It’s the summer of 2008, and the phone rings in NTNU’s National Laboratory for Age Determination. It's a farmer from the mountains of central Norway who has something he thinks the scientists at the lab will be interested in.

It isn’t that often that the scientists get calls like this.

More often than not, people are calling to see if the lab can date the timbers from old summer farms or wooden bits from family heirlooms, like bridal chests, that have been handed down over the generations.

But what the farmer says next makes them pack their bags and drive the five hours to his village.

Helene: the farmer ….said that he had a lake at 1100 meters in Bøverdalen, and he wanted to know how old the trees were.

Nancy: The little lake was on the farmer’s property, and the trees were actually submerged in the lake!

Helene: And then we asked him, how many trees? And he said, well, at least 30. And then we, of course, we had to go there.

Nancy: That’s how Helene Svarva came to find herself on the shores of Øvre Teppingstjønne, a tiny alpine lake at about 1000 metres above sea level. That’s well above the treeline for Scots pines, the trees most commonly used for dendrochronological dating in this part of the planet.

The farmer uses his tractor to drag a weird raft on blue plastic barrels up to the lake. They need the raft to reach the middle of the lake, where the old logs are submerged in the mud.

But the raft can’t do the whole job. Someone has to dive into the cold, murky waters to attach big chains to the logs so they can be winched to the surface. So Svarva, in a wetsuit, eases herself into the tea-colored water — and disappears.

CUE PODCAST MUSIC

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 talk about how researchers use tree-ring dating — or more technically, dendrochronology — to uncover secrets of the past. It’s a surprisingly simple technology that has become increasingly important for climate researchers across the globe.

In their careful records of climate change over the centuries — and millennia — trees offer a kind of crystal ball on our future climate, even as they record the past.

Climate researchers can use these windows on the past to test the climate models they have created to predict how greenhouse gas emissions will affect future climate.

Norwegian tree rings are part of this crucial work, but they also bear witness to some of Norway's most iconic historical happenings.

Tree rings have helped researchers figure out what REALLY happened in Norway during the Black Death.

They tell a surprising story about how Nazi occupiers in northern Norway hid their massive battleship, the Tirpitz, from Allied bombers.

And a new project, just begun, may help us better understand a critical aspect of future climate change — how precipitation will change as the planet warms.

We've already had a preview of the precipitation problem — and how unprepared we are for these changes.

In late September, New York City drowned in record rainfall, flooding the subway system and sending schoolchildren to upper floors of school building to avoid floodwaters. Extreme rainfall in Oslo in August was so severe — and unexpected — that it caused major landslides in the southern part of the country and took out a huge bridge on the nation's main rail line, which could take a year or more to repair.

Norwegian trees hold a piece of the puzzle that can help us understand this better than we do now.

But before we get into how researchers have used tree rings to figure out all these cool things, I'll let Helene, who is an associate professor at the National Laboratory, explain a little bit about how dendrochronology actually works.

Helene: So everybody knows that the trees make tree rings, right? And the reason why they make them is because they stop growing in winter. .... And so growth stops when it's cold and it starts when it's warm. When it's warmer, the trees make a wide ring. When it's colder, it makes a narrow one. And this happens to all trees.

So all the trees that grow in the same area of the same species will have a similar pattern of wide and narrow rings. And when you have enough of those patterns, you can match them against each other. So trees that grew at the same time will have a pattern that is similar enough to say that this date is the year.

Nancy: Researchers like Helene use something called a tree corer to take thin cores from living trees. The corer is a long, very thin hollow tube — a little larger than the width of a drinking straw — which is why they can take a core without generally harming the trees.

The corer has a sharp end and screw grooves on the business side, and a T-shaped handle on the other end. They turn the handle around and around, which causes the tip of the borer to carefully cut its way into the middle of the tree. You need to reach the middle of the tree to get its exact age. You know you've reached it when the core shows a small dot.

But how do researchers read the tree rings after they get their samples? I went to the National Laboratory for Age Determination to find out. It's in this small set of offices, and I was sure that the equipment they needed would be elsewhere.

Nancy: AX I was sort of wondering if this is maybe a period where we can walk around a little bit. I'm gonna have to figure out how I can carry all my stuff.

Helene:
It's right here. It's right here.

Nancy: Pretty much everything they need, as it turns out, is on a big table.

Helene: What we have here is a measurement table for dendrochronology. And it's a small plate attached to a rail. And on that rail is a wheel that you can turn. And when you turn the wheel, you move the plate. And it moves incrementally. And there's a box registering how far it moved. So when you put your tree rings on top of that plate and move the plate, then you can register how long it moved on the computer.

Nancy: The researchers also can magnify the tree rings by as much as a factor of 40 so they can distinguish individual rings, even if they are very narrow. And then you have a record of the pattern of annual rings and how much they differ in thickness.

Nancy: One researcher I talked to compared these patterns to barcodes. It works like this. Say you have a pine tree that's 250 years old, and you have enough old trees from the same region to see what the "bar code" is for trees in that area for those 250 years. Researchers call this record from many trees a "master curve".

Then let's say you get a piece of pine wood from the region that you want to find a date for — like a piece of a building. Then you measure the growth rings on that wood and see where it matches up to the bar code of the trees you have a date for. Or better yet, to the "master curve" for the region, which can go many hundred years back.

Nancy: Using this approach of matching overlapping patterns in tree rings means you can really go back in time.

Helene:
Yeah. So to extend the chronology really far back, first we used building timber and it goes back to 1,000 AD, a little bit before that. Then we have to look at archeological samples preserved in the ground. This goes a bit further back in Trøndelag — we are back at 500, but before that, there is not much wood preserved from human activity.

Nancy: 500 AD — that's nearly than 300 years before the Viking Age began, in 793!

In fact one of the longest tree ring chronologies on the planet is in Norway's neighbor to the east, Sweden.

There, researchers were able to use divers to pull submerged pines out of northern high altitude lakes, the most important of which is called Lake Torneträsk.

Researchers call these "subfossil" pines — because they were somewhat preserved by the cold waters of the lake, but hadn't been turned into stone, like true fossils. Those pines allowed the researchers to construct a chronology that goes back 7400 years!

Helene Svarva:
And what is maybe my unrealistic career goal is to do something similar in south of Norway — to go to lakes in the mountains in southern Norway, and to make a tree ring curve that extends for as far back in time as we can get.

Nancy: There's one more thing you need to know to understand why these high mountain lakes are so important. Helene explains.

Helene During the mid Holocene 6-8000 years ago, it was a lot warmer in Norway and in Scandinavia, 8,000 years ago, and then you had forests growing on the mountains higher up than you have today. And then you can have small lakes that they fell into, and then the forest retreated down but those trees remained in those lakes. So when you find that, you know, that this is probably old, then you can sample it and try to make a chronology if you have many trees.

Nancy: Hence the reason that Helene was more than willing to immerse herself in the murk of the lake. I had to ask, though: Was it scary or?

Helene:
Oh, it was fun. It was cold and fun.

Nancy: Sometimes the absence of trees — or tree rings — tells a different story. That's what Claudia Hartl found in 2016, when she took a group of German geography students to northern Norway, to a fjord near Alta, called Kåfjord.

Claudia is a German dendrochronology researcher and whenever she goes to northern Norway with students as she did then, she always cores trees to add to what researchers know about tree ring growth in northern Scandinavia.

Claudia:
So we built up tree ring width network over north Scandinavia, in Norway in Sweden, in Finland. And this was one of our sites. And we wanted to include this site into this network of pine trees with a climatological background. And then we found, the trees in Kåfjord, and then we had to report something else than only climate.

Nancy: What she found was a whole swath of trees that were missing a growth ring in the exact same year, 1945. They couldn't know this until they came back to the lab to measure the tree rings.

Claudia
We went back to the lab and ... and yes...we found that there was a missing ring in 1945, and lots of trees had these missing rings.

And as I said before, we know the growth pattern of the pine trees in Norway very well, and it was very unusual. So compared to other sites in northern Norway, trees at the other sites always built a ring in 1945, and these trees didn't. And so we knew, okay, it is a missing ring because we were able to compare it with other trees. And also, some of the trees also there had the ring, but very, very tiny and very, very narrow. And if there is one single tree within a stand, having a ring, then you know that all the others, the ring is missing.

Nancy: Claudia said it was very obvious — here's where the barcode analogy helps again.

Claudia:
The rings have different widths. So there are narrow rings and there are wider rings, and it's like a barcode. If you compare this barcode at this site with another barcode at another site, it should look the same. But if there is one stripe missing, then it looks different, you know? And with that, you can find out if there is a missing ring or not. It's a pattern.

Nancy: The missing ring was a huge puzzle. Why would a bunch of trees around the fjord be missing that one ring, while trees that were not that far away were fine? The date *might* have tipped her off — remember Norway was occupied by Germany at that time. But it took another German dendrochronologist, who lives in northern

Norway, to suggest the answer might lie in what happened in the fjord during the Second World War.

Claudia: Yeah, so I have a colleague, also a dendrochronologist in Norway, Andreas Kirchhefer. I first contacted him and asked him, Hey, do you know what happened in 1945? Because my trees all have a missing ring there. And he said, it might be connected to the Tirpitz, because it was anchored there in the second World War.

Nancy: The Tirpitz was a German battleship that was the heaviest battleship ever built by a European navy at the time. The steel in the hull alone was 30 centimetres thick! I saw a chunk of it in the war museum in Narvik and couldn't believe that a ship with steel that thick could float!

The Germans stationed it in Norway in early 1942 as a deterrent against an Allied invasion and to intercept Allied convoys headed to the Soviet Union. It travelled around a bit, but ended up in northernmost Norway, in Kåfjord.

That location was strategic, for three reasons. The first was that it allowed the Tirpitz to attack any allied convoys headed to the Soviet Union, which was also fighting the Nazis. The second was that Kåfjord was a long way from Britain, which was the country with the most firepower to attack the ship. And the third was that it was easy to defend the entry to the fjord — and at this stage of the war, the Germans were running low on fuel so that they didn't want to have to move the ship again and again.

Nancy: So Claudia did some digging.

Claudia:
And I read in some documents that the Germans used smokescreens, and then I also found pictures with artificial smoke. But another thing I could also find out then what the Germans actually used for producing that smoke.

Nancy: And here's the real reason for the missing rings.

Claudia:
For this artificial smoke, they used, chloral, it's a very difficult word, sorry, chlorosulfonic acid. So, this is very harmful. The people who prepared smoke sprayers and so on, they had to wear protection suits and masks, because this is an acid. And, also in this handbooks from the war, it's written that grass and everything is burned or turning yellow if it gets into contact with these things. And what we think is that this artificial smoke destroyed the needles of the trees or the leaves of the trees.

Nancy: When Claudia went back to take more samples in 2017, she even found remnants of the smoke sprayers on the sides of the fjord.
But this is in 1944. The Tirpitz was actually SUNK on November 12, 1944, by a squadron of 32 RAF bombers. It was struck by three bombs, and sank in just 11 minutes. So why no rings in 1945?

Claudia: If a tree doesn't have any needles or leaves, it can't do photosynthesis and cannot produce biomass. And what we saw is that these artificial smoke actions were in 1944, but the missing ring is in 1945.

So these trees, the needles were destroyed in 1944. And of course, a tree needs time to produce new needles. And if there are no needles, first of all, of course there is no incremental growth because no photosynthesis.

Nancy: This was not quite what Claudia expected when she took her students to Kåfjord!

Claudia:
I was surprised, but I was also fascinated because trees are like time machines. They can report the past. And this is just a perfect example for that because it tells you stories about the past, which you didn't expect and which you didn't know.

And then you have a new insights into the past and human impact on the environment. And I can see this now more than 70 years later. This is very amazing, I would say.

Nancy: Trees are such amazing recorders of historical events that they can even tell us about what happened during the Black Death in Norway, which first arrived in the port town of Bergen in 1349.

Here, again, it is something missing that provides the first clue of what really happened. In this case, the first discovery was by a retired NTNU researcher, Terje Thun, who more than anyone else in Norway is responsible for developing those really long tree-ring chronologies that we've been talking about. He's a genuine legend in Norwegian dendrochronology research. Unfortunately, he was unable to talk to me for this podcast. But he was Helene's PhD supervisor, and she worked with him on this particular question.

Helene:
What he found when building up these chronologies was that he had troubles covering the 14th century, there was not much material to find.

Nancy: Remember, Terje is not necessarily looking for trees from 1349, but for wooden buildings that would date from around this time, so he could take samples and match them up to the master curves — the master bar codes — for the region. But he couldn't find any buildings that were from that time.

Helene: And of course, they obviously thought, well, they didn't build anything new, during the Black Death because everyone had died.

Helene: So, we have in Norway, all of these farms called, Ødegård, deserted farms. These are very common place names all over Norway, so it was thought to be quite obvious that this is because of the plague.

But, time went on and Terje dated a lot of buildings, and he managed to cover the Black Death. And this was a problem in all of Europe to cover this period in the technology, lack of material. But it was covered everywhere. And because you can always find some house or church that has material. And when his chronology started getting a lot of material, he could see some patterns in it.

Nancy: He actually had more than 200 buildings from around this period. But he found only four that date from the last decades before the Black Death.

Helene: And what he did was that, he put up a diagram of the dates, the felling dates of the trees that were dated exactly.

Nancy: Here I should clarify that dendrochronologists can know the date of when a tree was cut or felled, if in their tree core or sample they see either the bark itself or something called the waney edge, which is a distinctive layer just underneath the bark. Just to state the obvious, if you find the bark or the waney edge of the tree, you know that the number of rings to the center of the tree is its age, because of course it won't grow after it's been cut. So given all his information, Terje found..

Helene: a gap in the felling years. But this gap does not start in 1349.

Nancy: Which is when the Black Death came to Norway.

Helene:
It starts before. And there's a decline in the amount of buildings or trees felled also before that. So, he wrote a paper in collaboration with me, where we speculated that this signifies a hiatus or stop in building activity and means that either the population is stagnated and they don't need anymore, or the population is declining.

And then a similar publication came out, and this was a researcher who had looked at almost all of Europe, and it was the same result. So, the question then is, why, why did they stop building houses in this period when it's not the black death?

Nancy: And do we know why?

Helene:
I don't know. Was it climate? Was it political? I don't know.

Nancy:
So there's some speculation, but no answers.

Helene: No, the trees, I think don't have an answer for why they stopped building. The trees can only tell that they did indeed stop felling.

Nancy: Helene and Terje's finding — that people stopped constructing buildings long before the Black Death decimated the Norwegian population — is also supported by the larger study that she mentioned. That research group looked at a huge swath of western and central Europe, and found a major decline in construction activity at 1300 — nearly 50 years before the Black Death. Those authors suggest this decline reflects a major societal crisis, associated with population stagnation or decline. There was a major famine in Europe from 1315-1317, but the decline in construction started even before then.

So yes, the Black Death was horrible. But something even worse — as yet unknown — happened nearly a half century before! And the way we know is because of the trees.

Helene:
Trees are honest.

Nancy: So we know that trees can tell us about past temperatures, because trees will grow better when the temperature is suitable for their growth. That's especially true for Norway. But now Helene and her PhD, Wendy Kumalo, have a somewhat more ambitious project they're embarking on.

At the top of the podcast, I talked about how climate researchers all over the world are scrambling to predict how global warming will affect future climate by using gigantic computer models. And how right now, one big problem that has been clear is the challenges of predicting precipitation. Helene wants to find trees that can tell us about past precipitation in Norway!

Helene: Historians are interested in looking at the effects of climate on the history record. And also, there are historical records or climate, like harvest, grain taxes, things like that, that are also indicators. And then we have these different proxies. And trees tell one story.

So a tree might not experience the same thing as grains. So we want to explore more closely this relationship between humanity and climate. And one thing that's, that's missing in Norway, and that's for obvious reasons, this is a reconstruction of the precipitation.

Nancy: I should remind people here that Norway is super rainy. Helene says we already know how trees in Norway respond to temperature because of all of the previous research that has been done. What isn't known is can they tell us about how much it rained in the past, under different temperature situations?

Helene: So what we want to do is look for certain sites where we have more precipitation limitation in the trees and see this other side of climate that might also had a great importance for society.

Nancy: The trick will be finding dry spots in Norway. Helene explains.

Helene So if you want to go for a temperature sensitive tree, you go high, high elevation where it's cold, or you go very far north.

But when you want this precipitation signal, you want to find a place that's dry, and that's not a lot of places in Norway. So we have to find these little pockets of dry and collect the trees there. And then the hope is that in these sites, we will have trees that are old enough to get a good reconstruction as far back in time as we can.

Nancy: It's too early in this particular study to report any results, but stay tuned!

Nancy: But what of Helene's dive into that high mountain lake where the farmer wanted to know how old the trees were?

Helene: And the farmer he drove us with his tractor, and we put it on the lake, but then we had to attach the chains to the logs to pull them up, because these were huge trees, like entire trees lying in the lake. So then I had to dive down and attach the chains so that we can elevate them and then pull them to the shore. And then we cut pieces off with chainsaw, a disc from each. And then we put the logs back.

Nancy: They put the logs back for future researchers who might have better techniques for analysing the logs.

Nancy: Unfortunately there were only 32 trees for Helene and her colleagues to sample, so they don't have enough trees to construct the kind of long tree ring chronology that Helene hopes someday to create. The mid-Norway chronology that she described, where researchers have material that dates back to 500 AD, required 3000 trees to make!

But they were able to date nine of the logs using radiocarbon dating. The oldest tree was estimated to date from as long ago as 7290 years before the present!

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 Helene Svarva and Claudia Hartl. 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.