Jemma Wadham

Marshall Poe
Welcome to the New Books Network.

Hello everybody. This is Marshall Poe, and I'm the editor of the New Books Network, and you're listening to an episode in the Princeton University Press Ideas podcast.

And today we have Jemma Wadham on the show and we'll be talking about her new book, *Ice Rivers: A Story of Glaciers, Wilderness, and Humanity* and it's just out from our friends at Princeton University Press, I should say, Jemma, welcome to the show.

Jemma Wadham
Thanks very much. Great to be here.

Marshall Poe
Could you begin the interview by telling us a little bit about yourself?

Jemma Wadham
Yeah, sure. I'm Jemma. I'm a glaciologist. I've been studying glaciers pretty much all of my adult life, I think, from the first glacier I met when I was about 20. I have a professor of glaciology position at UIT, the Arctic University of Norway and also at University of Bristol in the UK, and I'm the author of *Ice Rivers*.

Marshall Poe
Yeah, and I have to ask, how did you get interested in glaciers? This is not something that you think, oh, jeez, I'll become a glaciologist. Is that the right word, "glaciologist?"

Jemma Wadham
Yeah, no, that's the right word. I don't think I ever did decide to become a glaciologist, but when I was in my teens, I'd read about glaciers in geography textbooks, actually, and I found them absolutely fascinating, these vast rivers of ice, like a serpent moving down through the mountains that carved out the valleys and shape the landscape around them. There's something about that that really captured my imagination, I think. And then I decided to do a degree actually in geography and I chose my degree course based on how much ice there was in the curriculum.

I ended up going to Cambridge actually to study a lot of glaciers and then the more I learned about them and the more I kind of actually did on them, the more I wanted to study them further. So, I just kept going and followed my heart, I think, in terms of what I felt passionate about, which was glaciers.

Marshall Poe
Well, that's a heartening story. I mean, I have to say that in my own case, I studied Russia for many years. I have nothing to do with Russia. My people aren't Russian. They don't come from Russia. I grew up in a place about as far from Russia as you possibly could imagine, but that's what I studied. I don't know why I kept it in my imagination, as you say. So, could you tell us why you wrote *Ice Rivers* and what you were hoping to accomplish with the book?

Jemma Wadham
Yeah. *Ice Rivers* was a book that I'd never expected to write, actually. It emerged because I had a fairly large health crisis at the end of 2018. I had emergency brain surgery to remove a large growth

that was probably on track to kill me, which I had no idea was there. And as I was recovering from that, I had about six months off work full-time and then took another year to come back properly and I think that period I was really getting back in touch with myself and what I really cared about and I wanted to do something and I started writing *Ice Rivers*. I didn't feel up to writing a very hardcore scientific article like I would have done before and I thought, well, I've had all these experiences around the world and wouldn't it be fantastic if I can take people to these glaciers and be their eyes and their ears and take them on that journey, really. Glaciers aren't something that most people actually experience in their lives and I've been lucky enough to be at quite a number of them, actually. I think in writing it, it sort of just almost wrote itself, but in writing it what I wanted to accomplish primarily was to take people on a journey and to bring glaciers into their front rooms and for them to experience them, but also to explain how they work and why they matter to us. And so my primary goal was to fascinate people, you know, kind of the "awe" side of things really, but also to explain why they're changing fast as we warm the climate around them and why that matters and how they are connected to us as human beings on this planet.

Marshall Poe
Well, you've done a wonderful job of it, it's a very readable book and it's full of great anecdotes because you have been everywhere all over the world with glaciers, and we'll come to that in a moment.

I also wanted to say that after reading your book, one of the things I realized is that you may have never seen a glacier but you've seen what glaciers have done, almost everybody at least in North America has. And I'm thinking of [unclear] and big boulders that shouldn't be where they are. Like, in New England. They're just all over the place. Like, there's this enormous boulder. How did it get there? A glacier brought it there.

Jemma Wadham
Absolutely. In North America, a lot of it was beneath the very large ice sheet 20,000 years ago and it's the same in the UK, you know, I grew up in a landscape that had been sculpted by ice.

Marshall Poe
So that's exactly right. Yeah, and I was like, yeah, that explains why there are these enormous boulders where there shouldn't be enormous boulders. Very interesting.

So, I really think the best way to approach this is for you to give us a kind of tutorial on glaciers, and I'm going to ask some very simplistic questions about glaciers and I hope you can tell us the answers to these questions. In fact, I know that you can. So the most obvious one is, what is a glacier technically speaking?

Jemma Wadham
Well, it's not just a lump of ice, which is a misconception, but a glacier forms normally in the high mountains or near the poles where snow falls and it accumulates year-on-year and the pressure of that snow and slight melting and refreezing of it, eventually forms ice. And as more of that ice forms, it reaches enough thickness that the ice actually deforms under its own weight and starts to flow down the mountain.

And actually, that's the really key thing that makes a glacier a glacier is that a glacier flows. It doesn't just sit there. It's not like an ice cube you take out of your freezer and pop in your gin and tonic, it flows down the mountain and it flows in several different ways actually. So one way is that the ice crystals form under pressure, all glaciers flow that way.

But also many glaciers have water at their beds, you know, between the bottom of the glacier and the rock and that lubricates the ice and allows it to slip down the mountain as well. And then some glaciers, they erode their bedrocks, the rock beneath them, particularly soft rocks, and they have this layer of mud beneath them and that mud also gets squashed and deformed under the pressure.

So the glaciers can also ride down the mountain on this kind of conveyor belt of deforming mud. So there's three ways glaciers could flow, but the flow thing is really important to a glacier. And I mean, I guess I called it *Ice Rivers* because if you look at them from say high up on a mountain, and you looked down at it, it looks like a river of ice transporting water. Just like a river in an ordinary landscape would.

Marshall Poe
Right, to follow-up on that is the notion that they're not just lumps of ice. There are a lot of things in them, both chemically speaking and I suppose in terms of little animals and beasties. Can you talk first about what gets trapped in these glaciers chemically speaking? Like, there's a lot of stuff in there.

Jemma Wadham
There is. I mean anything that, you know, when snow arrives on a glacier's surface, it contains pollutants. It contains bugs that have been floating around in the atmosphere. So that eventually gets trapped in the ice, but what's really interesting about glaciers is, so 20 years ago we actually thought they were these sterile wastelands where no life could thrive, and what we've discovered is that they actually have huge populations of active single-celled, microorganisms surviving in the cold, in all sorts of weird and wonderful places that are quite challenging for life to live. And that those microbes aren't just transported in by the snow and become ice. They're actually growing and thriving and living off whatever they can mine from their environment, to allow them to survive.

And actually those microbes, the fact that a glacier is as alive as a handful of soil you might pick up in your backyard and that's really important, how a glacier behaves, and also how it connects and communicates with the environments around it. So, these microbes beneath the glacier, for example, it's dark, it's cold. There's not much to live off. They are actually breaking down the rock and using chemical energy to basically grow.

And in the process of breaking down the rock, they release nutrients from the rock into the water, which get swept out of the front of the glacier in the rivers and they're actually fertilizing lakes and oceans and helping life survive in other environments. So, you know, the life of the glacier is connected to life elsewhere, actually, it's not just the glacier. So I find that fascinating, the fact that glaciers are alive.

Marshall Poe
Yeah, I found it fascinating as well. And I know that every time we've said that we thought we found a sterile environment on the earth, it hasn't been sterile. So it's not terribly surprising that there are little beasties living in glaciers.

So we've talked a little bit about how they form and how they move, but I think most people will know that they grow and they retreat periodically and this is not on a human scale. Well, actually, recently it is on a human scale, but on a geological scale, they do this a lot. Can you talk a little bit about why this happens?

Jemma Wadham
Yeah, I mean glaciers are a mirror of the climate that they sit in really and as we know, climate changes and so for a glacier to grow, it has to receive more snowfall in a year than it loses in melt

water coming off its surface or coming off into the ocean in icebergs and then the glacier can advance. If the opposite happens and it's losing more meltwater, then it's able to kind of buildup during winter due to snowfall, then it retreats. And actually, glaciers have varied hugely in extent over the Earth's surface over, you know, thousands to millions of years as our climate has naturally changed. So, you know that the sort of last two million years, you had these cycles of kind of long cold glacial periods and short, warm interglacial periods. And actually, during a glacial, you might have a big ice sheet over part of North America and a big ice sheet over Europe and actually then they retreat back during the warm periods. And those natural cycles are set by the way in which the Earth orbits the Sun and how that affects how much warmth is coming into the Earth and affects the glaciers, but what we're entering now is a sort of unprecedented period of warming in the sense that it's driven by atmospheric greenhouse gas concentrations. And once again, the glaciers are mimicking what's going on with our climate.

Marshall Poe
So we're in these cycles whether we like it or not, but we've created another. I see just what you mean. Now, I'm fascinated by this because I live in New England, and when they grow and retreat, they carry a lot of stuff with them. How do they pick that stuff up and drop it? I just, I'm having trouble having a picture of this huge boulder getting picked up and moved several hundred, I don't know, a big long distance. How does that work?

Jemma Wadham
Well, so as a glacier slides over its bed or moves over its bed, you've got different parts of the bottom that might be frozen and thawed, actually, depending on you know, where you are in the glacier. So, some parts of the glacier might be melting, but then the ice is continually flowing.

And then the ice may enter a zone where actually it's not melting there. It's cold and so the water freezes around your big boulder, it gets picked up into the ice and then the ice kind of carries it on. If you go to the edge of a glacier, as I've done many times-- I've made my way into the edges of quite a number of glaciers to get samples-- You'll see that the bottom of it is quite commonly chock-a-block full of and sediment and lumps of rock. And actually that's called basil ice. And that's the dirty stuff that the glacier has picked up and frozen into its underbelly and then moved it along as it flowed. So it's quite clever, but there's lots of different ways in which glaciers erode and then pick up material but that's essentially how it sort of works.

Marshall Poe
How quickly do these glaciers move, that is advance and retreat? Are there generalities we can make about this?

Jemma Wadham
I mean, all glaciers whether they're advancing or retreating are moving forward because the ice is flowing, right?

Marshall Poe
Is it meters? Or is it hundred meters, or is it?

Jemma Wadham
Yeah, I mean, it depends on where you are. So, I mean some of the glaciers I've been working on during my career, so from the early 90s until now, particularly little glaciers in Alpine regions, I've seen them retreat a kilometer back over that time period and that's not uncommon in small valley glaciers in the mountains actually, which are quite sensitive to all warming climates. So you can see, you know, kilometers of retreat of that ice and also thinning from the surface. So the glacier I did my undergraduate dissertation on in the Alps, you know, when I was 20 in the early 90s, that shrunk by

a kilometer, but it has also sort of almost lost one of its limbs from the [unclear]. It's thinned so much. It's become detached from the main body of the glacier. If you look at this glacier now, it's actually quite shocking to see that change in, you know, what is really a quarter of a lifetime of a human.

Marshall Poe
They vary greatly in size, is that correct? There's some very big ones and some somewhat-- Can you speak to the variation? What are we talking about here to speak in statistical terms?

Jemma Wadham
A small glacier can be something that's only a few kilometers squared in area. So, you know, a kind of a sort of small village-size glacier, you know, a lot of our largest glaciers are actually ice sheets and they cover the landscape. They cover the topography, they are these big domes of ice and they have these glaciers that protrude out of them, out of their margins called outlook glaciers, and they're huge. I mean they are continent-sized really. So the scale is huge and variable.

Marshall Poe
This is kind of silly question. But I do want to ask it. Where are these glaciers? I mean, we don't have one here in Massachusetts where I am, at least I don't think we do, but where are they located in the world?

Jemma Wadham
I mean, glaciers to form, they need to be in places where there's snow fall, so there is enough precipitation coming out of the atmosphere to nourish them. And they also need to be in places which are cold so that snowfall doesn't melt away. So actually most of our glaciers are in our ice sheets. I mean, the majority of it is in Antarctica, but outside of the two ice sheets of Greenland and Antarctica, you've got very large expanses of glaciers particularly across the Himalaya. That's a very large glaciated region. You also got them in Northern Canada, parts of the US, down the Andes, basically where there's enough precipitation, you get glaciers.

But you could go to somewhere like Central Siberia where it's extremely cold and you don't have glaciers because there just isn't enough precipitation. It's too dry for them there. So they need both those things, they need the cold, and the kind of the wet snowfall coming in to appear.

Marshall Poe
That's a good answer. We talked a little bit about microorganisms that live in and around glaciers, but you talked a lot about bears in the book. What kind of larger animals subsist near, on, or around glaciers?

Jemma Wadham
Well, I mean bears aren't everywhere actually, so they're particularly the case in places like Canada and [unclear].

Marshall Poe
We do have bears where I am. No glaciers though. We have brown bears.

Jemma Wadham
Yeah, you don't find a lot of large mammals around glaciers. They need something to eat. So you don't have a lot of life, but you might. I mean, the things I tend to see are in Greenland is the musk ox, which were introduced actually earlier in the century. And also, you find arctic hare. You might find quite a bit of bird lice in migratory birds that come in with the summer season. Reindeer is

another one but this, you know, you don't find-- it's not like going on an African safari. There is less there for the food chain to kind of cope really, I suppose.

Marshall Poe
I don't know if you can answer this question. But how much of the Earth's water is locked up? Is that the right expression? Locked up in glaciers? Like, is there a percentage that we can say: this percent of water is in glaciers?

Jemma Wadham
Yeah. Well, the important fact there is actually the fresh water that's in glaciers. So it's nearly 70% of the Earth's fresh water is in glaciers, which is a phenomenal amount of freshwater.

And that's, you know, freshwater is obviously any water we would be able to drink. Yeah, and I always find that sum staggering. I mean, of course, most of it is in Antarctica - Antarctica's the biggest glacier landmass on the planet, but that's important and it's particularly important in mountain regions because these are places where, you know, water isn't necessarily always available and its present in the glaciers.

If you go to some of the rivers high up in the high mountains, like the [unclear] distributaries, sort of 80% of the water in those rivers can be glacial melt water and snow melt. And that's really important in kind of providing these lifelines for life in mountain environments, whether it's people or ecosystems that we depend on as well, but the freshwater is, that is a really key thing to note.

Marshall Poe
That's a lot of water. 70%. That is a lot of water.

So I want to talk a little bit about how you do the research you do, which is fascinating. I've read the book, so I know, but I imagine you have a lot of really cool kit to study these things, you know, drills and you mentioned chainsaws and I don't know what else. Can you talk a little bit about how you study glaciers?

Jemma Wadham
Yeah. I mean, the part of glaciers that I study is I normally work on the melt waters, coming off the glacier. So it might be what is on the surface and normally at the edge of the glacier, you have a, like, a big, what we called a portal, which is where the runoff comes out. And these are like, wild scary, rivers, chock-a-block full of sediment. Sometimes you look at one and you think you don't really want to go anywhere near that and then a lot of what we do actually involves very simple things which might be taking a sample of that water and filtering out the sediment. So separating that sediment from the water, popping it in a bottle and then bringing it back home to our laboratories where we're doing quite a lot of sophisticated chemical analysis on what's in the water chemically, or what's in the water, in terms of the microbial life, or the ecosystem in there. And then using that to understand the glacier and understanding the influence of that fresh water flow on the oceans, or even whether there's greenhouse gases like methane in it produced by microbes beneath the glacier that could go into the atmosphere which is a potential warming. So a lot of the kit we take is actually quite simple, we are working in a very challenging environment where you don't have power other than what you can harvest from the sun through solar energy.

And so we try to keep things quite simple. I mean, I have taken more sophisticated chemical analysis kits to the field and it's really difficult to keep it working. The dust, I mean, the dust is just horrendous. Dust everywhere. Just gets everywhere. So you take something up there and the extreme temperature variations from night to day, then you've got this dust floating around everywhere. It's quite difficult actually to get anything to work for a sustained period of time.

Marshall Poe
Yeah, I can imagine that's true. Chemistry is best done in a lab. That's my impression.

Jemma Wadham
Yeah, you have to be really clean. It's so easy to contaminate your samples. And so we try to keep things as simple as possible in the field and we spend a lot of time just surviving as much as doing work.

Marshall Poe
I can imagine. Yes, I mean and we should say that you took time to do this interview during an actual expedition, right? You're working now.

Jemma Wadham
Oh, yeah. I am. I'm halfway up in Northern Norway at the moment and I've been doing a very long slow trip, the southern part of Norway, visiting all of Norway's largest ice caps and sampling them to understand what's living there and what chemically is in the water and how much of it might affect downstream ecosystems. I'm actually sitting outside just at the edge of some mountains by [unclear] where I'm hoping to go tomorrow.

Marshall Poe
Well, thank you very much for interrupting your important scientific work. We appreciate it. Also, let's just say it's a miracle that we can do this. I don't know. I'm in Massachusetts and you're in Norway. That's amazing. So let's get to the topic that I think many people want to hear about and that is that is climate change. They're interested in it for good reason.

Can you help us understand how rapidly climate change is causing glaciers to retreat? Is there a simple way to explain this?

Jemma Wadham
Yeah, I mean, we know from our observations of how thick these glaciers are from satellites, actually, that they have accelerated their thinning over the last two decades. So it's not a gradual change in one direction that the change is accelerating. The thinning of both our ice sheets is accelerating and the retreat of mountain glaciers is accelerating.

It's really important to be able to measure these changes over decades, because glaciers don't necessarily show a big signal from year to year. They are slow, they move slowly and they react to climate change sometimes within a few years and sometimes a little bit longer. And so what we've seen over decades is this trend towards an acceleration in their thinning and their retreat and that goes hand in hand with the climate.

I mean, as I was saying earlier, they mirror what's going on with the kind of average climate of that area.

Marshall Poe
Is it happening universally? Are they retreating everywhere?

Jemma Wadham
I mean, there's always the odd one or two that buck the trend and sometimes they just have slightly different things going on and some glaciers are more protected than others. So you might have a

very small glacier that has these steep side walls and it shades itself, or it has more snowfall accumulation, but I think that the main thing is it's widespread in every glacier region of the world. Mostly glaciers are retreating, and that's the kind of main message.

Marshall Poe
Yeah. To go back to something you said and to become a little bit statistical here, because I think it's important: this is not a linear process. This isn't happening at the same rate. The rate of change is increasing, that is the rate of diminution of the size of these is accelerating. Yeah, so it's an exponential process. Why is that?

Jemma Wadham
It's partly because of the processes that are involved with glacier shrinkage and partly because it takes a while. As I was saying, glaciers don't necessarily react immediately. So it's a kind of a cumulative effect of many, many years of warming. And you get these feedbacks within the system where one change positively feedbacks on the other. So, the environments where glaciers sit are warming also much faster than the global average in some places, particularly in the Arctic.

So if you look at the warming, it's also not necessarily linear and the warming is not happening at a constant rate, which is why the glacier change is not happening at a constant rate.

Marshall Poe
Is their kind of an inflection point where, you know, if we raise the Earth temperature X degrees, then things are going to go downhill for the glaciers really fast?

Jemma Wadham
Like a tipping point? Yeah. I mean, a lot of people have theorized around where the tipping points might be particularly for our ice sheets because the amount of sea level rise locked up in say, for example, West Antarctica and there are different views on that.

Some people think we're close to the tipping points for the West Antarctic ice sheet. I think it's still a little bit unclear because we're entering a situation that we haven't been in before, that we haven't monitored, that we haven't measured. So, you know, we have to model it and we have to do it in models that capture all the processes that, you know, do a great job at the moment, but they're not quite there yet. And so I suspect we need to act like we are approaching a tipping point, is the sensible way to act at this point in time because it's quite possible.

Marshall Poe
Yeah. I wanted to pause a little bit about models. Most of these models are backfit, that is you have historical data. And so then you say, well we can explain why these things happen and it does explain the historical data, but we don't have any historical data for what's going on right now.

Jemma Wadham
No, no, that's right. Which is why sometimes people study the past and past periods of natural warming though. The last interglacial period about a hundred fifty-five thousand years ago where, you know, the average air temperature was maybe a degree warmer than now and so we can start to think about, well what happened then? But it's not the same situation as it was so it's a bit challenging. I'm not a modeler though, I study microbes.

Marshall Poe
So yeah, I understand. So then these glaciers will melt, are melting, or retreating as we say. Well, let me put it in the simplest possible way. What is going to happen to all that water?

Jemma Wadham
Yeah. No, I know exactly. I mean, I think what we're seeing is a lot of fairly catastrophic disruption to the global water cycle as a result of glacier change. But yeah, the water has to go somewhere, right? So what they're finding say in the mountains, sometimes that water gets trapped in lakes and then you get these catastrophic outburst floods. In fact, one of my chapters in my book studies these what are called, glacier outburst floods, [unclear] in southern Chile, this glacier has got some of the fastest retreat rates in the world. And so, sometimes that can cause a hazard in mountain regions. The ultimate destination for melt water coming off glaciers is normally the ocean, and so you're talking about rising sea levels. But some of the things that I'm studying are not so much about the physical dimension to those changes, but what about the biological dimension to those changes?

So what happens as you freshen an ocean to the ecosystems in that ocean? What happens, if melt waters that were previously a sort of nutrient, you have more or less of them? How does that impact our food webs? How does that impact our fisheries that we depend upon? So there are all these other dimensions, I think, that melt water and where it goes are perhaps less studied but are kind of important because they do provide services to us in oceans and in lakes. Water quality as well.

One of the glaciers I studied in the Peruvian Andes, which is the last chapter, is that the glaciers there, they're retreating over these rocks, which are very rich in metals, actually metal sulfides. And actually, as those metal sulfides are reacting in the air and being washed by the rain, that the rivers, which are meltwater, are becoming very toxic. So they've got very high concentrations of heavy metals and are also highly acidic, about the same acidity as your stomach, ph 3, roughly as the waters.

And so it's not just that it's more meltwater or less melt water, there's also a big question around, what's the quality of that melt water? Because, you know, a lot of people are drinking it or it might be sustaining food webs, and things we rely on around glaciers, not actually in the glaciers themselves.

Marshall Poe
Yeah. I think this question about where will the water go is more intuitive than most people will understand because anybody who owns a house, let's say in North America, does understand that the water that comes off your house or off your driveway, has to go someplace. For example, and I know this for a fact because if you let's say own a shopping complex and you want to build a large parking lot, you've got to work closely with the city to figure out where all that water is going to go, because it is going to shed someplace and you can't just shed it anywhere because it becomes somebody's problem. I find it very interesting.

So, do we have any fair idea of how much the ocean is going to rise in the next few decades? Are there any good estimates? I'm not asking you to make a bet or anything.

Jemma Wadham
No, well, the problem there is that how much they rise really depends on how much climate warms, because certainly in terms of glacier change, you know our future emissions pathways whether we decide to cut very, very drastically in the next few years, or we just kind of rumble along at the current rate, that makes a huge difference to our climate which makes a huge difference to the glaciers, which actually makes quite a big difference to sea level rise. If we're not cutting, we're just letting things roll on as they are, you've got the potential future of the West Antarctic ice sheet threat with a few meters of sea level rise in there. So the kind of the worst case fairly improbable predictions for sea level rise could be upwards of a meter by 2100 rather than tens of centimeters. And so you got this huge envelope where actually the uncertainty there, to some degree, will depend on what we do and what we do in terms of future emissions pathways.

Marshall Poe
Yeah, I find that answer, which I'm sure is correct, that it is essentially up to us, to be both encouraging and discouraging because we're, I don't know. I mean, it's a complicated question as to how we're going to reduce these greenhouse gases. Then as you mentioned, there are lots of little beasties in these glaciers.

They produce methane when they die, and then that all gets released. What happens to that methane?

Jemma Wadham
Yeah, well they are producing it as they are alive. That's what they do. That's their byproduct of how they create energy, it's a bit like a landfill site, they haven't got any oxygen. They've got some bits of carbon to live off and they're producing methane gas.

And then, we think that might be trapped beneath ice sheets in a solid form called methane clathrate, and we don't know how much, we don't know actually if it's there, but we know that these glaciers are producing methane. So, you know, there's just a lot of big unknowns around the life and part of that is because we only knew it was there in the last two decades. We haven't got this hundred-year history of knowing glaciers are alive and all the research that's gone into that. So it's kind of a trying to catch up really. We know they're alive. Why does it matter and how much?

Marshall Poe
Well, this prompts a thought, an editorial thought on my part. The people who fund Jemma's research should fund it more because we need to answer these questions. And we've only known for two decades. God knows what we're going to discover in the next two decades about this stuff.

Jemma Wadham
So it's actually surprising, you know, you find new things that come out of nowhere sometimes and you have to follow them. So, but yeah, we still have a lot of unknowns on the biological impact.

Marshall Poe
Yeah. Well, I'm going to let you get back to work because we've taken up a lot of your time. It's obviously very important work, more important work than I'm doing. The traditional final question on the New Books Network is, what are you working on now? Usually this means like a next book or something, but can you talk a little bit about exactly what you're doing now? Later today or tomorrow you're going to do this?

Jemma Wadham
So I am going to write a next book actually, I'm starting some work on that as I've been traveling up and I watch the mountains and the glaciers and I'm thinking about that because I do love writing and I'm definitely going to do that again, but what I'm what working on right at the moment as I'm sitting next to a glacier in Norway is that I'm trying to answer these questions that we just have been talking about really. And I'm trying to use glaciers in Norway that I can access by not getting on a plane with all their huge diversity of bedrock types that sit beneath them and their sizes. I'm trying to use that to develop models for, you know, how microbes might be important around the world and how glaciers interact and support downstream ecosystems, whether that's lakes and rivers or fjords and fisheries and how and why and how much methane gas they might be producing. So, all these questions I'm trying to answer as I'm wandering my way up slowly to the Arctic here.

Marshall Poe
Well, I wish you luck with that. And I have the greatest confidence that you will discover these answers and save us all.

Let me tell everybody that we've been talking to Jemma Wadham today about her book *Ice Rivers: A Story of Glaciers, Wilderness, and Humanity*, and it's out from Princeton University Press. I'm Marshall Poe. I'm the editor of the New Books Network.

Jemma, thanks for being on the show.

Jemma Wadham
Thanks very much for having me.

Marshall Poe
Okay. Thank you. Bye. Bye.