

Transcript | Physical climate risks implications for investors

Fiona Reynolds:

So we've got two great speakers with us today. I'm joined by Chris Goolgasian, who's the director of Climate Research and a portfolio manager at Wellington Management here. And then Zach Zobel, who's a scientist at the Woodwell Climate Research Center. So thanks for both being here. I'm going to start with you, Zach, and get you to [00:00:30] describe for the audience here really what the Woodwell Center does, what its mission, sort of the research approach. And then, talk to us also about why you partner with an asset management firm.

Zach Zobel:

Yes, sure. Well, so the Woodwell Climate Research Center is located in Falmouth, Massachusetts. We've been around for several decades now. Previously we were the Woods Hole Research Center, until [00:01:00] about August of 2020. So, for a good chunk of the time we were under a different name. Our mission really is action. We do academic-quality climate research. But the traditional academic sense that you may be familiar with is academic-quality research as a means to publish in academic journals. We take that [00:01:30] science and try to deliver it to stakeholders and policymakers, and asset managers, who can turn that into action, climate intelligence into action. And that really is the core of our mission at Woodwell.

In terms of why we would work with asset managers, simply put, nothing can get done without the financial systems being onboard. This is going to have to be a [00:02:00] rapid and total overhaul of how we've done things, basically for the last 100 years. We don't have much time to waste, and it can't be done without the financial institutes. It really, and

absolutely, they might be the most important vector. You have the political realm but as many of you know, things move a lot slower in the political realm than they may in the financial systems. And we don't have [00:02:30] much more time to limit global warming to a level that would be in agreement with the Paris Accord thresholds.

Fiona Reynolds:

Thanks. So Chris, can you tell us then about what you do at Wellington? So how do you take this information and integrate it into your investment process? And how does the partnership with Woodwell and Wellington work from your side?

Chris Goolgasian:

Sure. I'll just open with [00:03:00] thanks everybody for coming, and it's a pleasure to be here. I met a number of you last night as well. And maybe just talk a little bit about the most important role that we have, which is translation, because we take science and finance, and the two things have very little in common, and we learned that early on. And I'll tell you a quick, somewhat funny anecdote, which is Phil Duffy, who was the president of Woodwell when we started, and is now on call to the Biden White House, probably one of the [00:03:30] smartest people I've ever met in my life, and a wonderful, wonderful man. When we were negotiating back and forth, I said something about basis points, to which he said, "What's a basis point?" (laughter) And I said, "You're hired." This is who we want to work with, we want to work with a scientifically led organization, not something that's just trying to cater to Wall Street with green and yellow and red stoplight reports, and a lot of the things you have seen. And that translation to tell him [00:04:00] what a basis point is, and for them to explain to us why we're going to have more floods and droughts, in layman's terms that we can understand, that translation is everything. Like that's the whole magic of what we do.

I think of it a lot in terms of academic terms. If you look at the great school we're at here, I teach at a much less prestigious school, but I'm sure they have the same trait in common, which is that the departments never interact with each other. Right? Probably the finance department and the humanities department don't even know each other. [00:04:30] And that's a problem, and in the climate world, it's a big problem. And this interaction effect is everything, and it only hit me maybe in the last six months that the last SDG, which is public partnerships, if you go through the whole list, is actually probably the most important one. And I never really realized that until recently. So I'll start with translation is the key thing.

The second thing is, how [00:05:00] many of you have raised the same point, which is this stuff seems abstract, how do I implement it, etc.? It's a very long time horizon. And the main way that we broke through on that was upon a visit to the Center with Zach and team, on the top floor they have a mapping room, and they have two geospatial analysts who create these amazing maps, and that's when the light bulb went on for me, that we need to make this visual, and we need to get it out of [00:05:30] Excel rows and columns, right? Our industry lives in pattern recognition, looking backward to try and look forward, small-cap premia works for 80 years, it should keep working. Climate change is nothing like that, you don't have the history, so you have to be visual and creative, and actually say the projections of the future are what we're going to use for the future, not the history, which is how Wall Street works. We use the history [00:06:00] to predict the future.

So when we came back from that meeting, I said we have to create a mapping tool, put all of these seven risks, which Woodwell helped us define — heat, drought, wildfire, hurricanes, flood, water scarcity, sea-level rise — put them in a mapping tool with company locations and

company data in the tool, and now you're changing the investor mindset about the future, and actually instigating [00:06:00] a different part of the brain to start to think about what could happen, as opposed to how we normally look for rows and data of columns, looking backwards. So that mapping tool, we call it CERA, Climate Exposure Risk App, has really been the breakthrough to make climate more practical.

Fiona Reynolds:

Okay. So can you then, between you, can you sort of give an example of where the research has been used in an actual, [00:07:00] something that you've done, you've thought about your investments, you've done something because you've had this information that you might not have done otherwise?

Chris Goolgasian:

Sure, so we have lots of them. We've rated 1,600 stocks for their physical climate risk, just to put some numbers on that. So, you can think about materiality in your portfolios. About 40% of the 1,600 have received a 5 rating, which would be the highest climate risk. [00:07:30] Inverting that, 60% do not have a 5 rating, right? So, we're not saying that the entire stock market has material climate risk, because it doesn't, but some chunk of companies do have material climate risk, and those are the ones you have to focus on. And so in that list of 40%, we have a number of examples where either investors have changed position or, which happens much more frequently, engaged with the company about the issue. So you can think of -- let's take a semiconductor company; this is real -- [00:08:00] super water-intensive industry, kind of overlooked by, you know, much of the marketplace as a real large water user. But we have the drought and water scarcity maps for the next 30 years all projected out. We then pinpoint the locations of this semiconductor company. They're in a region with

massive drought problems. We talk to the management team: what's your backup plan for this? What's your assumed cost of water? What are you going to do if the government [00:08:30] says, "Semiconductor company, you can't access the water?" And then you talk to the management team and get a feel for, do they have the resiliency plan in place? Do they need to get it in place? What's the capex going to be? We also have frameworks that we give them with suggestions about what they could do; I've been terming this "light advisory." So we have lots of examples like that, but the key thing, and we've been very open about this, is we share the maps with them. [00:09:00] We share the analysis with them. We don't view this as, you know, we have a secret that you can't have. We want them to improve, so we give them all the information.

Fiona Reynolds:

Do you want to add?

Zach Zobel:

The decision making on the Wellington side stays maybe just one layer removed from us. But we get questions, and to just continue with Chris's example, [00:09:30] how might semiconductors be impacted by climate changes? And those kinds of questions, we don't necessarily know the company, we don't necessarily know what it is that Wellington wants to know that answer to, but we'll research the supply chain of semiconductors, we'll research what products are needed, in this case, the water-intensive nature of semiconductors. It was a more science-based approach on where might the weak points be in the semiconductor supply chain.

Fiona Reynolds:

So Chris, how are you then, it sounds to me like you're using a lot of this information in your company engagement and [00:10:30] stewardship. So, how are you integrating that, and how well is that being saved when you're dealing with the companies, and you've got all of maybe this information that they don't have?

Chris Goolgasian:

Almost exclusively to the positive. You know, we, I mean, you're a shareholder, so they're not going to reject what you say, right? But, you know, in many cases, it's to the extreme positive of, they've never seen the information before. You know, there's a wildfire [00:11:00] company and as Zach and team have educated us, wildfire in western Europe is going to be a real thing that in the past people haven't really priced in or had to deal with, and just this last six to eight months, we have seen record amount of acreage burned in some of the countries. And so, we provided the projected wildfire data to this company, and [00:11:30] in a follow-up call, the CEO said to me, literally, he said, "Where did you get these from? I've been Googling and can't find them." And I said, "They're not on the Google machine, you know, we created them. Someday they will be, like, all this stuff will get commoditized, but today they're not in the Google machine, we created them with Woodwell, and we think that these markets are going to be real growth areas for you, and we're wondering, are you targeting these countries for your product?" And so, I would say that reaction of "Where did you get this information from?" [00:12:00] is the norm. There's very little declining or denial that climate change is a real thing; most of these companies face it. They may not want to get into the politics of it, but they're facing it in their operations.

Fiona Reynolds:

So what other projects are you working on, Zach, at the same time?

Zach Zobel:

Currently, I'll leave it at two other [00:12:30] major projects. We have a few smaller projects, but we have essentially three major projects, one of which being our partnership with Wellington. The other partnership, or another partnership we have is with a company named Probable Futures. Their goal is mostly education. They are taking the science and some of the data layers that we produce, and they're making it freely publicly available.

Probablefutures.org is the website. [00:13:00] So far, we've done measures of temperature, precip, and drought, and they're providing education on how you should be thinking about what a climate model is telling you, how you should be using that information, how to understand uncertainty, how to understand that this is predictive in nature, but it is founded in equations that we know govern our atmosphere. It's very technical in nature, but they do [00:13:30] a very good job at explaining and bringing the science to everybody because the mission of Probable Futures is that we, climate intelligence, shouldn't be a for-pay thing. They want to provide everybody with the ability to view their own climate risk.

Another project that we're working on, which we're particularly proud of, is working directly with municipalities around the world. So far, we're just [00:14:00] one year into this project, and a lot of them have been in the United States, but we've also done places in Brazil, Ethiopia, Nepal, and India. And what we're doing is, we're working with town leaders directly to help them understand their climate risk. This is coming at it more from an adaption standpoint. An individual municipality — Chelsea, Massachusetts — is one of them. A very small, individual municipality doesn't have the scale to do large-scale mitigation, [00:14:30] to cut back on CO2 globally, but we're already past the point where mitigation's going to save us. We need to be factoring in both mitigation and adaptation. And these municipalities need

to be thinking about where there is risk. The flood modeling we do is a big-ticket item for a lot of these municipalities, but they're very interested in climate risk across the board and how they need to start preparing and adapting. And so those are our three main projects, with [00:15:00] a few other things in the background, but I'll stop there.

Chris Goolgasian:

I'll just jump in on that. So when we first started working with Woodwell, we said, "What's the biggest, you know, insight or, you think, underpriced concept out in the marketplace?" And Phil and Zach and Christopher and the whole team basically said the same thing, which was "Adaptation." And we said, "What do you mean?" And they said, "Well, all the pain of climate change is now baked in the cake. We have to adapt." [00:15:30] And so the scientific community has already moved beyond that we're going to mitigate our way out of this. We still need to mitigate, we need to do it faster, yes, yes, yes. But we have a lot of pain already baked in — you're seeing that pain live time in the last few years, and it's going to get worse. And the scientists have moved already into that realm, and they look at the world and say, "The world is really unprepared to become more resilient and adapt to heat, drought, wildfire, floods, hurricanes, etc. The world needs to speed that up." [00:16:00]

Fiona Reynolds:

Yes. Okay. On an adaptation thing, since we're talking about that — Zach, what would you say — you obviously work closely with Wellington, but there's lots of investors here in the room, asset owners, investment managers. In terms of what the science is telling you, and we've just talked about the fact that most of the climate's already baked into the system; we can't undo it, we have to adapt, and we have to obviously try to keep the world to under 2 degrees,

hopefully to 1.5 degrees. In terms of adaptation, etc., what would you say to investors that they should be focusing on?

Zach Zobel:

Well, it's quite a broad topic. First of all, you referenced the temperature threshold set out by the Paris Accord. [00:17:00] We're planning for a 1.5-degree world.

Fiona Reynolds:

You are? Okay.

Zach Zobel:

It's going to happen. Whether or not we overshoot it and then come back below 1.5 by 2100 is maybe a different question, but we're going to get to 1.5, almost with absolute certainty.

There are some scientists that still hold out hope that we can keep it below 1.5, but the vast majority of the science community is planning to adapt to a 1.5C world. We're currently in a 1.1C, 1.2C, and we're not even prepared [00:17:30] for that. And due to climate feedbacks, due to the way we still are consuming energy, by and large, in this world, 1.5 is pretty well baked-in, and so we're adapting to 1.5 and trying to stop us from reaching 2. That's kind of the mindset that we take. And so what we do is, we look at, across the board, all climate perils, and we look at, all right, [00:18:00] how much worse are they going to get from right now until we get to 1.5 degrees Celsius? So we look at everything from sea-level rise to flooding to temperature extremes, wildfire, and probably the one I'm most concerned about is how rapidly we're seeing increasing drought frequency. How will that impact our agriculture systems? How will that impact our available water? Drought is increasing rather rapidly but it's not uniform spatially. [00:18:30] Some locations may not see as much of an

increase in drought, but those locations might see a greater increase in flooding frequency. So just understanding the climate risk spatially and where it's at, and that goes back to Chris's point of bringing this out of numbers and showing it on a map — which I will do in a couple of minutes — is really the key here, because not every place is going to experience climate change in the same way, but by and large, scientists are trying to help plan for a 1.5 degree world, because that's what we should be adapting to right now.

Fiona Reynolds:

So I'm going to get you to show the map.

Zach Zobel:

Okay.

Fiona Reynolds:

But first of all, when we're talking about the overshoot, from what you're saying, because we're supposed to be getting to net zero by, well, it's supposed to get to 1.5 by 2050 — but you're saying that the overshoot could mean that it's as far out as 2100? [00:19:30]

Zach Zobel:

NASA now says that we have more than a 50% chance of having a year of 1.5 degree Celsius in the next 10 years. The net-zero pledges are awesome; it's great to see this language being more widely circulated, or more commonplace, but saying net zero by 2050, we will already be past [00:20:00] 1.5 by then. Especially if we say, "We want to be net zero by 2050; we'll put it off until 2040 and then we'll quickly in those next 10 years decarbonize" — that's not really how it works. It's not really what a net-zero plan should be; it should be, "We need to act

right now and get to that maybe by 2050," because it's not an easy process. I'm not saying it is by any means, but the process needs to start right now, because we're going to probably hit 1.5 [00:20:30] in at least one year over the next 10 – 15 years. And that's well before 2050, and so we can't procrastinate, I guess is what I'm saying.

Fiona Reynolds:

Yes. We can't wake up in 2049 and just say, "Ah, we better get busy."

Zach Zobel:

Yes.

Fiona Reynolds:

Which I think some people think will happen. Do you want to show your map?

Zach Zobel:

Yes, absolutely. I wanted to bring just a few examples of some [00:21:00] of the — I would say the bigger findings we've had with Wellington, some of the more impactful maps that we've shown. I mentioned a minute ago that drought is a huge concern for me personally and scientists as a whole, because drought is increasing rapidly in the observations, and this is just extreme drought probabilities in the Mediterranean basin over the next 30 years. That kind of brings up another, interesting [00:21:30] point that came out of this partnership with Wellington: Scientists have struggled a little bit in their messaging, especially in the purely academic sense, by saying, "This is what the climate's going to look like in 2100." People — the general public, by and large, not just asset managers, not just people in the financial system — see that and say, "That's a future-us problem." But what we do with Wellington is

we focus specifically just on the next 30 years, because it already looks bad enough.

[00:22:00] And so here is the annual likelihood of an extreme drought in the 2021 – 2050 time frame. This is based on conditions that we would expect, from 1971 to 2000, so not exactly present-day, but really not that long ago. That was about .5 degrees Celsius of warming if you want to put it into that context. We're now at 1.0 and this is representing 1.5 degrees [00:22:30] of warming, essentially. And almost every other year, over the next 30 years, we can expect to see summers, for those of you familiar with what's going on, like what we saw this past year, in a good chunk of the European continent. Here I just am showing the Mediterranean basin because it is one of the areas in the world that has the fastest-increasing drought probabilities. This is going to have huge impacts, like I said, on agriculture. Water levels — [00:23:00] the Po River in Italy is already run dry this year in some places. The Rhine River is too low to do normal shipments, which is very important to Germany; it's an important transportation route for shipments. I believe — last I checked was a month ago, and I don't think it's improved since then — but they were already down to about 20% of their normal cargo just due to the drought and heat waves, this past summer. And [00:23:30] this is not a one-off event. This is something that we expect to happen with greater frequency. And in some of these darker red areas, or just red in general, it could happen every other year by the time we get toward the 2030s and 2040s, if we reach 1.5 degrees Celsius.

Chris Goolgasian:

Zach, let me just jump in on —

Zach Zobel:

Oh, yes.

Chris Goolgasian:

— to investment, implications of this. So on agriculture, what we turned all this into is some statistics on the breadbasket crops, [00:24:00] the four major ones, and the work with Woodwell says that, in any one year going forward, there's a 30% chance of a 10% crop failure, so a 10% change in productivity of one of those four crops. So a 30% chance of a 10% decline. That's a massive shift. This is ex-of Ukraine and all this other stuff going on — this is just climate-related impact to the four breadbasket crops. And then the second thing, [00:24:30] which is not as apparent, but we came upon it pretty early, is — well, if you have all this drought and massive shift in water levels, it's going to impact hydro power pretty significantly. And we got concerned about that, like, three-plus years ago, and sure enough, now you're seeing all these articles about the hydro power's way down because of the levels of water. And so there's a lot of investment implications once you process this map and then start to extrapolate [00:25:00] what could happen.

Zach Zobel:

Yes, sure. So another thing that kind of goes hand-in-hand with drought, and this shows more of a global map, is the increasing frequency of wildfire. Wildfires are a particularly hard climate peril for us to predict because you still need an ignition source. And in California, for example, [00:25:30] and this is by-and-large true in most of the globe, maybe outside of Africa and the Amazon — in California, 80% of fires are actually started because of human error. We can't predict human stupidity, for lack of a better term. So what we did was we focused on a fire weather index. When are conditions going to be right for a large wildfire to take place, given an ignition source? [00:26:00] And what we found is that we're seeing almost 50% increase in a lot of these major fire regimes globally. This map is obviously not showing the entire planet. It's showing where FWI (Fire Weather Index) has predictive skill

and where there is vegetation to burn. So the gray areas are just simply areas that we decided there wasn't [00:26:30] a high predictive skill of this unit or of this index, and/or there wasn't vegetation. Like, we're not going to predict increasing wildfires in the Sahara, for example. So that's part of the translation process that we go through with Wellington. We could have done this exact index for everywhere in the globe, but we have to key in on the locations where we have confidence in increasing wildfires. And as you can see, that still encompasses a lot of really important global locations, [00:27:00] and, again, the Mediterranean stands out. Western — or eastern Australia and parts of southwestern Australia, which I'm going to talk about a little bit more on the next slide, also stand out. So I don't know if you wanted to add anything, or —

Chris Goolgasian:

No.

Fiona Reynolds:

Well, I live in Australia, so I'm very interested in what you've got to say on the next slide. I'm looking at that and thinking I need to move to New Zealand.

Zach Zobel:

Yes, possibly. [00:27:30] Another idea that's been hard to translate or to get across to the general public, and asset managers as well, is this idea that just because we have increasing drought or increasing wildfires as a result of drought, those same locations are also expected to see increasing extreme precipitation events. Their average annual [00:28:00] precipitation may be going down, but the frequency of these large, extreme precipitation events, the ones that cause the damage, that cause the flooding, can go up in the same areas that we also

have increasing drought or increasing wildfires. And there's been a perfect example of that just in the last three years. I know a few of you are from Australia, but for those of you who aren't, in 2019 to 2020, Australia had what they [00:28:30] loosely dubbed "The Black Summer," where they had wildfires throughout a large chunk of eastern Australia and places that haven't experienced a lot of wildfire risk historically; a very significant series of heat waves and droughts dried out the vegetation, and then it just takes a flick of a cigarette and you turn into a major brush fire. And that's what [00:29:00] took place in 2019 and 2020. Here on this map, the red outline is the extent of where we saw a lot of these wildfires. Now fast-forward to what's happened this year. The same locations that just saw a wildfire and extreme drought two years ago are experiencing a series of extreme precipitation events. Here I show the precipitation totals just from [00:29:30] probably one of the bigger precipitation events this year, but this certainly isn't the only one — where they're getting 400 millimeters of rain in just a week's time. That's several months' worth of rain for a lot of these locations. This caused massive flooding, especially in the urbanized areas, which aren't equipped to filter out that amount of water in such a short period of time. [00:30:00] So that kind of goes back to the adapting, or adaptation, side of things that we've been talking about. We really need to start planning for these precipitation events: How much quicker can we get the stormwater-management system to pump water off of the streets? Because these porous cities, where water can't infiltrate into the soil or infiltrate into the ground, because of concrete, that's the only way you can get it off the streets and out. So, [00:30:30] this is especially true in the United States; I'm not well-versed in Australia, but it's especially true in the United States: Our stormwater-management system is out of date, pretty much, in every major city in the United States — it's pretty much every non-major city, even the smaller ones and probably especially the smaller ones. Our levee systems are out of date, especially in the Midwest, where you have the Mississippi River, the Ohio River, and there are a lot of cities

[00:31:00] along those rivers where the levees are out of date, and that's also concerning. So just a large infrastructure upgrade is needed to accommodate for increasing precipitation extremes. Those are the only three slides. I just wanted to bring a couple of examples, a couple of maps in here to help maybe take it out of the abstract and give you examples of the kind of stuff that we've been showing Wellington over the last four years.

Fiona Reynolds:

Thanks, [00:31:30] that was fantastic. And of course, you know, some of the problems for people in Australia who have been through the fires and then the floods is they can't get insurance anymore. So then you have all of these other flow-on societal effects as well.

Zach Zobel:

Yes.

Fiona Reynolds:

I think they were talking about the average house in some areas to insure was something like a hundred or 130,000 dollars, which for the average person, they of course can't pay the insurance, [00:32:00] so then no one has insurance.

Zach Zobel:

Yes, we see similar things happening in Miami. Similar things happening in the Wildland Urban Interface, which is where you've built houses in pine forests or forests in California. Those communities are also struggling to find insurance. In fact, Phil Duffy, who Chris mentioned earlier, our former president, who's now in the White House, he has a cabin in

California, [00:32:30] and he can't get insurance, and he knows why, but it's still frustrating to him that he can't get insurance.

Fiona Reynolds:

Absolutely.

Zach Zobel:

He lives in that Wildland Urban Interface, where people have a desire to move into the forest because it is beautiful — nature's beautiful in general — and that desire is also putting us into harm, especially in fire — wildfire regimes.

Chris Goolgasian:

Yes, insurance is the first shoe to drop in changing real estate values, without question.

Zach Zobel:

Yes.

Fiona Reynolds:

Okay, [00:33:00] I'm going to open it up to some questions from the audience.

Q: What are some examples of practical adaptation investment ideas?

Chris Goolgasian:

Sure. I'll take that, Zach. So a lot of what you mentioned, we would still say is mitigation, not so much adaptation. Like decarbonizing, cement, renewables, energy, EV, battery storage, all

critically important, but we actually put that in the camp of mitigation/transition risk, not so much adaptation. In adaptation, there is not — to your point, there is not a lot of market cap [00:35:00] investable in public equities. I think they're going to have a lot more private companies and start-ups and all that, and we see them coming through, but in public equity space, you're talking about a small subsector of the industrial sector, some consumer discretionary companies. What are some examples? I'll give you a few. [00:35:30] What we try to do is take the seven risks — heat, drought, wildfire, hurricanes, flood, water scarcity, sea-level rise — and then find companies for each of those where 50% of the company's revenue is attached to one of those risks. So with heat, the world is massively under-air-conditioned; HVAC companies, as a simple example, would fall under the heat risk. Okay? With wildfire, when wildfires happen and when PG&E proactively shuts the grid down, [00:36:00] what's one of the first things people do? They say, "I need to self-power, I need a generator, I need to make my home more resilient." So we have home resilience — things like generators are investable. Things like impact-resistant glass for the person that lives in a hurricane zone, and they put up in their sliding door impact-resistant glass, so when the chair outside flies into the window, it bounces off — these are real things: There's a company that does that. [00:36:30] And I'll just end on that note.

One of my secular ideas is that governments are going to subsidize and provide incentives for resilience, for adaptation. As in some countries, you're going to get a free air conditioner, essentially. In the case of impact-resistant glass, the state of Florida passed a bill a few months back waiving the sales tax for two years on any consumer who puts impact-resistant glass into their home. [00:37:00] This is the government telling you, "We want your home to be more resilient for the storms," and then, of course, it's a benefit to that company as well.

So I think you're going to see a lot more subsidies and incentives for people to become more resilient, and then the trick is to find the companies that help enable that.

Q: What is climate / geo-engineering and does it fall within your investment universe?

Chris Goolgasian:

I'll let Zach handle the science on geo-engineering; in the investable world, it's really not investable in public equities right now. But do you want to just touch on geo-engineering?

Zach Zobel:

Yes, sure. Geo-engineering is a pretty broad topic. It can be anywhere from cloud seeding to trying to help make rain, essentially, in places that are experiencing drought, to as much as injecting aerosols into our [00:38:30] stratosphere to try to reflect some of the sun back into space, to keep things cooler. Basically mimic a large volcanic eruption, which we know produces a year or two of cooling. There's a lot of skepticism in the science. I would say more than 50% of scientists are not convinced that geo-engineering even works, and an [00:39:00] even greater percentage of scientists are more worried about the unintended consequences of geo-engineering than the actual benefit it could have. What if we block too much of the sun, and end up causing another Ice Age? What if, when we're cloud-seeding, we're getting it to rain in that location, but then there's no more moisture in the cloud when it goes to the location [00:39:30] just downstream? There are a lot of unintended consequences of geo-engineering, and it's very much a trade-off. I'm sure India would love us to put aerosols in the stratosphere, for example, but what do we tell northern Canada or Russia when we do that? Can we agree on how much to go in or how much cooling we need? Because it's not evenly dispersed. India probably would have liked it cooler [00:40:00] than

before we even started changing the climate, for example. So, there are a lot of geopolitical ramifications to geo-engineering; are we taking the rain from our neighboring country, is another example. But there are also a lot of unintended science consequences of geo-engineering that I think most scientists would say is not worth it. It would be easier to just mitigate our energy system and [00:40:30] decarbonize than to do some of these creative but somewhat far-out ideas to cool the planet.

Chris Goolgasian:

One — just one final thought on that: If you only read one book, it would be *Ministry for the Future* — fantastic. And there's a passage in there that turns this on its head, in which one character is anti-geo-engineering, and the other character says, "We've already been geo-engineering — it was called fossil fuels." And when you start to think about it that way, [00:41:00] the ethical quandary of geo-engineering should actually subside.

Fiona Reynolds:

Okay. So, we're going to actually continue the discussion on climate in the next session — we've got the role of investors. So, I think we've been really set up well for the continuing discussions throughout the day, so please join with me in thanking Zach and Chris for their time.

END OF AUDIO FILE

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