WWF MAGAZINE
No. 1
2019

ARCTIC OCEAN SPECIES AT RISK

Looking to the past to understand the future

8

DISAPPEARING SNOW

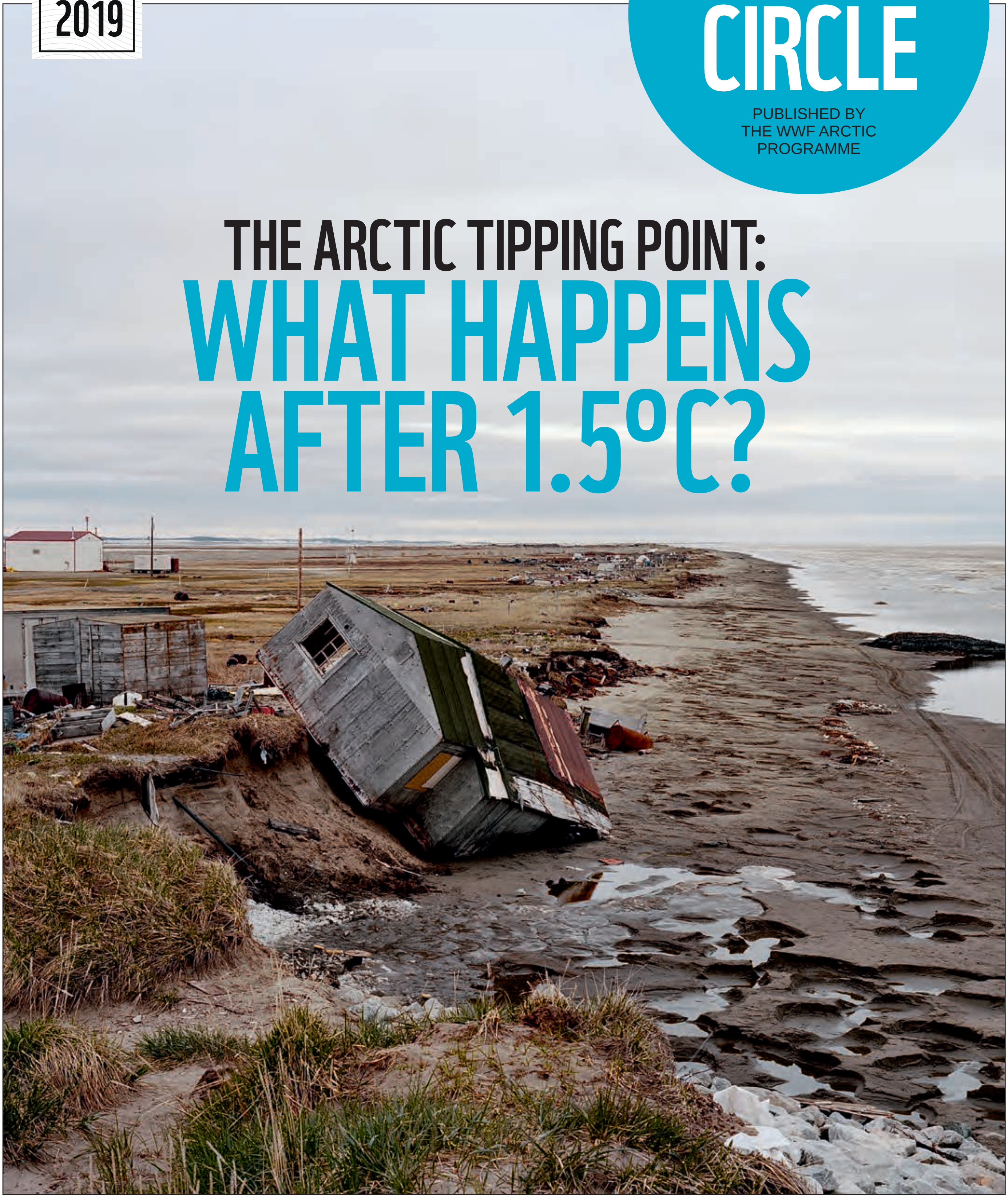
Vanishing snow cover challenges Arctic species' survival

12

THE CIRCLE

PUBLISHED BY THE WWF ARCTIC PROGRAMME

THE ARCTIC TIPPING POINT: WHAT HAPPENS AFTER 1.5°C?



ARCTIC TIPPING POINTS

The Circle 1.2019

Contents

The Circle is published quarterly by the WWF Arctic Programme. Reproduction and quotation with appropriate credit are encouraged. Articles by non-affiliated sources do not necessarily reflect the views or policies of WWF. Send change of address and subscription queries to the address on the right. We reserve the right to edit letters for publication, and assume no responsibility for unsolicited material.

Publisher:
WWF Arctic Programme
8th floor, 275 Slater St., Ottawa, ON, Canada K1P 5H9.
Tel: +1 613-232-8706
Fax: +1 613-232-4181

Internet: www.panda.org/arctic

ISSN 2073-980X = The Circle

Date of publication:
February 2019.

Editor-in-chief:
Leanne Clare, lclare@wwfcanada.org

Managing editors:
Sarah MacFadyen, sarah@sarahmacfadyen.com
Patti Ryan, patti@southsidecommunications.ca

Design and production:
Film & Form/Ketill Berger, ketill.berger@filmform.no

Printed by Lowe-Martin

Thank you for your interest in The Circle. Many of our subscribers have moved to an e-version. To receive an electronic copy in your email instead of a paper copy, please write to us at info@arcticwwf.org and help us reduce our costs and footprint.

COVER: House sliding into ocean, Shishmaref, Alaska.

Photo: Dana Lixenberg

ABOVE: Stranded tree on eroding beach in Lost Coast, Alaska, where climate change is causing rapid coastal erosion.

Photo: Ground Truth Trekking, CC, groundtruthtrekking.org

EDITORIAL

To protect the Arctic—and the rest of the world—we need bigger, bolder ideas and renewed commitment

AS ARCTIC SEA ICE SHRINKS, global interest in the region increases. Politicians and industry leaders are formulating and implementing national and international plans to maximize economic gains from an environmental crisis of global proportions—all in the name of economic development.

This interest was highly visible during the recent Arctic Frontiers conference in Tromsø, Norway, whose theme was Smart Arctic. After touching on sustainable development and the inclusion of Indigenous peoples and local youth, the discussion quickly turned toward old ways of thinking and a push for increased industrial development through more shipping. Entire panel sessions were dedicated to oil and gas and deep-sea mining development. Yet pushing for non-renewable extraction in the sensitive Arctic ecosystem will not create a sustainable Blue Economy in the region, and is far from the innovative Smart Arctic concept that was initially touted.

> **Without immediate action, the Arctic will continue to unravel, setting off system-wide changes that will be irreversible on timescales relevant to human societies.**

The recent Intergovernmental Panel on Climate Change (IPCC) 1.5˚C report shows how the Arctic has been warming at an unprecedented rate compared with the global average. Compared with pre-industrial levels, warming in the Arctic region has already exceeded 2.5˚C during the winter season (December to February).

Moreover, strong feedback loops—which are poorly understood and not completely included in today's climate models—could potentially increase the rate of warming over the Arctic in unpredictable and rapid ways within the next 10 to 20 years. One such loop is the thawing of permafrost across the northern hemisphere and the release of carbon that has been stored there since before the last ice age. When released, carbon dioxide and its much more potent cousin, methane, have the potential to accelerate the warming at an unknown rate. It is estimated that the amount of carbon currently stored in Arctic soil is twice that of all carbon currently in the Earth's atmosphere.

The Arctic's landscapes, wildlife and people are already stressed by the ongoing rapid warming and its cascading effects. The IPPC report also states that Indigenous Peoples and coastal communities are among those exposed to the highest risks from the consequences of global warming beyond 1.5°C. Arctic ecosystems are at particularly high risk. Two examples are high-Arctic species that have nowhere to go in a warming climate, such as caribou/reindeer and polar bears, and marine mammals that are losing the ice platform they depend on, such as walruses and seals.

PETER WINSOR is WWF's new Arctic Programme director. Prior to taking on this role, he spent 20 years studying the Arctic as an oceanography professor.

We have an urgent and critical need for new thinking and approaches to the climate change issue, including integrated approaches to tackle the the critical issues of environment, biodiversity and climate change in concert. We need an insurance function in place to give ecosystems time and space to adapt to rapid changes so people can still use the services they provide. Networks of marine protected areas are included in such a fuction as part of an ecosystem approach for managing the Arctic Ocean. Without immediate action, the Arctic will continue to unravel, setting off system-wide changes that will be irreversible on timescales relevant to human societies.

In this issue of The Circle, we bring you a range of voices and stories from different fields and areas of the Arctic to show how multidimensional these topics are. Climate change is pushing the world into an unknown state. That means we need to push ourselves to create new coalitions and ways of cooperating among researchers, civil society, governments and the public to openly discuss our options, explore the trade-offs, and find a sustainable way forward. We will have difficult conversations about controversial solutions and may need to establish new governance structures as a result.

The Arctic is the largest undisturbed natural area on Earth. Building resilience and adaptation for its people and protecting and conserving the landscape and wildlife of this unique area are urgent tasks. We must take up the challenge. ○

RUSSIA

Arctic wind farms reduce reliance on diesel

A NEW WIND FARM in the Russian Arctic is expected to help area residents reduce their use of diesel fuel by 500 metric tonnes per year. The farm, which opened in November, serves some 4,600 people from its location in Tiksi, a remote village north of the Arctic Circle.

The project is the result of a joint initiative of Russia's RusHydro electric company, Japanese researchers, and administrators with Russia's Republic of Sakha. The three groups joined forces to come up with a "polar microgrid" system to stabilize the power grid in the area.

The project involved constructing a 900-kilowatt

ARCTIC WILDLIFE

Caribou numbers down by half

THE NATIONAL Oceanic and Atmospheric Administration (NOAA) announced in December that reindeer numbers across the Arctic have fallen by more than half in the past two decades.

The news was part of the NOAA's 2018 Arctic Report Card, which points to climate change as the likely culprit. Numbers are down to about 2.1 million from 4.7 million—a loss of 2.6 million animals. In Canada, the Bathurst and Bluenose East herds have diminished by more than half since 2015.

The decline spells trouble for Arctic ecosystems and cultures, since the large herbivores are prey for wolves and biting flies as well as a key source of food, clothing and income for Indigenous groups. Many Indigenous cultures in the circumpolar North are built around caribou or wild reindeer.

Rising temperatures in the Arctic mean more rain, which freezes into ice sheets that make grazing more difficult.

Photo: G MacRae, CC, Flickr.com

wind power plant that can withstand high winds and temperatures as low as −50°C. The plant uses three turbines built by Komaihaltec Inc., a Japanese renewable energy company.

The village of Tiksi endures some of the Earth's most extreme climate conditions. The new power plant is expected to improve residents' living conditions.

GREENLAND

Lakes and ponds disappearing across Arctic

SMALL LAKES AND PONDS have been a part of the Arctic landscape for hundreds of years. But research by the American Geophysical Union suggests they are steadily disappearing from the Arctic tundra.

Scientists once thought that as climate change thawed permafrost, water would pool and actually increase the number of lakes across the tundra. But new research suggests the opposite is happening.

Over the last 50 years, hundreds of tundra ponds have vanished from a single corner of western Greenland. Satellite imagery shows that more than 400 ponds near the town of Kangerlussuaq have disappeared while others are smaller than they once were.

Researchers believe this may be the result of a variety of factors. A warming climate may be causing more water to evaporate. As the soil warms, small lakes may be draining into the groundwater. As well, thawing permafrost may release nutrients that increase the growth of vegetation that invades and overtakes small ponds.

© Snøhetta/Plompmozes

NORWAY

Arctic Circle hotel will be first in the world to generate more power than it uses

A NORWEGIAN architecture and design firm has plans to create a sustainable hotel at the base of a glacier just above the Arctic Circle. The hotel is expected to open in 2021.

Dubbed "Svart" after the Svartisen glacier in northern Norway, the hotel is expected to be the first in the world to produce more energy than it uses. Its energy consumption will be 85% less than that of a typical hotel.

Snøhetta, the design firm behind the innovative structure, set out to create a sustainable building that would leave a minimal environmental footprint in its pristine location over the waters of the Holandsfjorden fjord.

Key technologies aimed at helping the building minimize its energy use will include rooftop solar panels, geothermal wells and shade over some of the larger common spaces—such as a restaurant—in the summer months.

Getting there will be sustainable too: the only way to reach the hotel will be via an energy-neutral boat shuttle.

What happened to the snow?

Climate change = culture change

Snow (muohta) covers the Sápmi region—home of the Indigenous Saami people—eight months a year. It plays a central role in the Saami way of life and reindeer herding culture, as well as in climatic, ecological and hydrological processes in the region. But as KLEMETTI NÄKKÄLÄJÄRVI writes, the amount and structure of snow in the area has changed, and the snow-free season is growing longer. Saami people are living in an era of uncertainty that is triggering changes to their culture, language and livelihoods.

IN FINNISH SÁPMI, the average temperature has risen by 2.3°C since the post-industrial period. The early winter season in particular is 5°C warmer. If warming continues at this rate, the climate in Sápmi will resemble that of southern Finland by the end of the century. The effects of climate change are already evident in the Saami environment, livelihoods, language and even in their culture.

Reindeer culture is part of everyday life for Saami people. But reindeer need Arctic conditions to thrive, including snow that allows them to dig for lichen. Without these conditions, reindeer culture and the Saami way of life will change, erode and perhaps even disappear.

I have always lived in Sápmi, and have lived the Saami way of life. I have also studied Saami culture extensively, and I see the changes every day. Saami elders have told me how easy it was in

Changing snow and ice conditions are increasing the risk of accidents for herders.

If warming continues at this rate, the climate in Sápmi will resemble that of southern Finland by the end of the century.

their youth to predict environmental conditions, anticipate good or bad reindeer years, and plan reindeer work in advance. But no longer. The last decade has seen huge changes. Today there is extreme variability between reindeer years, and weather and snow conditions are impossible to predict properly.

MORE THAN 360 WORDS FOR SNOW

The importance of snow in Saami culture is best understood by looking at the Saami language. I estimate there are at least 360 words for snow in North Saami.

Photo: Klemetti Näkkäläjärvi

Snow conditions determine the success of the reindeer year. Saami people use the word guohtun, a concept that describes both snow and nutrition conditions for reindeer. Sadly, guohtun conditions are no longer predictable. The snow is different. Herders tell me it arrives later and has a different structure, and that the amount of snow is unnatural, with significantly more or less than normal for the season.

As snow conditions change, reindeer work models must also change. If not, some people's livelihoods will come to an end. In this sense, changes in snow are triggering both cultural changes and the use and need for the Saami language: when livelihoods that were unique to the Saami are lost, language shifts easily to Finnish. If that happens, future generations will learn only shadows of once-rich Saami culture and language.

WHAT HAPPENED? CLIMATE CHANGE HAPPENED

The different snow and ice conditions have made it more difficult for reindeer to dig underneath thick snow and ice crusts for lichen. It has also increased the risk of accidents for herders. Pastures have become landscapes of risks and losses. There have been fatal accidents in Saami communities related to the environmental conditions. Climate change has forced many herders to change their livelihood models. For example, some have introduced new technologies and are now providing additional food for reindeer herds.

In a warming climate, the Saami will likely survive as a linguistic minority, but their unique culture and knowledge system will fade away. Reindeer herding will be transformed from a cultural livelihood to an economic one or even to an industry.

Climate change mitigation and adaptation are a question of human rights for Indigenous People. Like other Indigenous Peoples elsewhere, the Saami have always adapted—to assimilation

Photo: Klemetti Näkkäläjärvi

Reindeer culture is part of everyday life for Saami people.

and changing environmental conditions and now, finally, to climate change. But we are facing a serious limit: How much adaptation can Saami culture endure without losing its uniqueness? Common terms like theoretical adaptation and resilience seem assimilative from the Saami point of view because they imply that the Saami must change their culture without the option of determining their own destiny.

It is important to understand the holistic effects of climate change—especially the easily overlooked cultural and intergenerational effects. To safeguard Saami traditions and culture, we need to make sure there will be some good reindeer years left. The way to do that is by limiting global warming. ○

Photo: Klemetti Näkkäläjärvi

KLEMETTI NÄKKÄLÄJÄRVI (Juvvá Lemet) is a Saami cultural anthropologist and linguist at the University of Lapland whose research focuses on Saami culture, language, traditional knowledge and livelihoods as well as climate change.

Sea change

Detecting and coping with the Grim Reaper of the Arctic Ocean

Canadian ocean scientist EDDY CARMACK wonders if it's time to face the possibility of mass extinction in our northern oceans.

Bad news on the doorstep
I couldn't take one more step.

—Don McLean,
from "American Pie," 1971

WHAT IS THIS "bad news on the doorstep" stuff? Isolated, the lyrics from Don McLean's timeless song lamenting the death of American musician Buddy Holly have a different meaning today. The "bad news on the doorstep" now revolves around the existential risk of climate change. And the Arctic—a harbinger of what may befall the rest of the world—is sending the loudest message of all.

It's common knowledge that sea ice loss is the leading signal of global warming, and that iconic Arctic animals, such as polar bears and walruses, are acutely stressed. Most researchers recognize that changes in the Arctic are severely affecting mid-latitude weather. But are we fully aware of another impending signal of global change? We are talking about progressive extinction in our oceans, whereby one by one—like the lights of a city going out—individual taxa die off in a process called extirpation that creeps across the planet like an environmental Grim Reaper.

Arctic air temperatures are rising at twice the global rate. So if the bad news climate models foretell potential 6°C to 8°C degree increases in air temperatures by the end of our century, should we expect the Arctic to warm by 12°C to 16°C? Will sea water temperatures reflect this change? This is a scary thought. But one thing to appreciate is the fact that by warming more quickly, the Arctic marine system is offering us a glimpse of the future. By daring to look, might we discover a means of coping with the greatest threat ever faced by our species?

Deep time and resilience

We now know there have been five, six or seven major mass extinctions (and dozens of lesser ones) since the Cambrian, each defined by a rapid, worldwide loss of species. Proposed causes include meteor impacts, mega-volcanic eruptions and global glaciations. All of them involved rapid climate change and came with fundamental changes to the Earth system that we are just beginning to appreciate. It seems that every contingency point in marine evolution comes down to triggers that disrupt only half a dozen or so key elements, such as temperature, oxygen, pH, salinity, carbon, nutrients and available light. When these elements change beyond allowable limits, the rules change: biogeography shifts, animals migrate or die, and the Earth changes.

Similarly, in the Arctic today, a game-changing underwater experiment is taking place, with massive changes in biogeochemistry that are swiftly affecting an entire ocean. At the very least, we must monitor and manage the basic "life variables" mentioned here—not only to cope with extinction of marine species, but to avoid our own as well from abuse and over-consumption of ecosystem services.

LOOKING AT THE PAST TO UNDERSTAND THE FUTURE

New studies from deep-time geology validate important insights.[1] It is thought that life first developed in shallow waters where the right ingredients are brought together. Ironically, it is these same shallow waters that now may be most threatened by mass extinction. Geological and climate modelling studies are showing that the Arctic Ocean lies at the centre of the action, as past extinctions appear to have been most severe in the high latitudes.[2] We can now match the projections of climate models for the next few decades to climatic events covering the past 50 million years.[3]

Fast forward to the present and ask: Why is the Arctic Ocean front and centre? Although it comprises less than 3% of the world's surface area, it holds a quarter of the world's shallow continental shelves and a third of its coastlines. As a result, it contains a disproportionate amount of rapidly warming real estate where multicellular life began and is now threatened.

COMING TO GRIPS WITH A NON-LINEAR FUTURE

When we think of global warming, we tend to think in terms of linear increases—in other words, 2°C of warm-

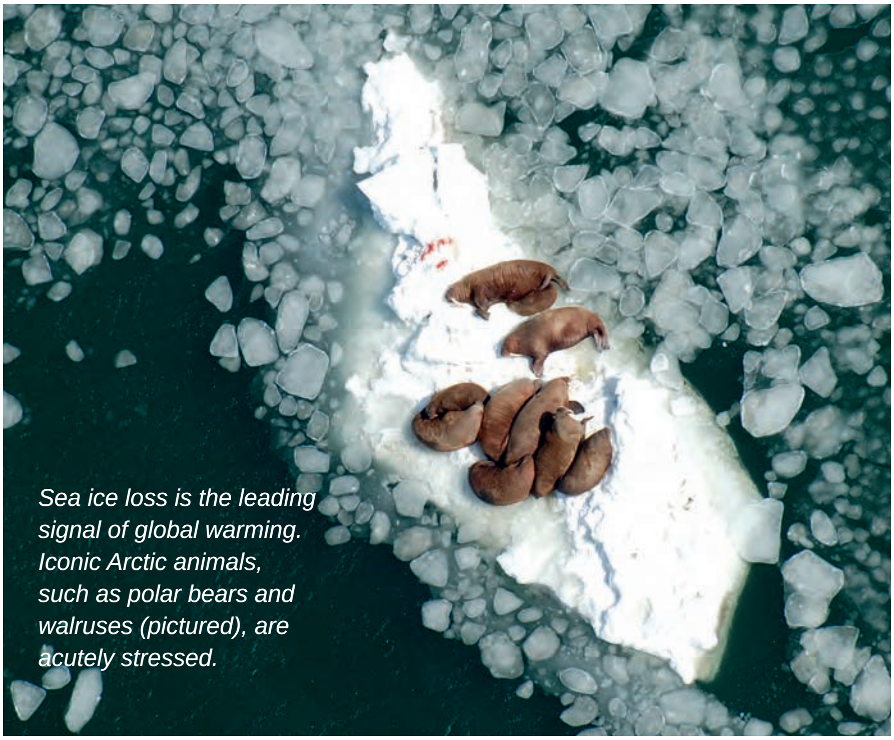


Photo: Alaska Region U.S. Fish & Wildlife Service, CC, Flickr.com

Sea ice loss is the leading signal of global warming. Iconic Arctic animals, such as polar bears and walruses (pictured), are acutely stressed.

ing means 2°C warmer. But we are entering a non-linear future, literally. The physical and chemical processes that affect the climate system and life on Earth are extraordinarily complex, so they are captured by parameterizations that mimic the laws of nature. These rate-governing equations are generally non-linear: the density of sea water, the capacity of the atmosphere to carry moisture, the rates of microbial utilization of oxygen and more are all governed by either exponential functions or power laws. Oxygen concentrations in the world's oceans have already decreased by 2% over the past 50 years, with the Arctic Ocean identified as a region of concern.[4] Non-linear systems are subject to surprise, as our Arctic marine system is now demonstrating.

Past extinctions appear to have been most severe in the high latitudes.

Organisms have evolved the physiological mechanisms they need to live where they do. For example, marine species require thermal, pH and oxygen limits to thrive.[5] When these are exceeded too rapidly to allow adaptation, species either move or die. Rising water temperatures are already testing the physiological limits of ecologically and culturally invaluable species such as the circumpolar Arctic cod and Arctic char[6, 7]; loss of these critical species would reverberate upward through the entire food web.

But extirpation will not occur uniformly or predictably. The consequences of change will spread along different pathways. Consider the Canadian Arctic archipelago, a vast continental shelf and mix of islands and waterways fed by an uncountable number of lakes and rivers and ultimately connecting water masses derived from the Pacific, Atlantic and Arctic oceans.[8] This complex geography means signals of warming and chemical change can attack from all directions—even from below, where vast amounts of methane locked in frozen ground await release.[9]

The dominant variables defining the windows of life are few—temperature, oxygen, pH, salinity, carbon, nutrients and available light—and all are undergoing significant perturbations now. Where do we start? How can we best make decisions about the vulnerability of thousands of species that comprise the complex and distinctive food webs in coastal sites around the Arctic?

Setting up a community-based coastal observatory is one idea, and easy enough to do. But Indigenous People living close to the land must play the key role here, because they know the land and can identify the local species that are most important to their way of life, and thus determine what to study first. This is the experiment we must launch.

Where we end is another matter. The above story spells out a worst-case scenario. It remains to be seen whether or not we heed the news on the doorstep and—in deference to the words of Don McLean—dare take the next step. ◯

EDDY CARMACK is a senior research scientist emeritus for Fisheries and Oceans Canada at the Institute of Ocean Sciences in Sidney, B.C. He has participated in more than 90 field investigations in high-latitude waters.

REFERENCES

1. H. Fischer et al., Nature Geosci., 11 (2018)
2. J. Penn et al., Science 362, 1327 (2018)
3. K.D. Burke et al., PNAS, 115, 52 (2018)
4. S. Schmidtko et al., Nature, 543, 335 (2017)
5. H. O Pörtner, & Farrell, A. P. Science 322 (2008)
6. H.E. Drost et al., J. Exper. Biol. 0 (2016)
7. M.J. Gilbert, & Tierney, K.B. Funct. Ecol., 32(3) (2018)
8. E.C. Carmack et al., Ambio (2012)
9. J.F. Dean et al., Rev. Geophys., 56, 207-250 (2018)

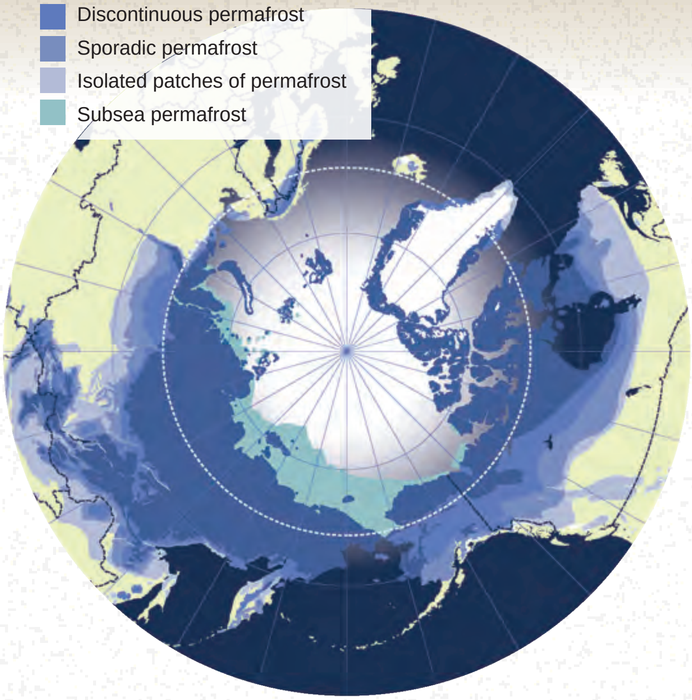
Thawing permafrost

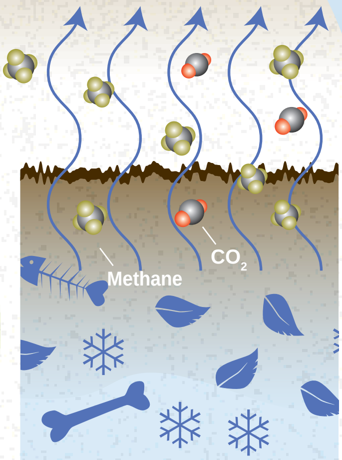
Permafrost contains a mixture of organic material, plants and dead animals that have been frozen since the last ice age 11,000 years ago. As the Arctic warms, permafrost is beginning to thaw. As it thaws, it decomposes and emits carbon, amplifying the climate change that is causing it to melt in the first place.

■ Permafrost occurs at an annual average air temperature of **-2°C** or colder.

19 million square kilometres of land in the northern hemisphere (an area larger than the entire continent of South America) is "influenced" by permafrost. Most of this land is in Russia, Canada, Alaska and Greenland.

- Continuous permafrost
- Discontinuous permafrost
- Sporadic permafrost
- Isolated patches of permafrost
- Subsea permafrost





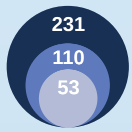
Carbon emissions from thawing permafrost

■ Plants, dead animals and organic material decompose as the Arctic warms and emits methane and CO_2.

Effects of thawing permafrost

No one knows for sure what the impact of thawing permafrost will be, but many experts predict a tipping point. Some scientists have come up with the "compost bomb instability model": the idea is that once permafrost begins to thaw, releasing massive quantities of carbon, permafrost may itself create a negative feedback loop and become a source of heat, causing an increase in soil temperatures, additional decomposition and methane release.

■ It is estimated that 16% to 24% of Alaska's permafrost will degrade by 2100.



■ **110 to 231 billion tons** of CO_2 equivalents could be emitted by 2040 because of thawing permafrost. (If all countries live up to their promises in the Paris Agreement, CO_2 equivalents would be about 53 billion tons in 2030.)

■ None of the CO_2 being released from permafrost is accounted for in the models used for the **Paris targets**. This is primarily because it is unclear what quantity of GHGs will ultimately be released.

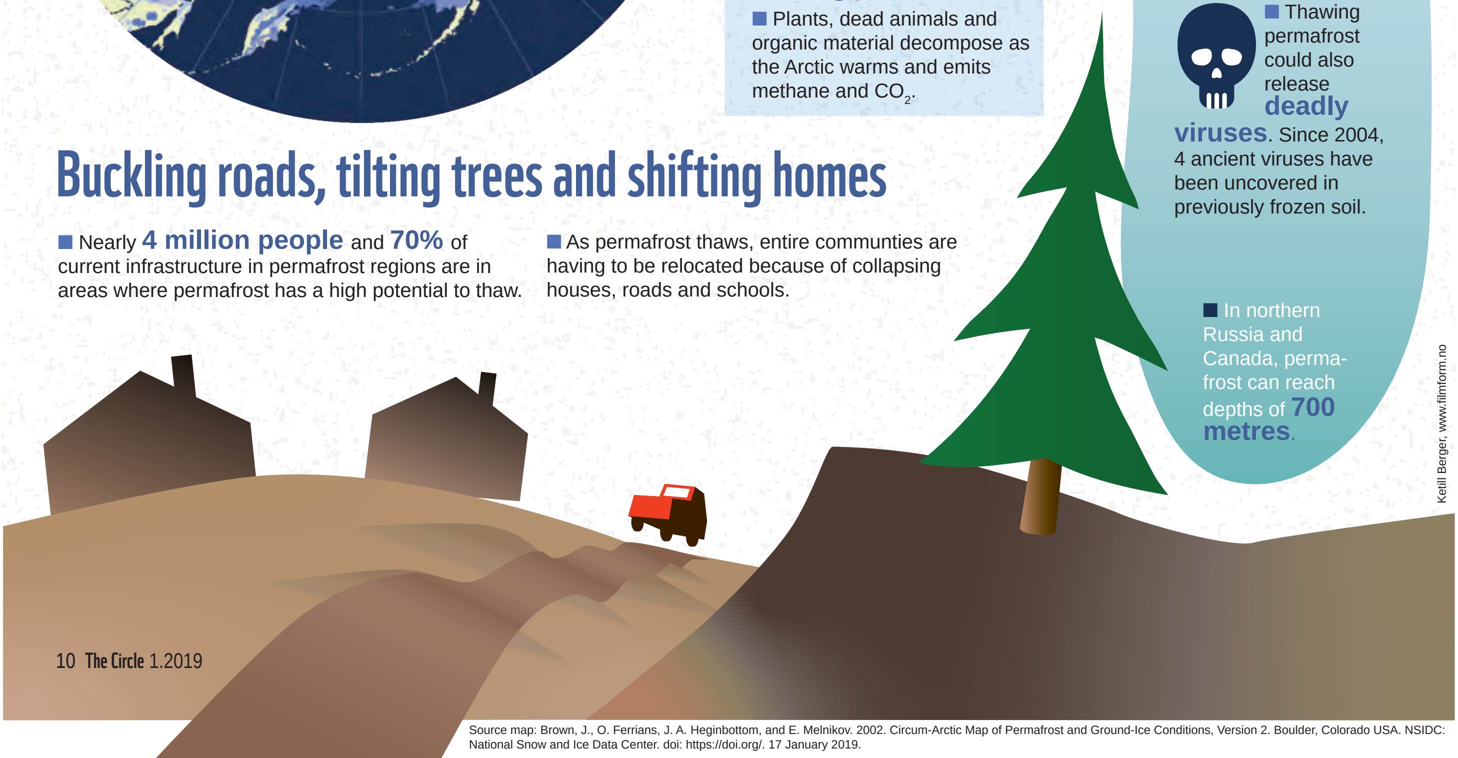
■ Thawing permafrost could also release **deadly viruses**. Since 2004, 4 ancient viruses have been uncovered in previously frozen soil.

■ In northern Russia and Canada, permafrost can reach depths of **700 metres**.

Buckling roads, tilting trees and shifting homes

■ Nearly **4 million people** and **70%** of current infrastructure in permafrost regions are in areas where permafrost has a high potential to thaw.

■ As permafrost thaws, entire communities are having to be relocated because of collapsing houses, roads and schools.



Ketill Berger, www.filmform.no

Source map: Brown, J., O. Ferrians, J. A. Heginbottom, and E. Melnikov. 2002. Circum-Arctic Map of Permafrost and Ground-Ice Conditions, Version 2. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. doi: https://doi.org/. 17 January 2019.

There goes my town: Thawing permafrost is destabilizing communities across the North

We've long known that infrastructure built on permafrost would struggle when the effects of climate change finally became impossible to ignore. Most northern countries have anticipated damage to roads, homes, buildings and even bridges and airport runways as the land beneath them thaws, softens and erodes. But understanding that something may one day happen and facing the relocation of your entire community are two different things.

Esau Sinnok lives in Shishmaref, Alaska, a town that has voted to relocate to the mainland because of problems caused by climate change.

Photo: Robin Loznak

ESAU SINNOK grew up in Shishmaref, an Alaskan village on a barrier island in the Chukchi Sea that is home to about 600 people, mostly Iñupiat. Over the course of his childhood, he watched the island lose about 100 feet along its coast. By the time he became an Arctic Youth Ambassador in 2015, he anticipated that by 2040, the entire island would erode away.

"Without sea ice, which acts as a buffer for the island, the land is lost due to storm surges. This is becoming more common and more dangerous in recent years," says Sinnok, now 21. "The ice also hasn't been freezing like it used to. I remember a few years back, it didn't freeze until the end of January. And temperatures were above 20°C, which is super unusual. Every year, it is harder to traditionally hunt and fish to provide for our family and community because of climate change."

There is no question that climate change is wreaking havoc on Shishmaref and other towns like it in several ways. For one thing, structures built on thawing permafrost are at risk of collapsing. Some residents' livelihoods are also under threat as climate change alters the ➤

“It really hurts knowing that your only home is going to be gone, and you

y

on traditions the way that your people have done for centuries,” says Sinnok. “It is more than a loss of place, it is a loss of identity.”

presence and patterns of the animals they rely on.

According to a report on Alaska’s native villages by the US Government Accountability Office, among some 200 villages affected to various degrees by flooding and erosion, at least 31 face “imminent” threats and may need to be relocated. A handful, including Shishmaref, will likely need to be moved completely as rising temperatures continue to cause coastline erosion, flooding and destabilization of structures. In fact, in 2016, Shishmaref voted 89 to 78 to relocate to the mainland.

But it’s been estimated that it would cost USD$180 million to relocate the town, and it’s not clear who will pay. With the US government continuing to drag its heels, Shishmaref is still in its original location, which continues to shrink every year.

“It really hurts knowing that your only home is going to be gone, and you won't hunt, fish and carry on traditions the way that your people have done for centuries,” said Sinnok. “It is more than a loss of place, it is a loss of identity.” ○

The importance of snow

Vanishing snow cover challenges Arctic tundra species’ survival

Winter conditions are often ignored in studies of Arctic areas because gathering data on winter conditions from remote Arctic areas is challenging. This photo of Pekka Niittynen's colleague, Julia Kemppinen, was taken in Kilpisjärvi, Finland.

Photo: Pekka Niittynen

The future of snow is inextricably linked to the destiny of Arctic flora and fauna. Most plants and animals in the Arctic tundra depend on favourable snow conditions to survive. For example, many require late-lying snow cover to overwinter, and large herbivores—like reindeer—can't reach their food if the soft snow packs are replaced with hard ice layers. PEKKA NIITTYNEN **explains why for many species, less snow may be an even greater threat than rising temperatures.**

THE ARCTIC TUNDRA is a winter wonderland where the snowy season prevails. Traditionally, the snowpack has left the ground exposed to sun for only a few months of the year—sometimes only for several weeks. Some years, summer fails to arrive entirely. The Arctic tundra has always been a mosaic of different snow habitats.

However, this is changing rapidly because snow conditions are sensitive to even the smallest changes in climate. In some Arctic areas, increased winter precipitation may still somewhat compensate for the effects of rising temperatures on snowpack thickness. But in many regions—including my study areas in northernmost Scandinavia—the reduction in the length of snow season has been dramatic. In fact, the season has shortened by as much as three weeks in just the last 40 years. Year-to-year variations are large, but the trends are clear: long-lasting snow cover is vanishing across the northern hemisphere.

In the Arctic, where vegetation creeps along the ground and nearly everything is covered by snow for most of the year, the thickness of the snowpack is the most important modulator of ground surface temperatures. With only a very thin layer of snow, the ground surface temperature can be freezing, but under a metres-high snowpack, the thermal environment is stable and mild.

I am involved in a research project investigating how the changes in temperature and snow cover duration are likely to affect the extinction risk for northern flora. The results so far show that many species may actually benefit from a warmer climate if snow conditions remain as they are. But since the warming will most likely reduce the amount snow, it may wipe out a large part of the flora that are typical to Arctic ➤

PEKKA NIITTYNEN is a doctoral candidate at the University of Helsinki in Finland. His research focuses on the interactions between snow and plants in the changing Arctic.

Since the warming will most likely reduce the amount snow, it may wipe out a large par a that are typical to Arctic mountains, such as snow buttercup and mountain brook *saxifraga*.

Photos: Pekka Niittynen

mountains, such as snow buttercup and mountain brook saxifraga.

Although the significance of snow is widely recognized, winter conditions are often ignored in studies of the Arctic areas. This may seem surprising, but the reason for this shortcoming is practical rather than ideological: gathering data on winter conditions from remote Arctic areas is extremely challenging. Polar nights and freezing temperatures do not tempt researchers to step outside, and the harsh conditions are a true trial for the research equipment.

We have tackled these practical difficulties by using satellite imagery and hardy miniature logging devices. Satellites have provided us with detailed information about Arctic snow conditions since the 1970s. What researchers need most is patience to process the massive datasets and computers with plenty of power and memory. Small temperature loggers have proven themselves weather-proof in the harsh Arctic winter conditions. As long as reindeer and lemmings leave the loggers untouched, they offer in-situ data to validate the satellite record.

Thanks to remote sensing and species distribution models, we know that winter and snow are hugely significant for the future of northern nature and organisms. Many Arctic and mountain plants grow and flower during very short summers. If the snow cover duration shortens and summers lengthen, the more southern species will benefit and could compete with Arctic species for survival, leading to the extinction of some Arctic species.

Mountain avens and glacier buttercups, two iconic Arctic flowering plants, require very different snow conditions, but both are very much affected by these changing conditions. Mountain avens would benefit from a shorter snow season, but the increasing temperatures will be a drastic disadvantage. Conversely, glacier buttercups require a thick snowpack. Vanishing snow cover will wipe the species out, especially its southernmost populations.

The problem is we don't know exactly how the snow will change as the climate warms or what the Arctic snow conditions will be like if we succeed in limiting global warming to 1.5°C or 2.0°C.

We can predict temperatures fairly accurately, but it's more difficult to predict rainfall—and even more difficult to predict snowfall. Our study shows that depending on the rate of change in snow conditions, the snow will either buffer or speed up changes in Arctic biodiversity. Either way, the uncertainty is certainly frustrating. ○

Wildlife disease

Ice-age relics: emerging wildl

The muskox and the lungworm that can infect it, Umingmakstrongylus pallikuukensis*, offer us a chance to understand the relationship between climate change and emerging diseases in the Arctic.*

Photo: Fabien Mavrot

What muskoxen can tell us about ife diseases in the Arctic

From the massive decline of sea ice to changes in the smallest microbes, climate change is dramatically altering the Arctic ecosystem. Increasingly, new diseases, or "new to science" diseases, are being found in Arctic wildlife. But are diseases really on the increase? And if so, what are the consequences and what should we be doing about it? SUSAN KUTZ **and** PRATAP KAFLE **have found that ice-age relics—the muskox and its parasites—can teach us a lot about how climate change is affecting wildlife diseases and people in the Arctic. ➤**

Scientists and local hunters and trappers have been working together to determine whether newly observed bacteria in the Arctic are in fact new, or were just previously undetected.

Photo: Susan Kutz

FOR GENERATIONS, northern Indigenous Peoples have cohabited with and depended on wildlife—and healthy wildlife remain key to maintaining the physical, spiritual and economic health of northern communities.

SUSAN KUTZ is a professor at the University of Calgary, Canada. Her work focuses on muskox health in the changing Arctic.

PRATAP KAFLE is a researcher at Dr. Kutz's lab, investigating the impacts of climate change on lungworm distribution.

Yet increasingly, alarmist reports of "killer cat parasites" or "zombie bacteria" in Arctic wildlife are causing concern for northern people who have depended on wildlife as a source of food for generations. Our collective task now is to better understand the impact of climate change on the health of Arctic wildlife so we can predict and detect changes, manage for healthy populations, and ensure that these animals continue to exist for generations to come.

The muskox and its lungworm, *Umingmakstrongylus pallikuukensis*, offer a chance to understand the relationship between climate change and emerging diseases in the Arctic. Known as "*Up*" for short, the muskox lungworm was first discovered in 1988. Its name is derived from the Inuinnaqtun word "Umingmak" (meaning muskox) and "pallik kuuk," the local place name where the parasite was first discovered.

This impressive roundworm reaches up to 65 cm in length and lives coiled in nodules in the lungs of muskoxen. Adult worms can produce millions of eggs every day. They hatch into larvae that journey up the animal's respiratory tract and are later swallowed and passed in the feces. The larvae then penetrate the foot of a slug or snail, where they develop until they reach the infective stage. Muskoxen are infected by accidentally eating these infected slugs, or infective larvae which leave the slugs and remain in the water or vegetation.

Until the 1990s, these roundworms were restricted to the western mainland of the Canadian Arctic. This was presumably due to climate, since the parasite's ability to develop in slugs and snails depends on temperature. In fact, prior to 1990, larvae generally required

Alarmist reports of "killer cat parasites" or "zombie bacteria" in Arctic wildlife are causing concern for northern people who have depended on wildlife as a source of food for generations. Our collective task now is to better understand the impact of climate change on the health of Arctic wildlife.

Investigating a dead muskox (cause of death: Erysipelothrix*)*

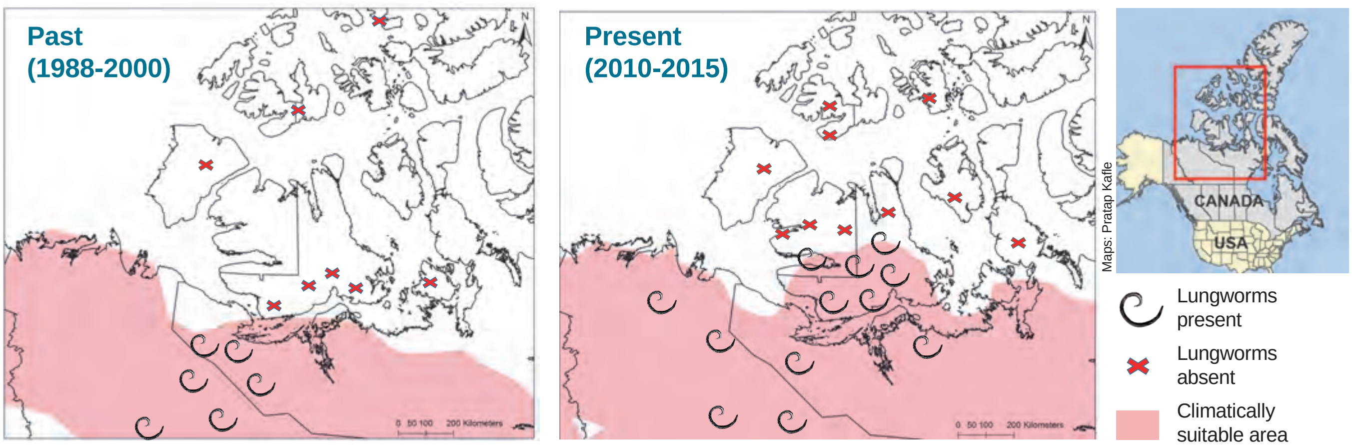
Photo: Susan Kutz

Slugs are needed for the development of the larval stages of the lungworm. Muskoxen acquire lungworm infection after accidentally eating infected slugs or larvae that emerge from the slug.

two full summers to reach the infective stage. But warmer temperatures have accelerated this development. In 2008, *Up* was found on southern Victoria Island, Nunavut for the first time. Since then, community members and scientists have watched the lungworm expand its range rapidly north and east on the island. This fieldwork, together with lab-based ecological studies and habitat modelling, links the lungworm's expanded range to ongoing Arctic warming.

Lungworms do not directly kill muskoxen, nor can they infect people. But their climate-driven range expansion alerted scientists to the fact that other, less well-known diseases may also be changing. For example, in 2010, unusually high numbers of dead muskoxen were reported on Victoria Island. ➤

Range expansion of muskox lungworm with climate warming



Maps: Pratap Kafle

Climatically suitable areas were determined by modelling developmental thresholds with temperature simulations from the global climate model (Community Climate System Model - 4).

Veterinarians determined that the cause of death was a bacterium called *Erysipelothrix rhusiopathiae*.

Since this bacterium had not previously been reported in the Arctic—nor in muskoxen—scientists and local hunters and trappers have been working together to determine if it is in fact new or was just previously undetected, and whether there are other health concerns for muskoxen. They also wonder if the sudden appearance of *E. rhusiopathiae* and its widespread impact—it is associated with a high mortality rate and population declines—are linked to climate change.

What they know for sure is that this bacteria can also infect people, so ongoing partnership and communication with hunters has been essential to provide a message that balances the need for hunters to protect themselves while acknowledging the importance of muskoxen for food security.

Up, the muskox lungworm, may be the poster child for how climate change can affect parasites in the Arctic. But the emergence of *E. rhusiopathiae* as an important cause of death in muskoxen—as well as hunters' observations of other "new" diseases—remind us that there are likely many pathogens in the Arctic whose existence we don't even know about yet. Nor do we yet understand how climate change may be influencing their impacts on wildlife and people.

What is clear is that, in this vast landscape, science alone will not be able to offer all the answers. We need to draw on multiple bodies of knowledge—including western science and local and Indigenous knowledge—to understand what diseases are present, what new diseases are emerging, and how climate change is altering their dynamics in Arctic wildlife. Such information will be critical for us to anticipate emerging disease threats and implement measures to conserve and protect unique species and the northern people who depend on them. ○

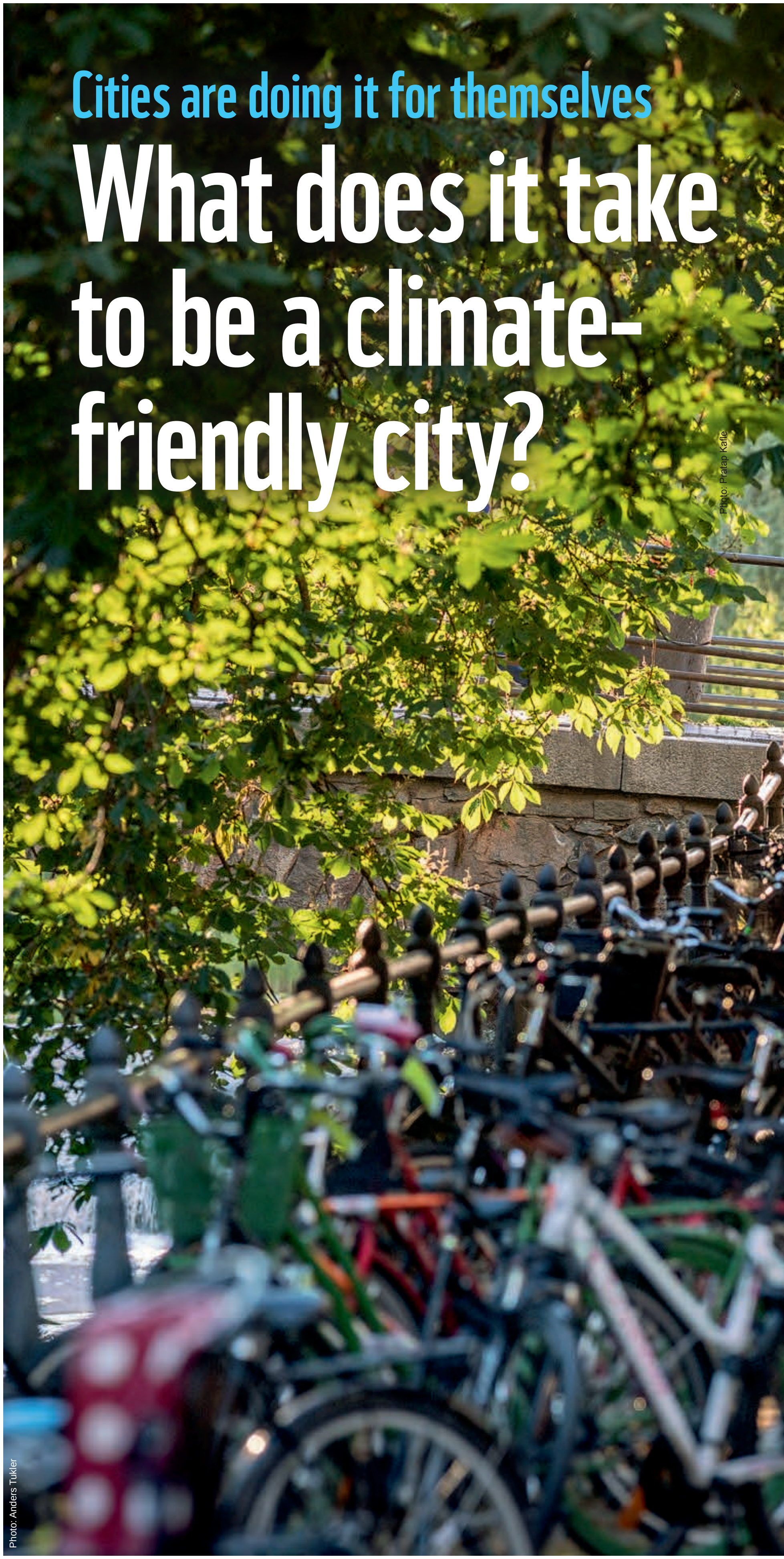


Photo: Pratap Kafle

Photo: Anders Tukler

Cities are doing it for themselves

What does it take to be a climate-friendly city?

Uppsala, a Swedish city with a population of about 150,000, was WWF's global climate city of the year for 2018. WWF selected the city from a list of 132 cities in 23 countries as part of its annual One Planet City Challenge. The municipality stood out because of its strong performance across a number of key categories, especially its cross-sector sustainability interventions and leadership in surrounding areas. ➤

We asked ERIK PELLING, the mayor of Uppsala, how his city has tried to reduce its environmental footprint and what advice he might have for cities that have similar objectives.

Uppsala was named the global winner of WWF's 2018 One Planet City Challenge. What achievements played the biggest role in winning that distinction?

In Uppsala, the entire community works together toward the municipality's clear, ambitious and politically mandated goals. The goals—to be fossil-free and renewable by 2030 and climate-positive by 2050—are both in line with science-based requirements and the Paris Agreement. We are working toward them in all sectors, but have been especially successful in the fields of transportation and energy.

What is the most significant climate-friendly initiative that Uppsala is currently undertaking?

The Uppsala Climate Protocol is an initiative that unites local businesses, universities, authorities, civil society and environmental organizations. These groups represent a third of Uppsala's energy consumption, and they are working together to phase out fossil fuels used for heating and transportation. For example, district heating in Uppsala, which is the city's main source for heating, will be fossil-free by 2020, and the city's waste combustion will be fossil-free by 2030. As well, by 2020 at the latest, the city will have only fossil-free cars. A more challenging goal is to have all of the city's procured transportation and non-road mobile machinery be fossil-free by 2023.

What are the easiest things you believe cities can do to become more climate-friendly? What are some of the more challenging things?

The easiest thing to do is make the transition within your own organization.

> "In order to succeed, you also need clear leadership, a willingness to work together and a recognition that dealing with climate change can no longer wait."
>
> **Erik Pelling,**
> **Mayor of Uppsala, Sweden**

A more difficult but equally important step is challenging others to do the same. No country, no city, no company and no person can single-handedly stop climate change. We have to work together, and in Uppsala we have clearly shown that this is possible.

Are most Uppsala citizens pleased to support its climate-friendly initiatives? Are many residents critical?
There is a broad political consensus here, and we collaborate with businesses, universities and other organizations on our climate initiatives. Solutions can sometimes create debate, but my impression is that Uppsala's citizens want their municipality to be a climate transition leader.

What is your advice for other cities around the world that would like to become more climate-friendly?
I would say that you can make some progress by working alone, but you will not really solve the problem without collaboration. Everyone needs be engaged and involved in the climate transition, and no organization or group of people should be left behind. In order to succeed, you also need clear leadership, a willingness to work together and a recognition that dealing with climate change can no longer wait.

Do you think cities around the world have the power to make a significant impact on global climate change despite inaction (or slow action) by many national governments?
Absolutely, and it's already happening. Cities and municipalities have an enormous responsibility for the climate transition regardless of whether their national governments help them or not. But clearly it is easier if all levels of government are aligned in same direction.

No country, no city, no company and no person can single-handedly stop climate change. We have to work together.

Along with becoming climate-friendly, is Uppsala also a leader in climate adaptation?
Yes, Uppsala was Sweden's 2017 leader in climate adaptation. Some examples of our ongoing work in that area are awareness and routines for handling heat waves, infrastructure and innovations for handling large volumes of stormwater, and the preservation and expansion of green areas for temperature balance and water management.

It's clear that our climate measures are creating positive momentum in many related areas. For example, in 2018 alone, Uppsala was recognized with the Socially Sustainable Businesses Award and named the nation's Climate Municipality, Best Bicycle City, Fastest Growing Municipality, Public Heath Award Winner, Best City and more. We have shown that contrary to being an impediment, Uppsala's climate transition work is the driving force behind its positive development. ○

■ WWF's One Planet City Challenge invites cities in participating countries to report on their ambitious and innovative climate actions and demonstrate how they are delivering on the 2015 Paris Agreement on climate change. Since the challenge was launched in 2011, WWF has engaged more than 400 cities across five continents. In the 2017–2018 round, the challenge's themes were sustainable transport and mobility.


Photo: Anders Tukler

Uppsala's citizens want their municipality to be a climate transition leader.

WWF'S position on carbon capture

WWF believes that relying heavily on CO_2 removal to mitigate global warming is a high-risk undertaking because we still don't fully understand the reliability, costs, benefits, impacts or risks of many carbon capture approaches.

For that reason, our position is that the world's immediate priority should continue to be cutting greenhouse gas emissions rapidly and deeply, since cutting emissions faster reduces our future need for CO_2 removal.

That said, WWF acknowledges that some CO_2 removal will likely be needed to limit the global temperature rise to 1.5°C—both to cancel out hard-to-mitigate residual emissions and/or to reduce the atmospheric CO_2 concentration in the event of temperature overshoot scenarios.

In that context, it's important to understand that all CO_2 removal approaches have potential trade-offs or limitations. To the extent that they are used, we recommend prioritizing approaches that permanently sequester CO_2 in natural systems—especially approaches with proven benefits for people, nature and climate.

Using basalt rock for carbon capture

In 2016, scientists and engineers working at the Hellisheidi power plant in Iceland proved for the first time that it was possible to pump carbon dioxide emissions into the earth and convert them to stone within a short time. As part of a pilot project called Carbfix, the plant mixed the gases with water and injected the resulting solution into volcanic basalt. Within less than two years, 95% of the injected carbon had solidified.

This was encouraging since prior studies had predicted that converting CO_2 to rock could take hundreds or thousands of years. The Hellisheiði project suggested that the conversion could be much faster when basalt is used. Since then, the project has moved from a pilot to a permanent solution and now cleans up a third of the power plant's emissions. In 2017, CarbFix processed 10,000 tonnes of CO_2.

Innovation

Can carbon removal

Under the 2015 Paris climate accord, 195 countries committed to limit global warming to 2°C above pre-industrial levels. In November 2018, the Intergovernmental Panel on Climate Change (IPCC) published a report stating what needs to happen if we want to keep warming below 1.5°C. But as PETER WADHAMS points out, both aims have an embarrassing fact in common: they cannot be achieved simply by reducing carbon emissions. They require us to actually remove carbon dioxide from the atmosphere.

The Climeworks Direct-Air Carbon Capture Plant, Hellisheiði, Iceland.

save us?

THE PARIS AUTHORS recognized the need for carbon removal, but didn't suggest how to do it. The IPCC authors went further: they explicitly rejected the use of geoengineering methods to cool the atmosphere on the grounds that there may be unknowable side effects. This leaves direct removal of carbon as the only method available to bring net emissions to zero.

To survive climate change, we have to develop technology to perform a massive CO_2 removal economically. Success would bring two benefits: Not only would the rate of warming slow, but if the CO_2 level dropped to a level lower than today's, we would return to a climate of the past. This would allow us the luxury of tackling the other myriad problems

If we want to save the Paris Agreement—and we cannot reduce our emissions to zero—we must combine

reduction with the physical removal of at least 20 billion tons of carbon dioxide from the atmosphere

Photo: Arni Saeberg, CC, www.helena.co/media

facing the world, from food insecurity to water shortages to overpopulation.

The world now emits 41 billion tons of carbon dioxide per year, and the amount is rising. The current level of carbon dioxide in the atmosphere is already high enough to bring about a warming of more than 2°C. What this means is that if we want to save the Paris Agreement—and we cannot reduce our emissions to zero—we must combine a significant emissions reduction with the physical removal of at least 20 billion tons of carbon dioxide from the atmosphere per year indefinitely.

Currently, the best proposed way to remove carbon dioxide is through direct air capture, which involves pumping air through a system that liquefies and stores the carbon dioxide or converts it into a substance that is either inert or useful. Enterprising researchers have already developed systems that work by passing air through anion-exchange resins that contain hydroxide or carbonate groups that, when dry, absorb carbon dioxide and release it when moist. The extracted carbon dioxide can then be compressed, stored in liquid form and deposited underground using carbon capture and storage technologies.

The usual immediate objection is to ask how we can cope with 20 billion tons of CO_2 per year. One proposed solution is to convert it into artificial limestone and then crush it to form an aggregate. Every year the world uses tens of billions of tons of sand and aggregate in construction, especially concrete production, using vast amounts of energy to do so and depleting the environment of sand. This would be a use of CO_2 where the magnitude of the demand matches that of the supply.

PETER WADHAMS is an oceanographer, glaciologist and professor of ocean physics in the Department of Applied Mathematics and Theoretical Physics at the University of Cambridge, UK. His research focuses on sea ice and climate change processes in polar regions. His book about the loss of ice on Earth, *A Farewell to Ice*, was published in 2016.

The challenge is to bring the cost of this process to below US$40 per ton of carbon removed, since this is the estimated cost to the planet of our emissions. At the moment, most methods cost more than $100 per ton, but there are dramatic developments with great promise under way. Three companies have already opened pilot plants: Global Thermostat (United States), Carbon Engineering (Canada) and Climeworks (Switzerland). Carbon Engineering, operating in Squamish, British Columbia, employs a complex process that uses solar power to cause absorbed CO_2 to react with hydrogen to produce a biofuel that can replace fossil fuel.

But Climeworks is the trendsetter. After building a small plant that ➤

fed absorbed carbon dioxide into a greenhouse, it opened a small-scale commercial plant in Iceland aimed at removing carbon dioxide from the air and using water to pump it down into basalt rocks underground, harnessing Iceland's abundant geothermal power as a source of energy. Here the carbon dioxide is literally turned to stone—it mineralizes rapidly because of the type of rock and the pressure. Once turned to stone, the carbon dioxide is out of the planet's energy system for millions of years. This is an enormous breakthrough.

A compelling criticism of carbon removal is that it may discourage us from trying to reduce our carbon dioxide emission levels, shifting our focus to unproven "emit now, remove later" strategies. Even the IPCC talks about "overshoot" whereby the CO_2 level is allowed to rise beyond a safe limit and is later brought back down (by unspecified means). It doesn't help that as a global population, especially in the West, we are reluctant to give up the comforts and conveniences of a fossil fuel world. Education is needed to make people at all levels (including US presidents) realize that we cannot continue as we are.

Effective carbon dioxide removal operations will need to be in place very soon. We need to immediately assess which direct air capture method offers the best chance of success, and check out other gentler methods that have been proposed, such as afforestation on a gigantic scale, or methods involving marine CO_2 absorption on algal mats.

If, as I suspect, a direct chemical method is all that will do the job in time, then we'll need to develop the equipment, funding and logistics for extracting about 20 billion tons of carbon dioxide each year, indefinitely. If we can manage this, we can save our society and our children's futures. After all, if carbon dioxide is the chief cause of climate change, its removal would be our salvation. ○

Experimentation

Turning down Earth's thermostat with solar geoengineering

As our planet warms, scientists are searching for ways to cool it. One experimental idea is to interfere with how sunlight reaches the Earth. FRANK KEUTSCH, a professor of chemistry and chemical biology at Harvard University, spoke to The Circle about a project he's working on to investigate the risks of doing so. The Stratospheric Controlled Perturbation Experiment—or SCoPEx—is trying to determine some of the risks and efficacy of introducing sunlight-reflecting particles, such as sulfuric acid or calcium carbonate, into the Earth's stratosphere to alter the climate.

What exactly is geoengineering?
The geoengineering we talk about in the context of climate change falls into two very different categories: carbon geoengineering and solar geoengineering. The difference between the two is the promise they hold. Carbon geoengineering addresses the cause of climate change. It is when you take carbon out of the atmosphere and store it underground or try to convert it into something else we can use. But it's expensive, complicated and slow.

Solar engineering is cheap and fast, but it doesn't do anything to address the causes of climate change. As opposed to reducing greenhouse gas emissions, the idea is to change the energy balance by reflecting sunlight back into space. We know that this will cool down the planet because there will be less energy coming in.

In fact, natural experiments have been conducted for us in the form of large volcanic eruptions that have resulted in a noticeable cooling of the troposphere. So we know this works—and it makes sense that if you have less sunlight, the surface will be cooler. We also know that there are a number of side effects from doing this.

What are the risks of reflecting the sun away from the Earth and back into the atmosphere?
The question we are trying to answer

Photo: Eliza Grinnell

Understanding the SCoPEx project

- SCoPEx is a very small-scale project. It's designed to cause perturbations at about 20 km altitude across a length of a few kilometres using a few hundred grams of sunlight-reflecting particles.

- The aim is not to alter the climate, but to investigate stratospheric chemistry and dynamics. Harvard University's Frank Keutsch says the experiment, if conducted, will neither affect the climate nor cause any localized impacts.

- SCoPEx has been very controversial in the environmental community for some time. If it does go ahead, its timeline will be determined by both technological readiness and a governance process, with an advisory committee assessing when and whether it is appropriate to begin.

Frank Keutsch is a professor of chemistry and chemical biology at Harvard University.

with respect to solar geoengineering is actually not "Can it cool down the planet?" but rather "What would the impacts be on climate and the Earth system overall?" For example, could it destroy the ozone layer or change the temperature of the stratosphere?

I like to compare solar engineering to opioids. When we take painkillers, they hardly ever address the problem. They address the symptoms by reducing the pain. One of the big dangers of solar geoengineering is that if we don't notice the pain, we may continue the behaviours we shouldn't be doing. We won't get a warning signal telling us there's something wrong.

A danger with using solar geoengineering is that the symptoms—the pain from climate change—will be less. As a result, there are people who will say, "Let's address the cause later because it's hard and it's expensive and we don't quite know how to do it now." This is ➤

the moral dilemma that people have with solar geoengineering, and I think it is a very valid argument. In addition, if we put a foreign object or substance into a system, there will be side effects. The idea that there could be a form of solar geoengineering that has no side effects is, I think, entirely utopian.

So, what is the goal of your research?

I'm interested in knowing and quantifying different types of risks associated with solar geoengineering. We do not know the risks well enough. I believe if we don't know the risks, then it's very hard to talk about what solar geoengineering can mean as a tool in the climate change toolbox.

If we know there are risks involved, why consider solar geoengineering at it all?

The idea of putting millions of tons of sulfuric acid into the stratosphere would probably strike many people as crazy or scary. But if you look at the reality of climate change, I think the direction we're headed in right now is also really scary. If you asked me, "Frank, can you tell me what exactly is going to happen when you do this?" I would tell you we may never have those answers. There will always be uncertainties. Yet at the same time, I think we already know that with climate change, there is a huge danger.

So we need to do something—and the reason to do research now is to get ahead of the game. We need to pursue a better understanding of the risks of solar geoengineering because we don't want to find ourselves in a situation later where the climate impacts become so large that they create an overpowering pressure for some form of action—and then stratospheric solar geoengineering is pursued without enough knowledge of its risks and efficacy. ○

■ For more information about the ScoPEx project, see the Keutsch Research Group's FAQ page at https://projects.iq.harvard.edu/keutschgroup/scopex.

Final word

Arctic nations are responsible What are they doing about it?

To limit the impacts of a climate-changed Arctic to levels that will be safe for humanity, we need a worldwide movement to curtail the global temperature rise to 1.5°C beyond preindustrial levels. This movement needs leadership. So far, the Arctic countries have shown little.

FOR MANY Arctic communities, and indeed for entire societies in the northern hemisphere, fish and shellfish from the Arctic Ocean are an essential part of life, providing food, income and cultural context. If we manage them well, we could theoretically use these renewable resources forever. However, scientific reports increasingly warn that if we are not ambitious about limiting global warming, Arctic fisheries may fail, as they will not be able to keep up with the rate and complexity of the consequences of change. In light of forecasts that the quantities of fish further south will be drastically reduced as the planet warms, this warning to the Arctic countries and the global community could not be more serious.

This is just one example of the global importance of Arctic climate change impacts. Another is the rapidly diminishing Arctic sea ice accelerating warming for the entire Earth. Warming from past and current emissions is also committing the Greenland Ice Sheet to multi-century melt, amplifying the sea level rise that already threatens tens of millions of people in coastal zones worldwide. There are many more examples, and all of them should remind us that what happens in the Arctic does not stay in the Arctic. The fact that the Arctic is warming at twice the rate of the rest of the planet means every bit of reduced global warming counts twice in the Arctic. What better motivation could there possibly be for leadership on ambitious global action from Arctic countries?

What happens in the Arctic does not stay in the Arctic.

Yet so far, we have seen the contrary. There was virtually no Arctic presence at the recent climate negotiations in Poland, even though in 2016, Arctic nations accounted for 22 per cent of global emissions. A closer look at the contributions of many Arctic countries to the Paris Agreement (as shown by the Paris Equity Check—see "Find out more") reveals that if the world were to follow their example, we would be looking at a planet that is 4°C to 5 °C warmer overall by 2100—and 8°C to 10°C degrees warmer in the Arctic.

Meanwhile, Norway is giving away 24 new offshore oil licences. Hydrocarbon development in the Russian Yamal region is accelerating in unprecedented ways. Plans for producing oil in Alaska's National Wildlife Refuge are being

for 22% of the world's carbon footprint.

In 2016, Arctic nations accounted for 22 per cent of global emissions.

revived. This kind of "leadership" constitutes dangerous interference with our planet.

The Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5˚C clearly illustrates the global risks of exceeding 1.5˚C, and spells out how every bit of warming matters. It also clearly demonstrates what we need to do to reach that goal. Further, it states that while reaching this goal is not geophysically impossible, every year matters and every choice matters. In other words, it's up to us. When the IPCC Special Report on the Ocean and Cryosphere in Changing Climate is published later this year, it will further specify the regional and global impacts and risks of a changing Arctic. Societies should and will demand answers and leadership from Arctic governments.

This is a critical time for Arctic states to commit to identifying and promoting the most promising solutions. We need Arctic states to become responsible stewards of their people and to develop truly sustainable, nature-based economies. These goals demand leadership for speedy, ambitious and transformative action.

There is little time to prepare. To begin with, let us expose the false narrative of hydrocarbon-based sustainable development in the Arctic.

WWF encourages Indigenous Arctic leaders, the business community, supporting scientific institutions and innovators to encourage and initiate the transformations needed to keep some of the Arctic frozen and humanity safe. ○

MARTIN SOMMERKORN is head of conservation at the WWF Arctic Programme. An Arctic ecosystem ecologist by training, he also serves as coordinating lead author for the Polar Regions Chapter of the IPCC's Special Report on the Ocean and Cryosphere in a Changing Climate.

Find out more:

The Paris Equity Check:
http://paris-equity-check.org/

IPCC Special Report on Global Warming of 1.5˚C:
https://www.ipcc.ch/sr15/

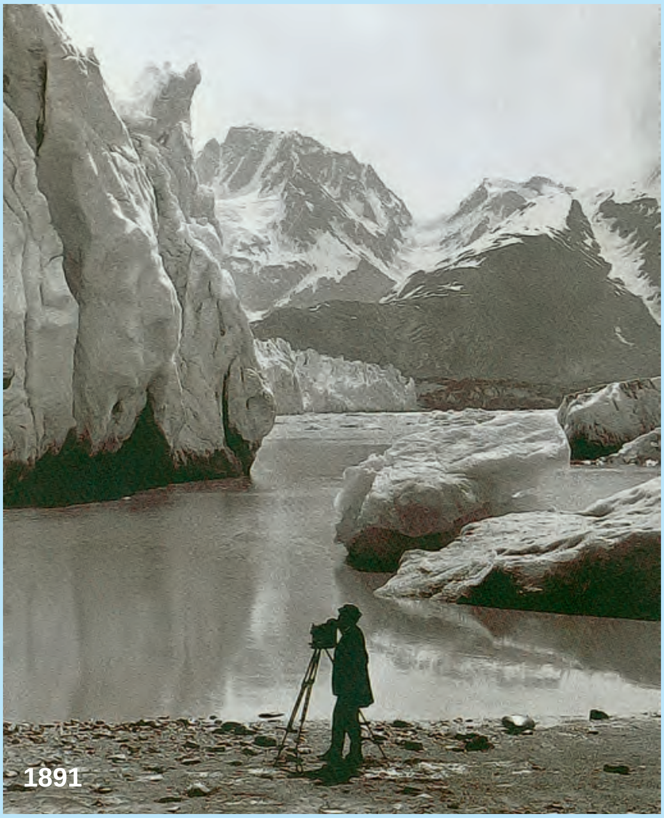
IPCC Report on the Ocean and Cryosphere in a Changing Climate:
https://www.ipcc.ch/report/srocc/

WWF Arctic Climate Change:
https://arcticwwf.org/work/climate/

Return WWF Arctic Programme
275 Slater Street, Suite 810,
Ottawa ON, K1P 5H9, CANADA

THE PICTURE

The retreat of Muir Glacier



Postcard by L.V. Winter and P. E. Pond.

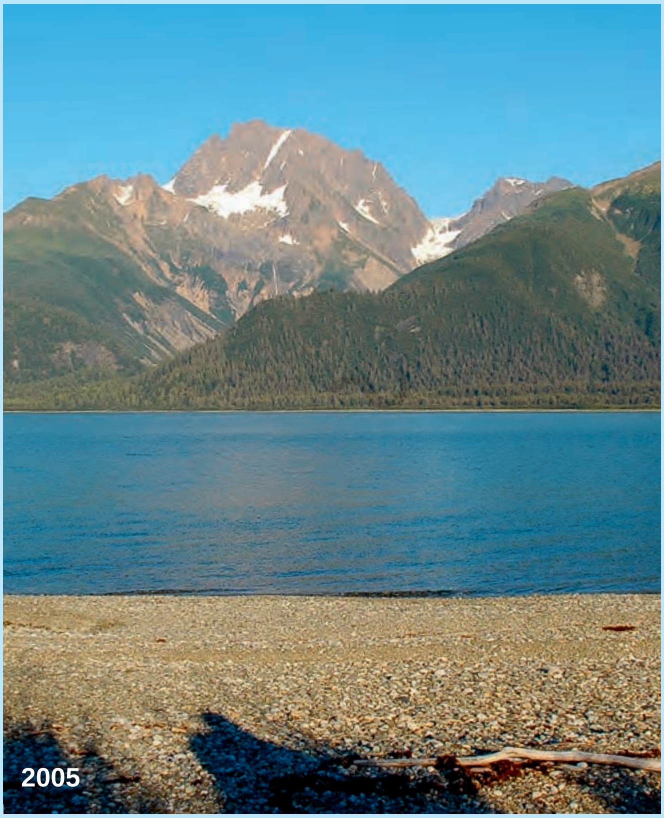


Photo: USGS, Bruce F. Molnia

These photographs, taken from the same location on the west shoreline of Muir Inlet, Glacier Bay National Park and Preserve in Alaska, show the striking changes to the glacier caused by climate change. Since the late 19th century, Muir Glacier has retreated more than 50 kilometres.

Why we are here
To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

www.panda.org/arctic