Tea Bags on the Tundra

Nancy: I'm on a little plateau at the base of Iskoras mountain, a low peak in far northern Norway, outside of the town of Karasjok, about 1000 kilometers as the crow flies from Trondheim, and far above the Arctic Circle. Getting to here from town requires an hour-long drive on rough dirt roads, and then another hour's hike over a low ridge, to where I am now.

It's early June, and quite windy and chilly. There aren't a ton of trees here, just stunted birches with wispy little leaves that are so small they look like they're not sure they want to open up in the weak sun.

In front of me is a weird bumpy depression filled with a crazy quilt of open water, grassy bits and little hillocks made out of peat. These little hills are called palsas, and inside there's a core of ice.

Some of them are dry on the top and cracked open, wide open, like a crusty boil that has split.

And wandering around, out in this mix of freezing water, bottomless mud, and wet peat is a young man wearing a pair of chest waders. He's carrying a trowel and a bag filled with tea bags.

Daniel:Lipton tea bags, green tea and rooibos exactly

Nancy: His name is:

Daniel:I'm Daniel Angulo Serrano.

Nancy: And he's burying these tea bags. Lots of them.

Nancy: And how many bags have you will you bury?

Daniel: 100 More or less? Probably a little bit more.

Nancy: How many of you buried so far?

Daniel: Now, 90 Something probably? I will have to look at my excel but yeah, I have done almost all the work. Yeah.

Nancy: I can say with certainty that Daniel is not testing new ways to brew tea. Instead, his efforts are part of a larger study where a team of researchers is trying to solve the riddle of how global warming is affecting this landscape — and how those changes in turn might amplify future warming.

Nancy: I'm Nancy Bazilchuk, and you're listening to 63 Degrees North, an original podcast from NTNU, the Norwegian University of Science and Technology. Today, I'm going to take you out in the field with this team, to hear what they're finding out about thawing permafrost and greenhouse gasses.

Because the palsas, those bumpy hillocks, are a special kind of landform that only occurs in bogs where there is permafrost, or permanently frozen ground. And it turns out that they may hold the key to understanding just how hot our planet may get.

Global warming over the past few decades has meant that more and more permafrost has thawed. In fact, the Arctic is warming two to three times faster than the global average. And when permafrost thaws, microbes get to work on all the organic material that's previously been frozen solid. These microbes release carbon dioxide and methane, both of which are greenhouse gasses heating up the planet.

But how much? How fast? How long? Is this good news for the planet, or bad? Or both?

These questions matter, because there's a lot of permafrost — by some estimates, it's found in as much as 25 per cent of the northern Hemisphere. And locked up in that frozen, partially decomposed peat is an estimated 1460–1600 Gt of carbon. That's almost twice the amount already in the atmosphere. In layperson's terms, it's a LOT.

But more than telling you what the researchers are finding, I also wanted to let you in on just what it takes them to find these kinds of answers. That's why I've travelled all this way to look over the shoulders of the team here, out on this cold arctic plateau.

I think it's fascinating how scientists have to find indirect ways to get the answers to the big questions they are trying to ask.

They're like detectives at the scene of a crime, working with witnesses that can't really talk, and trying reconstruct what has happened.

Not only do they need to figure out how to ask questions of mute witnesses, they need a kind of time machine. Especially when it comes to global warming, they need to be able to look into the future to tell us, as best they can, how things will change.

And part of that is, yes, the tea bags.

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Lisa: I think it's important to realize that permafrost, actually intact permafrost is what we call it a carbon sink, which means that it actually takes carbon out of the air, and stores it in the ground.

Nancy: That's

Lisa: Lisa van Solt from the Netherlands. And I am currently doing my Masters conservation and restoration ecology at Radboud University in Nijmegen, which is in the Netherlands

Nancy: Lisa is one of the researchers working with Hanna Lee, an associate professor in biology at NTNU who is head of the team that I've joined for this visit to the field site.

Lisa: And because it's frozen, the microbial community cannot access it and digest it so it will not be producing methane or co2. And due to the temperature increase, it's actually becoming a possible source. So it means that it's not only increasing the emissions it's already had, it's actually like doubling it. That's why it's a very important thing. And also permafrost is very big, it's the entire top of the world and some in the Alps. And if for example, if all of that sink would become a source, yeah, we're done. It's over then and the two degrees, we will never make it. So that's why it's important.

Nancy: To figure out what is happening with CO_2 and other greenhouse gasses, the researchers need to find ways to trap and measure the emissions from the permafrost that is thawing now. Hanna explains.

Hanna: I'm trying to quantify the importance of co2 and methane emissions and uptake.... from the thawing period, and then even beyond, many hundreds years of thawing permafrost.

Nancy: We all know that CO_2 is a greenhouse gas, but methane, which is produced by microbes digesting rotting plants and famously, burping cows, is 30 times more potent than CO_2 when it comes to warming the planet.

Hanna: So right around the time I finished my PhD, that's what people started to wonder about. Methane became an important source of greenhouse gas from thawing permafrost. But we don't really know how much of methane is being produced from thawing permafrost. .....

Nancy: Scientists make computer climate models, which they use to help policymakers see what could happen to the planet under existing greenhouse gas emissions, and how temperatures could change as we (hopefully) reduce emissions. But as Hanna said, permafrost is still a big question mark.

Hanna: So there's an idea that — and these are all hypotheses now — that when permafrost thaws, then there's going to be rapid increase in co2 and methane release.

Nancy: The models are important in figuring out our carbon budget. A carbon budget is just what it sounds like, but instead of having money to spend, a carbon budget tells us how much more carbon humankind can release without dangerously warming the planet.
By knowing how much carbon is being released by natural sources, and by knowing our total CO_2 and other greenhouse gas emissions, we can know just how much (or little) is left in our carbon budget.

Hanna: if we end up finding out that, well, climate warming is actually emitting a lot of methane from thawing permafrost, then this means that we really have to cut down even more on our emissions. So that's why it's important to really understand the processes, what's driving these things.

Nancy: Although I have come to Karasjok in the summer — such as it is — Hanna comes here year 'round to measure emissions. That's important, because scientists and climate modelers have assumed when permafrost is frozen, it's not really emitting greenhouse gasses. But it's more nuanced than that. Hanna explains.

Hanna: So we came out here in March, everything was covered in snow. And we dug up the snow, about 50 centimetres to one metre of snow to take measurements here. And then I was expecting Oh, nothing is going to happen. It's going to be no emissions, no activity, but then there was huge amounts of methane that's just pumping out. And I was so shocked.

Nancy: Other researchers have found that permafrost can release lots more CO_2 in the late fall and early winter than was previously thought, because a warmer climate means it takes these landscapes longer to refreeze than they used to.

Many of these studies are done using remote sensing, like satellite imagery, to gather information. Far fewer measurements are done out in the field, like with Hanna's research. And being in the field enabled Hanna to see what was happening at a time when most people believed emissions would be next to nothing.

So what's going on? The key is one type of vegetation that commonly grows in these areas, called sedges. Sedges look like grasses, but have a different structure. Hanna explains.

Hanna: (Karasjok 2 tape) Sedges have this straw structure, then it's really just pumping, transporting methane that's in the deeper part of soil all the way into the atmosphere very, very quickly.

Nancy: Hanna says this process can go on year round, because even with the surface of the pond freezes, it can remain thawed deep below.

Hanna: And when it's not frozen, the microbes are still active — it's very cold so the microbes are not *very* active.

And so methane is continuously being produced over the winter. And if the soil surface was frozen, then it would not be transporting all of this methane to the atmosphere. But since the straw structure is there, and it's going all the way through the ice layer, then what what is likely happening is that all of this methane that's produced over the winter in the deeper part of soil is then just transported out to the atmosphere.

Nancy: How important this mechanism is in the big picture remains to be determined. But it could be quite significant. And here's another thing: Remember what I said about the researchers needing a time machine? This site is exactly that. Different areas of this field site represent different times in the life of a palsa.

Hanna: We don't have to wait 200 years for the bog or the vegetation to grow back. We just find a natural succession area and assume that 200 years from permafrost thawing event, it could or most likely will turn into that kind of environment. And we substitute space for time. So this natural gradient is very interesting, because we don't have to wait 200 years to understand what's going to happen.

Nancy: Some areas have big healthy palsas, big bumps with ice cores in their centers. Elsewhere there are palsas that are beginning to thaw — those are the big ugly peat mounds with cracks across them. And then, once the ice core inside the palsa has completely thawed, the palsa collapses and leaves a depression, which fills with water.

Hanna: So when permafrost thaws, and then the land surface collapses, then it ends up becoming like a pond and a bog. And there's a standing water table for long periods of time. And then after 100 or 200 years, from the permafrost thawing and land surface collapsing, vegetation starts to regrow in these places, but not all vegetation grows. So the first thing that grows in this boggy area are not even plants. They are mosses like Sphagnum that start to grow and fill in the pond and the bog. And then it starts to create this very thick organic layer within the pond and it starts to fill in the pond. And then when the surface gets dried enough, then these grass looking plants called sedges start to grow.

Nancy: There's still a lot to be learned.

Hanna: But as time goes by these ponds and lakes can dry up. And then it might actually transition towards back to an aerobic environment.

Nancy: Aerobic means that there is oxygen. Most plants — and animals, like us, for example, like to live in a place where there is oxygen. So if the soil or peat is dry, the microbes in the soil will release CO_2 as part of the decomposition process, but not so much methane.

Hanna: Under aerobic conditions, then methane emissions may not be so important, or there may not be so much methane emissions from compared to how much methane was emitted during this early thaw period.

Nancy: You can see that the situation is very complex. That's all the more reason that researchers like Hanna need to collect this information, now. But what does it actually take to measure all this information?

Nancy: Earlier I described the landscape itself. But I didn't describe all the scientific equipment — and there's a LOT of it. There's pipes sunk into the ground to measure ground temperatures, bright orange flags marking different areas where the researchers make greenhouse gas emissions every time they come out to the field site. And then there are these open-topped hexagonal plexiglass chambers, which look like little greenhouses — which is actually what they are, as Hanna explains. Unfortunately it was really windy when I recorded this little piece of tape, so you'll have to listen carefully.

Hanna: These open top chambers are part of a global research network called the International tundra experiments. And what they do is because they are like a greenhouse, they warm the inside air temperature about two degrees Celsius.

Nancy: Remember, 2 degrees C is kind of the magic number here, because that's what was named in the 2015 Paris Agreement as a goal. To quote the EU: The Paris Agreement sets out a global framework to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C.

Hanna: And so the environment inside is mimicking a two degrees increase in the future. We are interested in observing and understanding how warmer climate have an effect on the tundra environment.

Nancy: When I'm out with the researchers in June, one of the most important activities is measuring the amount of greenhouse gasses being released by different areas in the field site. Remember, they've selected this site as a kind of time machine, so the different areas where they measure — on a melting palsa, in a bog area with sedges, in a healthy palsa — can give us an idea of how greenhouse gas emissions will change as the permafrost thaws.

Nancy: One of the researchers who is out in the field with Hanna is

Anja: Anja Greschkowiak. And I'm a PhD student at NTNU. I'm at the biology department in the multiscale biology group.

I measure gas emissions from different plots, which are representing a timescale of permafrost degradation. And we correlate the emissions to the stages of the degradation. And I personally would like to connect those emissions to the surface of the ground to make it recognisable from space from satellites.

Nancy: The idea behind Anja's PhD is that by collecting actual emissions information from the field, and connecting it to satellite information from the same time, researchers wouldn't need to go out in the field to get this data. In the future, they could look at the satellite information they've gotten at this future time, and compare it to satellite information taken when the researchers actually collected emissions information. Anja says this is the first step:

Anja: it's a lot of effort to bring people to the field, it costs a lot of money, but I feel like you have to be out here to make estimations. I will look at data from space. But I have to see like, how big are those mounds? How deep are those ponds? How big are those ponds? To make decisions about the data I want to use and for that, I need to see it.

Nancy: In this case, Anja gets to see it up close. When I'm out in the field with them, Anja and Lisa van Solt, who you heard from at the top of the podcast, spent much of the day taking measurements in different parts of the field sites. Some parts are dry, and some… Not so much.

Nancy : describe where you're standing right now

Anja: I stand on a very wobbly floating plank in the middle of a thaw pond. So that is airing out as we have now collected the trace gasses, they have to get out of the chamber. So that we start fresh with the new measurements. Yeah, while balancing on what you can see are very unstable planks.

Nancy: In fact, one of the first things I did when I arrived in northern Norway was to go with Hanna to a buildings material store to buy more planks. The researchers are always having to build small bog boardwalks as the site changes and more and more permafrost melts.

Nancy: Anja makes the measurements using a machine called a Li Cor, which we'll hear about in a bit, and calls them out to Lisa.
Anja 862.8
Anja 866.8
Anja 866.2

Anja But that is already the variation within one and all the while concentrating not to drop anything into the pond

Nancy: Lisa tells me what they're doing as Anja waits for the machine to be ready.

Lisa: We have a airtight see through chamber, which catches all the gases released that an ecosystem produces. And then the air gets sucked into this machine, which then tells us the amount of co2 and methane. And water that is, well in our chamber. We're also measuring the photosynthetic rate by measuring the PAR which is photosynthetic active radiation, which is just how intense the sun is basically. And the higher the better because then the vegetation will work harder. And now you'll see this is more effective and we're also looking at the moisture but this plot is wet. So moisture is 100 but we'd like the other ones dry was also measure moisture content.

Nancy: This measurement is really critical, and hinges on that machine I mentioned earlier, a portable gas analyzer called a LiCor, after the name of the company that manufactures the equipment. One thing you need to know about this machine is that it costs a lot of money. And the only people who can fix it are the manufacturers, based in Lincoln, Nebraska.

Anja: You have to be really careful that no water, absolutely no water, goes into the LiCor

Nancy: What's the LiCor?

Lisa: The gas analysing machine? Trace gas analyzer officially. It's our best friend.

Anja: Yeah, water comes in here and we're done for the year. For a year. Yeah. It has to go back to the manufacturer to the US.

Nancy: As the field season goes on, the access to all the sites where they make measurements gets trickier and tricker.

Anja: and the more often you come like every day, everything gets a bit like worse it gets wetter. the planks get more unstable because several people walk over it back and forth and that makes the underground layer even softer. And then becomes more and more challenging.

Nancy: Is this really what you thought you wanted to do when you signed up?

Anja: I was told there are no bears so yes, okay, good.

Nancy: In case you couldn't guess, Anja is a little uncomfortable about bears. She's happy...

Anja: There are no bears.

Nancy: That's true. It's true. Yeah, lots of water though.

Nancy: You can hear that Anja and the rest of the crew are having fun in this beautiful, cold, wet landscape. But they are also all driven to do what they can to help us tackle climate change. Anja explains her piece of the puzzle and why it matters.

Anja: Well, so in a lot of carbon budgets, carbon estimations, the permafrost emissions are not that well represented. So when we estimate or when other scientists estimate the temperatures in the future, they work with emission budgets. They say, Okay, if we keep emitting like that, it's going to be so and so many degrees warmer, or if we stop emitting if we would even actively bind carbon from the atmosphere somehow, we would end up with that and that temperature. And for that, we need to know Yeah, our budget or the planet's budget, and only if all the emissions are correctly captured, we're able to estimate those things. So, yes, this is why I think everyone who lives on this really beautiful planet should care about what the thawing permafrost is emitting.

Nancy: But what about Daniel Serrano, the intrepid researcher wading around in the bog with a trowel and two kinds of tea bags? Daniel is a bachelor's student, and this piece of research is his bachelor's project.

Daniel: I'm studying a degree in biology in Madrid, in my home city. And I'm here, on an exchange programme. Doing my thesis with Hannah. It's kind of similar to the bachelor thesis that that you have here.

Nancy: And the tea bags?

Daniel: this is about measuring the decomposition rate of the permafrost. And it's pretty special because of this unique site that we have here. But basically, what I'm doing is with a simple really simple method, that is using teabags, the same as you can have in your house.
And they're simulating dead plant material. So they are going to be decomposed like other plants and then we are measuring this composition at the end of the season. And we are going to relate that with the thaw of the permafrost and we are going to see probably that is the areas with the more thaw are going to have, higher rates of decomposition.

Nancy: Who knew that tea bags could give us insights into global climate change!

Nancy: I'm Nancy Bazilchuk, and you've been listening to 63 degrees North, an original podcast from the Norwegian University of Science and Technology.

My guests on today's episode were Hanna Lee, Anja Greschkowiak, Lisa van Solt, and Daniel Angulo Serrano. If you want to know more about the research discussed in this episode, check out our show notes. And if you've enjoyed today's show, tell your friends and leave us a review. Sound design, and editorial help from Historiebruket. Thanks for listening.