it down, that I think has a very, very creative approach to working with industry to try to direct things in the right direction and where they talk about the compass. And they say there are basic system conditions for sustainability that if we don't maintain we will be going in the wrong direction. And it's just a total no-brainer. It's very simple. Substances from the earth's crust must not systematically increase in nature. Obviously, that's not sustainable if you do that and substances produced by society must not systematically increase in nature. We cannot keep pouring waste into nature. The physical basis for the productivity and diversity of nature, i.e., the green part, the autotrophic cycle cannot be systematically deteriorated. And then they add to this we must be efficient enough to meet basic human needs. We have to work toward efficiency which is working toward tightening this recycling here. And they've been very effective in many countries in pointing industries in the right direction. Every time that they make a decision about what metal to use in a particular manufacturing process, they look at how much of that metal has already been mined. Is there an alternative metal that they could, etc. They're constantly using at this compass. OK. Obviously, the compass is not pointed in the right direction. A no-brainer. Building cars that use more fuel and get less miles per gallon is not the right direction. So some of these are very easy to answer. And I don't want to cast dispersion on SUVs, but in case you didn't recognize it that's what that is. I mean fuel efficiency is here, we can have it if we want to, and we need to work on that. And finally, well, this isn't finally. This is second to finally. I love this cartoon. This is the [doctor Saturn? or whatever looking at the earth and diagnosing our planet at this stage in its evolution. And finally I'll leave you with this image which is my favorite image of the earth because it has no national boundaries and it really does remind us that it's a living planet and that time is now. I mean, I know this sounds overdramatic but it's not. I mean we've changed this planet so much in the last 200 years relative to all the years before. And the next 50 years, your time to make a difference is absolutely critical, so I hope you guys will go off and save the planet for us. Have fun and have a great summer.