>> [Background music] NEWSCASTER: Here are some of the horrific headlines.

>> NEWSCASTER: The UN is issuing a dire warning on climate change.

>> NEWSCASTER: ... harrowing scenario of how human civilization might collapse in the coming decades.

>> NEWSCASTER: One million species now face extinction. Many-

>> CATHERINE RIIHIMAKI: Have you ever felt it's all hysteria?

>> NEWSCASTER: Existential threat to human civilization.

>> CATHERINE RIIHIMAKI: That environmental Cassandras have been around too long to take seriously?

>> NEWSCASTER: There will be irreversible damage.

>> CATHERINE RIIHIMAKI: Or maybe they're right about the coming environmental apocalypse, but it's just too late or too big a problem to do anything.

>> NEWSCASTER: Experts say that we have until 2030 to avoid catastrophe.

>> CATHERINE RIIHIMAKI: Let's pause the soundtrack for a minute and ask the experts. Should we be scared?

>> STEVE PACALA: Yes, we should be scared. We should be scared stiff. But we shouldn't be scared to inactivity because there's a lot we can do to solve these problems.

>> CATHERINE RIIHIMAKI: That's Professor Steve Pacala. Steve is one of the most knowledgeable people on the planet about, well, the planet.

>> STEVE PACALA: I'm a professor of ecology and evolutionary biology at Princeton University. I've worked on, primarily on problems of carbon and climate for the last several decades and really, in all dimensions of the problem.

>> CATHERINE RIIHIMAKI: My name is Catherine Riihimaki and I'm a geoscientist who works on science literacy. Steve is here to help us understand the scope of the problems and to start us on a journey toward practical solutions that will require expertise and buy-in from people across our societies. Steve, welcome to episode one of All for Earth.

>> STEVE PACALA: I'm happy to be here.

>> CATHERINE RIIHIMAKI: Tell me a little bit about how you frame the broadest view of today's environmental issues and the ways in which they may intersect with each other.

>> STEVE PACALA: So there are four big environmental problems that are much in the news. You hear a lot about the climate problem these days. It's really on, on, on everyone's mind with the coming election in the US and that sort of thing and emerging as such a big, a big issue. But you also hear a lot about the water shortage, the water crisis and the fact that humanity's need for fresh water is growing at a time when climate is disrupting its supply, climate change is disrupting its supply. You hear a lot about the food problem. Humanity's demand for food is, is slated to double by mid-century over the next 30 years. At the same time that we're trying to solve the climate problem and at the same time we're trying to solve the water problem. And of course need water to grow, to grow crops. And finally you hear about the biodiversity problem, the, the impending possibility of a mass extinction caused by people. So these four huge environmental problems - climate, water, food, and biodiversity - are all happening simultaneously. They interact with one another and that the solutions for some would actually damage others. And so you have to, you have to solve them all simultaneously if you want to avoid calamity. And unfortunately, this is falling on the coming generation now. There's 30 years in which to do this, sort of the lifetime of a career. It's the, the sad bequest of my generation to theirs.

>> CATHERINE RIIHIMAKI: Can you talk a little bit about some specific interactions, sort of how the trade-offs might work for one issue intersecting with another?

>> STEVE PACALA: Sure. The, the, you hear all the time that one of the big solutions to solve the carbon and climate problem is to grow trees. We're going to grow trees all over the place because trees eat atmospheric carbon dioxide, the primary greenhouse gas that humanity has added to the atmosphere by burning fossil fuel and that is causing climate change. And trees eat this stuff for a living and turn it into tree. And that removes co2 from the atmosphere and helps to mitigate the climate problem. This always sounds like a great idea because it would allow you to still do some emitting and take the emissions back by growing trees. But the problem is that you need a huge amount of land to do this, and that land has to come from somewhere. Just about all the land on the planet already has a designated use. It's either there's growing crops or it's supplying fodder for livestock or it's a biodiversity preserve. And if you then take, say, a large amount of agricultural land out of production to grow forest on it to solve the climate problem, then what do you do when the food supply needs to double?

>> CATHERINE RIIHIMAKI: Okay, let's keep playing this game. So, how about water and climate and water and food?

>> STEVE PACALA: Yeah, so water and, and food is pretty obvious. Climate change changes the distribution of rainfall around the planet and then inevitably puts some of the rain where the people and the agriculture aren't, right? And the people that are left behind are now encased in and surrounded, circumscribed by borders that are not necessarily permeable. And what are they to do?

>> CATHERINE RIIHIMAKI: You know, it, you said water is obvious but I think it's not obvious to people how much water we use for agriculture as opposed to directly drinking this stuff, right? And so I think the perilousness of that situation, that something like three-quarters of our water usage is for agriculture, I think that sort of highlights the potentially dire nature of how then changing water supplies might impact real people.

>> STEVE PACALA: Yeah, I mean that's a great point. So much of our water use is for irrigated agriculture. Now, the good news is that like a lot of these problems, there is the possibility of avoiding the worst of the catastrophe, right? Because, because with water, there are policies that can make much more efficient the use of water in agriculture and for other purposes, but we'll talk about that I guess later in the program.

>> CATHERINE RIIHIMAKI: We can talk about that now. Now is a great time to talk about that.

>> STEVE PACALA: I didn't want to be jumping the gun. But you know, it's always easy, in my, in my business I work on both the environmental problems themselves and on the solutions. And people I know in the, in the first, in, in sort of the first profession, people work on environmental problems, are constantly bummed out. And they're bummed out because we aren't taking these things seriously enough and the problems are getting worse. The climate problem is probably the worst of these because, you know, everybody knows there's this dire problem and then where are the big emissions cuts, you know? And at the same time, if you're a scientist everything you study is getting more and more negatively impacted. You discover more and more negative consequences all the time. On the other hand, if you're a person who works on solutions, because these problems have caught the attention of the best and brightest, so many young people with real talent have moved into these areas. We have experienced a revolution in our capacity to address them. And so if you're a technologist in one of these problems, you're, you tend to be kind of an optimist because all of a sudden you have the tools you need to address them. Because I work on both, I feel whipsawed. But, but, but there, there really is reason for optimism.

>> CATHERINE RIIHIMAKI: Well, so I'm curious, you know, what, what skillset you feel is really needed to solve these problems. You and I have worked together on a course that you developed in investigating the ways in which these four issues collide. But the other aspect of it is not just that you're bringing together four issues, but also different dimensions of looking at the problems and so you represent a scientific perspective. We have an economist, we have an ethicist, we have someone who is really bringing kind of a communications and culture perspective. Can you talk a little bit about sort of why you feel like the, all of those dimensions are needed?

>> STEVE PACALA: The scale of these problems is global and, and humanity has never successfully tackled a problem of this sort, let alone four of them simultaneously. If you were to successfully solve these problems, among other things, you're going to need to plan the use of every square meter of the Earth's surface at mid-century. And it would require a degree of international cooperation that is, is, is difficult to imagine. So the easy way to think about it is that if you want to solve just for instance the climate problem, you need to have technological, the technological capacity to provide the energy that people need without the, the, the greenhouse pollution that our current energy system produces. So, technology is really important. You need to understand how much of that you need and by when, and those are scientific issues, all right? So, so the science, the basic science is important and the sort of engineering technology is important. But of course the, the technology has to be economically and politically feasible to implement. It can't be something that nobody could actually accomplish, could actually do.

>> CATHERINE RIIHIMAKI: Right.

>> STEVE PACALA: It has to be ethically defensible or you're never going to sustain the political momentum to get the job done. And it inevitably is going to involve the creative side of humanity, because it's, it's, it's a generation, it's decades to solve these problems. And you have to sort of stain the empathy of a species for all of us, over, over that period. You know, these problems don't just affect us in the United States. They affect people in, in Assam province in India and in, you know, all over the world, people very far removed from us, and, and very unlike us and we're going to have to understand what they're facing. Because their capacity to, to, to withstand the, the damages is sort of much less than ours.

>> CATHERINE RIIHIMAKI: And, and it seems like the sort of arts and literature part of that is partly around building empathy that's beyond just policy and sort of making our hearts feel what they're experiencing, not just our heads understand it.

>> STEVE PACALA: Yeah. I mean, the arts and literature are all about, they're the only way we have, really, to be able to understand the way a person very unlike we are in a culture that's far removed from ours, maybe even a time that's far removed from ours, the way that person feels. And so, and so so much of our understanding comes from how we feel about, about something.

>> CATHERINE RIIHIMAKI: Right. So let's zoom in then on sort of the specifics of solutions. Do you see things that are coming into discussion that are grand enough, big enough scale that they can make a difference, but are also feasible to accomplish, and sort of, it seems like that tug is really important. That, you know, it's got to be huge because these are huge issues but it also has to be feasible to happen.

>> STEVE PACALA: With the climate problem, 15 years ago if you said do we have a cost-effective technology to replace fossil fuels wholesale, the answer would have been well we do, but it's expensive. All right. It's really expensive. And now just in the last few years we've experienced sort of the coming-of-age of an energy revolution that is unlike any we've seen in more than a century as a species. All of a sudden, wind and solar are the cheapest forms of energy, far cheaper than any other

form in the right location and getting cheaper by the minute, all right? This was the result of sustained, thoughtful policies by the nations of the world that have slowly but surely brought down the cost of wind and solar and made it possible to generate electricity without, without putting greenhouse gases in the atmosphere and for cheaper than we can do it today. Now, of course the problem is that the wind doesn't blow all the time and the sun doesn't shine all the time. So the, the source is intermittent. You need some sort of firm source of power to back those up. One of the firm sources of power is natural gas with carbon capture and storage. The natural gas supply, though, even a few years ago was not sufficient to, to expand to the level that you would need if you were going to rely on that as the firm source of power. But there was a, there was a shale gas revolution and the cost of natural gas is now much lower than it has been and the supply is more than sufficient for what would be needed. Finally, you hear of that batteries, after not really changing, we had lead acid battery cards in, in the early, you know, in 1900. And, and, and we had them, you know, 15 years ago. And then all of a sudden lithium-ion batteries leaped out of cell phones and into cars, and now every major automotive manufacturer and most companies think that we've got a completely electric future for our light- and medium-duty vehicles. And the, the price of energy storage is going down fast enough that you can see a time when a lot of the firming up of the energy supply can be done by something other than fossil with carbon capture and storage or nuclear which are currently our two, our two cost-effective options. So that's also changed fundamentally.

>> CATHERINE RIIHIMAKI: Are there things that are right now looking forward that will do the same thing that policies for bringing down solar and wind costs have done leading up till now?

>> STEVE PACALA: So are we investing sufficiently in R & D? Well, as an R & D person the answer's no, all right? We should be investing more in long-term R & D; at the same time, this energy revolution is in, is, is in full swing and so many smart people are firmly lodged in it now that I expect more, more innovation. We have probably even more acute need on the, on the food side. We have to, we have to double food production on the current arable land if we're going to solve these problems. And we can probably do it but that's going to require sustained, hard effort, but we do have tools that we can bring to bear on this. But that's a science problem still and it's a science problem that's got to keep going steadily. The, you know, the, the crop varieties have to stay ahead of a changing climate and they have to say, stay ahead of evolving pests for that whole period. On the water problem, there are a lot of technological solutions that can be done also but there's some great policy solutions as well. As you know very well, Catherine, I think I learned it from you, the, the, if you price water, if you actually charge for the water that, that farmers used to irrigate, then the, the use of water goes down just dramatically by a factor of ten or even more. So so much of the solution to the water problem is changing the sort of political acceptability of distributing the resource in a way that causes people to care about how much of it they use. And on the biodiversity problem, there we've kind of got to leave nature alone to maintain the biodiversity. We have to actually set land aside. And we know how to do that, but the one thing we can't do, for instance, is to cut down the tropical rainforests and the way not to cut down the tropical rainforest is to be able to grow our food on land that, that isn't tropical rainforests currently. And to solve the climate problem without converting for instance the tropical rainforests into a gigantic biofuels plantation or something like that.

>> CATHERINE RIIHIMAKI: So let me bring it to like a really specific example, which is the one that everyone is talking about right now, the Green New Deal. Do you see the discussion around the Green New Deal as being a net positive or problematic for actually making progress on some of these issues?

>> STEVE PACALA: So, so I applaud the energy and the intent and the enthusiasm behind the Green New Deal. I think that, you know, I, I was in Washington at the, the, I think it was with the House of Representatives the day the Green New Deal came out. And, and it was fantastic because I went from fringe to center, you know, in one fell swoop. And the thing about the Green New Deal that they've embraced and embraced correctly is, is the job that humanity faces. The, the job that humanity faces is to eliminate net greenhouse gas emissions by humanity altogether. The problem with co2 is that essentially it stays in the atmosphere for so long. You should think about it as forever. The real answer is sort of centuries but still, it's up there for so long that you actually just have to stop emitting it or it just keeps making climate change worse and worse and worse and worse. And so to complete and, and when, how soon do we have to eliminate it? Well, you know, there's a lot of work that's been done. The, the political solution is to limit the atmospheric or the climate change to two degrees Celsius mean, mean warming or one and a half degrees aspirationally. That was part of the Paris, Paris agreement. And to do that, we basically have to eliminate greenhouse emissions by humanity sometime for two degrees late in the century, for one and a half at mid-century. Even if you were going to do two degrees in developed countries, you'd have to do it by mid-century. And so that means this sort of thirty-year period coming up. You've got to go from basically a full-on fossil economy to nothing, to, to, to net zero emissions. So, so that's what the Green New Deal has embraced, is that wholesale swapping out and it's put the agenda in the front of everybody in the United States now. And so that's really to be applauded. Now exactly how fast you could do it, what sort of policies there are there, there's a lot of hard work yet to go there. But I actually was talking with some of the people that are working hard on the, on the policies behind the Green New Deal and that's still evolving for them. The first documents that came out I think are probably best viewed as aspirational-

>> CATHERINE RIIHIMAKI: And very vague.

>> STEVE PACALA: And very vague, yeah. And so what will finally be transpired? Well, we'll see, okay? There's a lot of hard work that needs to be done there.

>> CATHERINE RIIHIMAKI: I want to just finish our conversation talking about what you're working on now and maybe as a starting point for that, reflecting on where you started 15 years ago which is that perhaps what you're most known for is the strategy of incrementally reducing how much co2 we're emitting and the whole bunch of that put together would get us to a more stable climate. Can you talk about how that work has evolved and what specifically you're working on now.

>> STEVE PACALA: Sure. The, the, in 2003 I think it was, alright, more than, more than 15 years ago, a guy named Rob Sokolow and I were annoyed that one of the claims that was common in public discourse was that humanity lacked the technology to get started on the carbon and climate problem. We knew that we didn't have the technology to sort of finish off, to go to net zero emissions, but we also strongly suspected that we had the technology to get started in a serious way. And so we decide to figure out what technologies were in the marketplace already that could cause, allow humanity to freeze emissions, which we did not do, right? In 2003. Freeze them through 2050 and then subsequently would be in a much better position to drive them down when we had better technology. And so we inventoried the technologies that could do that. And, and there turned out to be more than we needed to get the job done. Now we, we thought about the problem in that way because

we, because we lacked the technology to solve the problem altogether. We just had enough, enough technology to get started in a meaningful way. And as I said, there's been a revolution since then and so all of a sudden now we actually have the technology to finish it off. And so it's been marvelous to see the energy come out in the Green New Deal and the many other proposals to do this and the growing interest in conservative and Republican circles too in addressing this problem. And so, and so here at Princeton we've put together a project that has many, many different participants in it from all kinds of organizations and companies and whatnot. And what we're doing is to cost out for the United States the transition to one of several net zero emitting energy systems. We're trying to be completely policy agnostic and so we're costing out the transition to one that would be favored by the, by the most intense Greens with no fossil or nuclear at all in it. We're trying to cost out systems that would be in which we use everything that we currently have which would include fossil and nuclear. And we even costing out one for instance in which the, not in my backyard backlash, for all the wind and solar you need actually causes us to invest even more heavily than would be economically optimal in, in fossil, with CCS and nuclear. So we're trying to actually just provide a blueprint, find out, you know, how many hard hats you've got to, you've got, you, you've got to hire and where and when, how many miles of, of high-voltage DC lines do you need to build, and how much of the cost, where you're going to put them and how do you get them regulated, you know, how do you get them through the regulators and how many miles of pipe and how much steel and how much aluminum, how much everything. How much land to figure out what the sort of structural impediments are to the transition to, to bring as much rationality as possible to the developing passion here so that, so that everyone can sort of have a more productive debate.

>> CATHERINE RIIHIMAKI: And who's at the table for those discussions?

>> STEVE PACALA: So we, so there were personnel from a wide variety of, of organizations and, and it's, it's probably not right to say that the this project is endorsed by all these organizations. We haven't even come to a conclusion yet but the people who are actively working on it come from organisations as diverse as the Academy but also environmental NGOs, some of the biggest environmental NGOs. And also some of the biggest fossil energy companies in the, in the world.

>> CATHERINE RIIHIMAKI: And it's important to have them there because-

>> STEVE PACALA: Well, it's important to have them there because they know a lot, alright, about, about some, some aspects of this problem. When it comes time also for, for the veracity of this work to be judged, you want evidence-based decision makers to, to, to look at it and to be able to look at it. And so some people, and so the, the, the group I mentioned spans a broad range of political constituencies, too.

>> CATHERINE RIIHIMAKI: Right.

>> STEVE PACALA: And, and might help obviate some of the confirmation bias that would otherwise develop in that process. But the main reason I want all those people at the table right now is that they all know something, right? They've all attacked this problem from different angles and it's such a hard problem that you actually have to have all those voices in the room to come up with any solution that

you can, that'll actually work.

>> CATHERINE RIIHIMAKI: So you said that you don't have conclusions yet but I want to finish with two questions. One is are you optimistic that some this will be feasible? Maybe not every single pathway but that it will be doable? And then the second question is what happens next? Who do you need to convince?

>> STEVE PACALA: So I actually absolutely believe this is feasible now. The United States is the best resourced country in the world to, to go to net zero. We've got fantastic resources for wind and solar. We've got fantastic technological capability that, you know, that develops new things all the time. We've got a fantastic supply of natural gas. We have geologic reservoirs that are mapped better than any place in the world where we could put co2 if we, if we needed to. So, and also we have a land, okay? We have all kinds of land. We're actually a land rich country in a way that few countries are. And so, and so doing some negative emissions by, by for instance growing trees is actually feasible in the United States whereas it wouldn't be feasible in many other countries. So I actually do believe that this is feasible, not just feasible but probably possible to do for about what consumers pay today. All right, so this is really just a, an orange instead of an apple if we just go about it in a deliberative way. Who do I have to convince? Well, the answer is this is a resource for people who want to do the convincing. That's the way I look at it. We're not going to sort of go out and do the convincing. That's not our job. Our job is to make sure that people who want to convince for a living from all different perspectives, people who want market-based solutions, people who want command and control, people who want a carbon tax, whatever, that they know what it means to actually solve the problem.

>> CATHERINE RIIHIMAKI: But primarily policymakers.

>> STEVE PACALA: Oh, yeah. But, but also, but also people in, in companies. And you know, what is a policymakers respond to lobbying. Who does lobbying and, you know, groups with money, right? So, so, and interests. So it's really everybody.

>> CATHERINE RIIHIMAKI: Yeah.

>> STEVE PACALA: Right? And ultimately, it's policymakers that are going to have to make the decision and not just federal policymakers but also state, local.

>> CATHERINE RIIHIMAKI: Well Steve, thank you so much for all of this insight. Thank you for setting the stage for a series of interviews delving into more details about the environmental challenges and solutions and hopefully we'll be able to get into even more aspects of all of the topics that you've given us a glimpse of, so thank you.

>> STEVE PACALA: Well, thanks for inviting me.

>> CATHERINE RIIHIMAKI: Steve Pacala is a professor at Princeton University and one of the leading voices in environmental science and policy. Please subscribe to our podcast feed to get our subsequent episodes. I also hope to see you all in person October 24th and 25th at Princeton University for a celebration of 25 years of the Princeton Environmental Institute. Several of our podcast guests including Steve Pacala will be speaking at the forum and there will be many more leaders in all aspects of the environment and sustainability. Until then, be well.

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