Dr. Zoe Panchen: So my name is Zoe Panchen, I'm a postdoctoral fellow in the Geography Department at UBC, and I study how arctic plants respond to climate change. The arctic climate is warming at over double the rate of the global average, so the temperatures up there are getting warmer faster than anywhere else in the world.

So the plants in the arctic are quite unique, they're very small and low to the ground. It's warmer down there, believe it or not, it's 10 to 15 degrees C warmer at the ground than up where we normally measure temperature, which is about head height, so much higher up. So it's colder higher up in the air than right down. There's a nice warm layer where the soil is re-radiating the heat up so the plants are very low and small. They're also often cushion-shaped so they form this kinda little hemispherical dome and that kinda creates a little micro-climate, so they create their little warmth, it keeps the nutrients, there's not many nutrients there, so it creates a little soil pool and a little warm patch for itself. So these are very cute when they're like this. [laughs] But it helps them to grow better by creating their own little micro-climate.

So I think one of the big differences, and we're already seeing this, that plants are gonna get taller and bigger. And that's particularly what we're seeing with the shrubs, so they're expanding in both directions, upwards and outwards. So a single plant will be taller and it'll have a bigger diameter or spread further over the ground. One other thing we already see but in a slightly different way is I think there will be much more **[2:00]** lush plants. So where there are areas of high nutrients, so near to rocks where birds perch and then they poop, and so they provide lots of nitrogen to the soil. Where animals have died, usually of old age or they've been killed by a wolf, then you'll also find a very lush area of vegetation there so you see it's very, and you can see this from a long way off, so the landscape can look quite barren and brownish, yellowy, not much green. But then you'll see this little nutrient-rich area and it's a really lush green and it's very tall. So I can imagine that, in the future, that you might see that appearing more. If the climate's warming, then there'll be more decomposition and therefore more nutrients in the soil, so therefore you might see that more around. So you're gonna see bigger, taller bushes and greener landscape. In fact, I've heard that the elders around Iqaluit on Baffin Island have said that they think that the area there is much greener than it used to be in years gone by.

What we're actually seeing as the climate warms is a lot of shrubification, so we're seeing in the arctic, plants are getting, the shrubs are getting bigger, taller, wider, and in some respects, shading out some of the other species up there, particularly lichens and mosses. The lichens is a staple food for caribou, so

that can have knock-on effects all the way up the trophic levels. So trophic levels, I mean that things feed on other things up the chain. **[4:00]** So the caribou eat the plants and then the wolves kill the caribou and eat the caribou, and so you have multiple trophic levels. So the plants tend to be at the bottom of those trophic levels.

So we're seeing kind of changes in the species composition, which species are more abundant. What I do my research on is phenology, which is the timing of nature's seasonal events, so like the time of flowering, the emergence of insects, the arrival of migrating birds. And typically what we're seeing are the plants are flowering earlier because it's warmer, and fruiting earlier, leafing out earlier. So that can have a benefit because the plants up there are not very reproductive successful, so they're not able to produce very many viable seeds. Often the season is so short that the summer season is finished before the seeds have matured. So in those years, then there's no seeds produced that could germinate the following year, or very few. So with a warmer growing season, and with a longer one, so with it being warmer, it stays warmer later, so there's more chance for the seeds to ripen, and with the warmer temperatures, we think that there's more chance for more seeds to be viable.

Also, there's not much decomposition that goes on up there, so because it's so cold, the microbes that tend to decompose some of the plant litter do very little, if anything. So with a warmer climate, the microbes, there might be more activity in the microbes, and therefore you get more decomposition, which means that there's more nutrients in the soil **[6:00]**, which would then benefit the plants. So there's lots of things going on that can benefit the plants up there, but there will be some winners and some losers, because there's definitely plants that are not responding very much to climate change, and they will likely be the losers. And those that are responding and adapting to the changes will be the winners, I think.

I don't know whether they're extinct yet, it's hard to know, we know actually very little about what's up there and where. So for instance, some of the work that I'm doing up there at the moment, we have plots, where we're warming some of the plots artificially or by having a mini-type greenhouse around the plot, and what we've seen is that the willow is basically taking over, so that's a winner. And what we're also seeing is that the arctic poppy is becoming less common in those warmed plots compared to the general landscape. So there are some of the plant species, higher order plant species that may also become more rare or confined to places where there's less competition. Because I think some of the species survive up there because they can grow in really harsh places, but there's no competition, so

they're the ones that win out in that, but those areas where there's less competition will become fewer as the climate warms. So because they are melting so much and you're getting these torrents of water coming off, there's a lot of erosion. So we're seeing the edges of the rivers where the plants are located just being worn away and dropping in, and the plants being washed away. So we see a lot of that. And obviously then there's a lot of sediment going out to the sea and being moved **[8:00]**. So disturbance is one thing. The glaciers are retreating so that's creating new areas for plants to grow. So some of the early plants that we see colonizing these areas that have become bare of ice are: poppies are one of the first species to see there and some of the grasses too, colonize it pretty quickly. There's been some studies up at this fieldsite I'm working at where they've actually looked- they know where the glacier was in the 1950s, and since the 80s or 90s they've actually been tracking where the glacier was in each of those years. Now we just do it with a GPS. We just walk along the edge of the glacier with a GPS running and we can map the edge of where the glacier is now. Before, they used to put stakes. So there's a whole line of stakes, and those stakes can be 10 feet, 15 feet apart from one year to the next. So we know where the glacier was, so then you can go look and see what plants are growing and you have that yearly progression getting closer and closer to the glacier to see what plants are growing. So you can kind of see what we call succession. So who were the plants that colonized first and who comes second and then so on.

So one of my favorite's is the moss campion. The latin name for that is Silene acaulis, and it is the quintessential cushion plant. So it forms this beautiful little dome of bright green, tiny, tiny leaves. The leaves are only 2 or 3 millimeters in size and very, very dense. And then it produces these beautiful pink flowers that have a wonderful honey smell. So that's probably one of my favorites. There's a couple of others that I quite like. There's a lot of saxifrage species up there, and one of **[10:00]** the first to flower is the purple saxifrage. It's actually the flower of Nunavut. But one of my favorite saxifrages is called 'Saxifraga flagellaris,' I think is one name, platysepalus is I think another name for it, and the common name is the spider plant. And so it's kind of a little rosette. THis is another form of how the plants protect, so it has a little rosette and whorls of leaves that gets, um, so the older leaves are the outside ones and the newer, newer ones inside. And in the winter those outside leaves close up and it forms kind of like a little ball. And the outer leaves are harder and drier and so they protect the newer leaves in the middle. ANd then what it does is it produces little baby plants, like a strawberry. So it has a little runner that comes out and there's a tiny little baby plant, and that plant will be plopped down into the soil around the mother plant. And so what you see is a bigger plant in the middle and a little circle of

baby plants around the outside. And then it also has a nice, bright red, um, bright yellow flower. And the stalk is quite red and then a nice big yellow flower. The yellow flower is probably as big if not bigger than the pilot-the little balls of leaves at the bottom. And then my third favorite, the third one I'll talk about is the lousewort pedicularis species. So there's quite a- two or three or four, maybe even five or six different species across the arctic in North America. And it has, usually, bright purple flowers and multiple flowers on one stem, and they kind of have a little hood over the top, the petals over the top form a hood and the ones at the bottom **[12:00]** kind of form a three-pronged lip. And they're beautiful bright colors and the bees tend to come for them. So the bees are huge in the arctic, and they kind of come and pollinate those flowers. So they're kind of nice to see.

So the leaves are actually what we call 'xeromorphic,' so 'xero' meaning 'dry' and 'morphic' meaning 'shape.' So they are designed to deal with dry conditions. So the arctic is actually very dry. The precipitation they get up there is very low, and in the high arctic we call it a polar desert, so it really is desert-like. And some of the functions of having a leaf that's resistant to dry and heat are also the types of functions or characteristics you'd want for having a leaf in a cold environment. So the leaves are very thick and have what we call a cuticle, so that's kind of like the skin, very thick cuticle, they have lots of hairs, which kind of keeps the moisture in, and they also roll the edges of the- so the mountain avens does this beautifully. So it rolls the edge of the leaves, so instead of the leaf being flat, the margins of the leaf roll under. And that again is reducing the surface area, so there's less surface area for water to evaporate from. And they keep their leaves- so these leaves, because it takes a lot of resources to produce a leaf, you need nutrients in the soil and water and photosynthesis to produce the sugars, so they tend to keep their leaves for more than one year. So those leaves need to survive over winter in minus 20 degrees C, or minus 40. Sometimes they're covered in snow **[14:00]**, so that is kind of like an insulating layer, but it still is a fairly tough environment for them to live in. So that's why they have that very xeromorphic characteristics.

Erosion along the coastline is a big thing, some of the villages up there are about to fall into the ocean. Yeah, and I mean I've seen, you know, I've seen the glaciers retreating, I've seen huge chunks of the glacier breaking off and you know I've seen those stakes that we were talking about that mark where the glacier was, so I've seen how much the glacier has retreated just by having seen where somebody previous has put those stakes in the ground.