

0:00:05.7 Sarah Crespi: This is The Science Podcast for January 7th, 2022. I'm Sarah Crespi. Each week, we talk about the most interesting news and research published in science and the sister journals. First this week, we have science journalist, Olga Dobrovidova. We talk about plans to set up a national permafrost observatory in Russia. Then we have researcher Filippa Lentzos. She joins me to discuss her insight piece on the dangers of transmissible vaccines for controlling invasive species and viruses found in wildlife.

[music ends]

0:00:44.3 SC: The Arctic is warming much faster than the rest of the planet, and it's not just ice sheets that are at risk, it's also the permafrost. Olga Dobrovidova is a science journalist based in Moscow. She wrote this week on plans to coordinate permafrost monitoring in Russia. Hi, Olga.

0:01:02.5 Olga Dobrovidova: Hi, Sarah.

0:01:04.4 SC: Is permafrost exactly what it sounds like, permanently frozen stuff?

0:01:09.1 OD: Well, at least it used to be before climate change came into the picture. Yeah, it can vary in depth how much ice is in there, so it can be spotty or it can be full-on permafrost. In total, it covers two thirds of Russia. So that's a huge swathe of land.

0:01:25.1 SC: Yeah, and is melting the problem here or warming up?

0:01:29.3 OD: It can indeed melt, but the problem is even if the temperature goes up slightly, the properties of permafrost can change, and that matters if you build something on it. I think this is the biggest difference for Russia as opposed to other countries who have permafrost. We've got a lot of permanent structures built on top of it. Roads, pipelines, even cities and towns. So it's not just an abstract issue of permafrost melting somewhere, it can impact people.

0:01:58.2 SC: Right. What happens when the ground suddenly changes its status, when it goes from hard, hard permafrost to soft, squishy dirt or mud.

0:02:08.3 OD: Last year in May, a fuel depot was destroyed in part because the permafrost underneath it was damaged, close to Norilsk. It was partly because I think the conditions of permafrost nowadays are really poor due to climate change, but also due to perhaps poor management, some negligence. So that fuel depot got destroyed, and the fuel leaked into a northern river, it turned it rusty red really, and it ultimately went into the Arctic ocean. It was really an environmental disaster, and the company responsible for the depot had to pay quite a lot of money. I think it's the biggest settlement in modern Russian history, at least for an environmental disaster. And this year in December, they announced they're gonna invest about as much money as the Russian government is gonna invest in their system. So the Norilsk Nickel, the company, will track permafrost where it matters to them, right?

0:03:05.1 SC: Right. Pipelines, factories, that kinda thing.

0:03:08.7 OD: They really need investing in their own system too.

0:03:12.4 SC: What exactly is permafrost management? Is that something that a city or a town that is built in this kinda region has to pay attention to?

0:03:22.3 OD: If you ever get a chance to visit these towns, you can see a lot of the buildings built actually higher up the ground on some kind of open foundations, a meter or so, perhaps two meters above the ground so that the building itself doesn't heat up the permafrost underneath it. And those are ventilated, but you have to keep them clean, you have to keep the circulation going. Those are essentially self-cooling foundations for buildings. And there are also techniques to build stuff in the right way on this permafrost, but the problem with this is a lot of the standards that are used in building in the Arctic region come from an age before climate change was a thing, and they don't take these climate-change impacts into account. So any redundancy they might have might already not be enough for these buildings.

0:04:15.0 SC: So do you mean that climate change is making things different? And so the buildings and the other maintenance things that people are doing aren't as effective?

0:04:23.7 OD: It's like load-bearing capacity, right? How much stuff it can keep stable on top of it, all those measurements, all those parameters in the building guidelines were designed essentially in the pre-impact era when this was not that visible. We're actually seeing some impacts. I know that in the northern towns, some of the newer buildings end up being demolished because they're unlivable, essentially, they start cracking and tilting to sides because no one had considered that this would be an issue, so soon at least.

0:04:57.6 SC: But there is a statewide or a nationwide monitoring effort that's being planned.

0:05:02.8 OD: Yeah.

0:05:03.4 SC: Is it much different than what's been done before to track permafrost in the country?

0:05:08.1 OD: To understand why this is important, you have to go back a bit into the Soviet times, where permafrost tracking was really a unified, nationwide effort. After the collapse of the Soviet union, a lot of the research institutes went their separate ways, and in the absence of funding for a system, the permafrost monitoring became spotty, which means that if a university or a research institute has some sort of interest in a particular region, they track permafrost there. Some of those organizations feed their data into international systems such as the CALM network or the GTN-P, Global Terrestrial Network for Permafrost, which gathers data from across the world really, but that depends essentially on their goodwill, so if you want to do this, they do this. And most of them actually end up studying the regions that are of interest to them. So it's a biased sample and the coverage is really kind of spotty because you can't really make any conclusions about the general state of permafrost.

0:06:09.1 OD: One other issue is, outside this international projects, no one's really sharing the data between them. So companies like Norilsk Nickel usually have their own tracking efforts because,

again, they're interested in keeping their investment safe, but they have no motivation, no incentive to share that data. The biggest thing about this particular plan is that the data that is gonna be collected, since this is government data, and the agency in charge is mandated to collect environmental data and share it with users. At least we can count on the data to be accessible.

0:06:42.5 SC: When we talk about monitoring permafrost, what exactly does that entail?

0:06:46.9 OD: Generally, there are two essential climate variables. It's the active-layer thickness, so how deep the permafrost thaws in the summer, and also a temperature profile. So you drill a borehole up to 30 meters, I guess, perhaps even deeper than that, and then you put temperature trackers at different depths and you monitor the changes in temperature.

0:07:08.1 SC: Can you talk a little bit about how the monitoring stations will be set up?

0:07:11.8 OD: Ultimately the task went to the Ministry of the Environment, which delegated it to its climate and weather service. This service, Roshydromet, has a network of weather stations across Russia, and some of them are essentially on permafrost. They will take 140 of those stations and they will add these boreholes to measure temperature, and I think they're hoping at least to start drilling this summer in the first stations. By doing this close to the weather stations, you can firstly combine the permafrost data with weather data. This also helps in modeling and helps connecting the permafrost and the climate system in general. The other thing is you don't essentially have to invest a lot in the infrastructure 'cause the weather station is already there.

0:08:02.1 SC: It's already wired and it's already got scientists, that kinda thing, yeah.

0:08:05.3 OD: Yeah. So it makes rolling out these first stations really that much easier. And I think the third issue is that you get what's called background measurements, which helps establish a baseline for what's happening to permafrost outside these towns and cities where it's impacted both by climate change and management. By having a baseline, you can compare the other more precise, perhaps more detailed measurements, such as the ones Norilsk Nickel will make in Norilsk. They will have a baseline to compare their data to something and make conclusions about for instance, attribution, whether a particular event is caused by climate change or just poor management.

0:08:47.1 SC: We should talk a little bit about carbon release from the permafrost that's melting. We talked about shifting foundations, broken pipelines maybe, but there's also this issue that when permafrost melts, a lot of carbon can come out.

0:09:01.2 OD: That's true. I think the stocks there are even bigger than anywhere else perhaps. It's bigger than the atmosphere I think at this point. It's not a priority for this particular system. It's not a stated priority at least, but the data that the system is gonna generate, it can be fed into models that will ultimately predict the carbon sinks and permafrost and the potential to release that carbon into the atmosphere much better.

0:09:25.8 SC: So it'll help people build those models?

0:09:27.9 OD: Yeah. Essentially if that data becomes available, it's really gonna help improve on the models. I was told by experts when working on this story that the models these days are really having a hard time pinning down the scale of the impact, and the more data we have, obviously the models are getting better.

0:09:44.4 SC: When we talk about monitoring for earthquakes or volcanoes, there's kind of an alert system built in. Is that going to be part of this? Is this for in the moment understanding of what's going on with permafrost or is it more data collection to monitor over the long term?

0:10:02.0 OD: I think it's more about collecting the data and especially establishing that baseline that we really need. I also visited a permafrost research station in Igarka on the way to Norilsk in Central Siberia. One funny and kind of sad thing about this was, there was a map on the wall, a permafrost map which was dated 1985 I think or something. This was before I was born. And the scientists told me that this is the newest map they can get. There's no better map that would cover the entirety of Russia. There's better data, sure, but you can't really get a bird's view of this.

0:10:36.4 OD: And I think if the system goes forward, there's really gonna be a chance to get a better grasp of what's going on because that GTN-P study that came out in 2019, this was I think one of the first attempts to collate the information about permafrost warming. It actually showed some of the stations in Russia indicating a full-on degree of warming in permafrost, and that's considering the scale of the issue, there can never be enough stations. You always want more data, you always want more coverage. I think that data will be useful to both track the state of the problem and ultimately adjust those guidelines too. As I said, for Russia, this is mainly an issue of keeping people and buildings and infrastructure safe.

0:11:22.6 SC: This plan came out of a report from scientists that made recommendations, and that report really asked for almost 10 times more money than is being spent. How is this, what is actually going to happen, different from what was proposed?

0:11:37.4 OD: That's true. The minister in charge of the Environment's Ministry, he was previously at another ministry, and in that capacity he commissioned a report which was done by really the leading permafrost scientists in Russia. Those scientists came up with a separate government entity really to monitor permafrost, to track this information that would oversee a huge system which would include some very complex and detailed monitoring, not just measuring temperature in the permafrost, but also doing all kinds of salinity monitoring and ice monitoring, all sorts of things. They were hoping for much more money and a much more independent structure, I would say.

0:12:18.5 OD: But ultimately the government went for a system that would be controlled by the Climate and Weather Service. At least they tell me, and I think that makes sense, that this was done in order to roll out the system as quickly as possible. So Roshydromet really has the resources to start this. They might not be that familiar with permafrost monitoring, but they do have some soil monitoring that they do, and they have a research institute that oversees Russian research in the Arctic and the Antarctic. So they do have some capacities to do this, but then I think everyone walked away a bit frustrated from what they got, but that I guess happens quite often when it comes to national systems, right?

0:13:06.9 SC: Yeah.

0:13:07.8 OD: I really hope they do start working on this and launch this system as soon as possible because the data will really be useful. And one point that I think is crucial that an expert makes in this story is I really wish that Russia would decide to share this data with other scientists too. Not just keep it to ourselves, but really feed it into a global system, which will make it that much more useful really for everyone.

0:13:33.2 OD: Alright, thank you so much, Olga.

0:13:34.9 SC: Thanks, Sarah.

0:13:35.7 OD: Olga Dobrovidova is a science journalist based in Moscow. You can find a link to the article we discussed at science.org/podcast.

Don't touch that dial, researcher Filippa Lentzos is next. She's gonna talk about regulating self-spreading vaccines.

[music]

0:14:01.7 SC: Here's an idea. Wild deer can carry malaria. Let's make a malaria vaccine that works in deer and keeps them disease-free, and the vaccine can spread from one deer to the other, so we don't have to find them all and give them shots. Problem solved. Or how about this? There is an invasive lizard in Florida. They're bigger than all the natives, they're taking over, eating all the food, squeezing out the animals that we want to live there. Should we make a virus that spreads only among these invasives, leaving everything else alone? These are not new ideas. Self-spreading vaccines, self-spreading engineered viruses, these were conceived of long ago, but creating them and purposefully releasing them into the world has been deemed too dangerous, too risky by experts, but as Filippa Lentzos and colleagues write in an insight this week in Science, research and funding for efforts like these involving self-spreading vaccines, engineered viruses, it's happening, even today. Hi, Filippa.

0:15:00.5 Filippa Lentzos: Hi, Sarah.

0:15:01.5 SC: These ideas have been around for decades, what prompted you to write about this now?

0:15:06.0 FL: There's a whole bunch of new research going on in this area, and so it seems like while it's been laying dormant for a while, essentially, there's been renewed interest in the last few years.

0:15:18.6 SC: Why are we saying... 'Cause I said it, and you're eventually gonna say it, self-spreading vaccines, self-spreading virus, rather than transmissible or contagious?

0:15:28.8 FL: You can say both. My preference is self-spreading because I think it's easier to understand.

0:15:34.8 SC: So we're talking about two different things here. Self-spreading engineered viruses and self-spreading vaccines. What exactly are those?

0:15:42.8 FL: To me, self-spreading viruses and vaccines are basically lab-modified viruses that are developed to spread between hosts in the environment. So they spread much like diseases do, but instead of spreading diseases, self-spreading vaccines spread immunity. So that's an easy way to think about how they work. You're adding genetic material from a pathogen to a virus, and that added material will then stimulate some kinda antibody creation in the host.

0:16:13.0 SC: This is something we try not to have happen now. We don't want someone with a live virus vaccine, for example, to spread that to someone else, for a number of reasons.

0:16:23.2 FL: That's right.

0:16:24.0 SC: What are some common scenarios for using this technology?

0:16:27.7 FL: The motivation behind some of the research that's going on right now is to use these kinds of vaccines for wildlife management. So essentially, what you would try to do is protect against zoonotic diseases that sometimes leap from animals to people, these spill-over events that we've heard so much about.

0:16:50.2 SC: Yeah. You mentioned this could be done with crops, where the plants are already in the field and you wanna treat them out there with a self-spreading vaccine, for example, but that's not what most of the current research or past research has focused on.

0:17:05.5 FL: The bulk of current research is focused on wildlife and we've got some historical cases of attempts to do that. Back in the late '80s, we had Australian researchers that were developing different ways to try to either sterilize or kill wildlife. Similarly in the '90s, you had Spanish researchers that were trying actually to do the opposite, they were trying to protect native wild rabbits using self-spreading viruses. So as you were saying in the introduction, this idea has been around for a while, but it's kind of come back now in the last five years.

0:17:43.3 SC: What are some of the really big concerns about developing and deploying this kind of intervention for wildlife management or for other reasons?

0:17:51.2 FL: The concern is that lab-modified, self-spreading viruses are genetically too unstable to be used safely and predictably outside of contained facilities, and especially as self-spreading vaccines, but once they're released, it's unlikely that you can remove them from the environment, and the consequences might be irreversible, and there's potential global spread, and so essentially, the concerns were all around continued evolution and unwanted mutations.

0:18:19.2 SC: It's not a technological hurdle here that's preventing these things from happening. All

of it is probably feasible but it's really just not something we should do, at least according to the experts that looked at this problem in the '80s, in the '90s.

0:18:33.9 FL: And the regulators have looked at this too, that's right. So it's not the technological issue primarily, I think it is the fact that this will be entering a social context for human vaccines definitely, but there are also concerns around wildlife management using self-spreading vaccines.

0:18:52.3 SC: Is it a practical intervention to try to vaccinate wildlife against something that may jump to people because we don't know which virus is gonna jump to people?

0:19:03.1 FL: Basically, the arguments behind for wildlife immunization with self-spreading vaccines don't really hold up to scrutiny because the vast majority of viral species simply haven't been identified by science, so we don't know what we're up against. That's one of the arguments that doesn't hold up. Another is that viruses are really very dynamic. There's lots of mutation, there's lots of evolution going on. So of the viruses that we do know about, how are you going to prioritize the particular spill-over risk that you're gonna focus on? What particular genetic event is it that's gonna happen, in which particular wildlife species is it, at what locations? They're all these unknowns. And the finalizing points, it's just the plain logistics of this, how in practice can you sustain and monitor the immune response to the vaccine in wildlife populations? How are you gonna know if it works or not?

0:20:01.6 SC: What approaches are people trying or should they be trying instead?

0:20:04.9 FL: Well, I think what most virologists would advocate for instead of self-spreading vaccines is just for surveillance at the human/animal interface, especially in hotspots, and once you identify a potential spillover, you need quick intervention, rather than going into the wildlife itself and trying to prevent a spillover. So to some extent, it seems not a very logical argument to be making but the point is it is being made and it's being made with considerable funding. There are heavyweight funders funding this research from the NIH, the EU Horizon's Project, and DARPA. It's still a very small community, but over the last five years, they've still had over a dozen scientific publications on this, and it's got a fair bit of coverage in popular science and in media. And so the idea is seeded, it's being put out there but you're not seeing the discussion within the scientific community about, what are the anticipated benefits of this, are they realistic? What are the potential harms, what are the potential risks? How do we weigh those?

0:21:21.5 SC: Yeah, it does seem like that discussion was had, people kind of agreed, and then it was forgotten about because it's been so long, and it's like zombie science, it's just gonna keep showing up, people are gonna keep proposing it, and testing it out, and, do we need to have these discussions again with virologists, with epidemiologists, with wildlife management?

0:21:40.7 FL: I think the answer really is to have a more open debate about whether we should be doing this kind of research at all. This is clearly a global concern, so we need to have a global governance effort. That means at the international level, we need to update existing regulations around this to reflect contemporary societal values, and these will have shifted in light of the COVID experience, for sure. We also need national governments to clarify and if necessary, update

any relevant legislation and guidance they have in this area, and I think we need to ask more of the researchers and their institutions, and the funders who are working on these approaches to actively articulate credible regulatory paths that they believe the safety and efficacy of self-spreading vaccines can be established.

0:22:36.0 SC: This seems especially important if the research is being done by one country with the aim of applying it in another country for a problem that isn't local to the researchers.

0:22:48.2 FL: Yes, we do see that happening. We do see, for example, funders in the United States funding research going ahead in Africa, for instance, saying, "Oh, this is gonna be of huge benefit to them," but it is also at a risk to them. And so there are questions around outsourcing risks, there are questions about for whose benefit is this, really? And I think that discussion needs to be brought more to the fore and more to the communal level and not be kept in these very specialized niches or groups.

0:23:26.2 SC: What are some of the safeguards that have been proposed or that people discuss as a possibility for something that's self-spreading?

0:23:34.7 FL: What the researchers are currently claiming is that there are approaches that exist that will suppress viral evolution so that these viruses that you release won't mutate in the environment. They also say that the viruses and the vaccines can be fine-tuned so that they only have pre-determined lifetimes. Now, none of that is proved.

0:23:57.2 SC: Oh, I was gonna say, how does that hold up? [chuckle]

0:24:00.3 FL: Yeah, not very well, like these are claims that are being made, but they've not been proved, they've not been evidenced, and I think there would be a lot of suppressed faces if they could evidence the fact that evolution doesn't continue with viruses. We're talking in the middle of an Omicron wave, we are, I think all of us, very conscious that viruses evolve in the wild.

0:24:24.6 SC: In my experience on social media, some of the wilder things I've seen are people saying, "Oh, well, the covid vaccines, the coronavirus vaccines are spreading person to person." Obviously, that's not true, but it's not something we should avoid talking about.

0:24:39.6 FL: No, I think that's right. I mean, I think there would be an incredible backlash against any suggestion that we would introduce self-spreading vaccines for humans, and we see that particularly with the anti-vaxxers movement, for instance, and what was interesting before this article came out in Science. I wrote with some of my co-authors another smaller piece for the Bulletin of Atomic Scientists, where our title, which was "Scientists are working on vaccines that spread like a disease, what could possibly go wrong?" Attracted an incredible amount of clicks and attention, and that was primarily from the anti-vaxxer community. They thought, from the headline, that this could be something to back up their arguments, but of course, if you read through the article, that's not at all what it was.

0:25:32.0 SC: I have to admit that when I first read Self-spreading Vaccine, I was like, "You know,

maybe," but as soon as I read your piece, I was like, "Oh no, we do not wanna give people vaccines that don't want them because they could have a reaction, they can have an immune-compromise situation, there are so many reasons.

0:25:48.4 FL: That's right, there are more vulnerable communities out there, of course, but what is interesting, it is, it does seem like an inherently attractive idea especially when you think about it in terms of not humans, but wildlife. Could we just have let a virus loose on bats that then would have ensured the coronavirus didn't spill over into the human population? It seems a very attractive idea at first glance.

0:26:15.5 SC: But the practicalities and the dangers are really big questions.

0:26:20.9 FL: Yes. I mean there are safety aspects to this, there are ethical aspects to this, there are also security aspects to this. So it needs and warrants a much deeper discussion, and the steps that we're seeing currently, where researchers are suggesting this is a possibility right now, I think are worrying, when we haven't had that discussion.

0:26:42.4 SC: Alright, thanks, Filippa.

0:26:44.0 FL: Thanks, Sarah, it's been good to speak to you.

0:26:45.8 SC: Filippa Lentzos is a senior lecturer in Science and International Security in the Department of War Studies, and in the Department of Global Health and Social Medicine, and also Co-Director for the Center for Science and Security at King's College London. You can find a link to the inside article we discussed at science.org/podcast.

0:27:06.6 SC: And that concludes this edition of the Science Podcast. If you have any comments or suggestions, write to us at sciencepodcast@aaas.org. You can listen to the show on the Science website at science.org/podcast. You could subscribe there or anywhere you get your podcast. The show was edited and produced by Sarah Crespi, with production help from Podigy, Megan Cantwell, and Joel Goldberg. Transcripts are by Scribie, Jeffrey Cook composed the music. On behalf of Science Magazine, and its publisher, AAAS, thanks for joining us.