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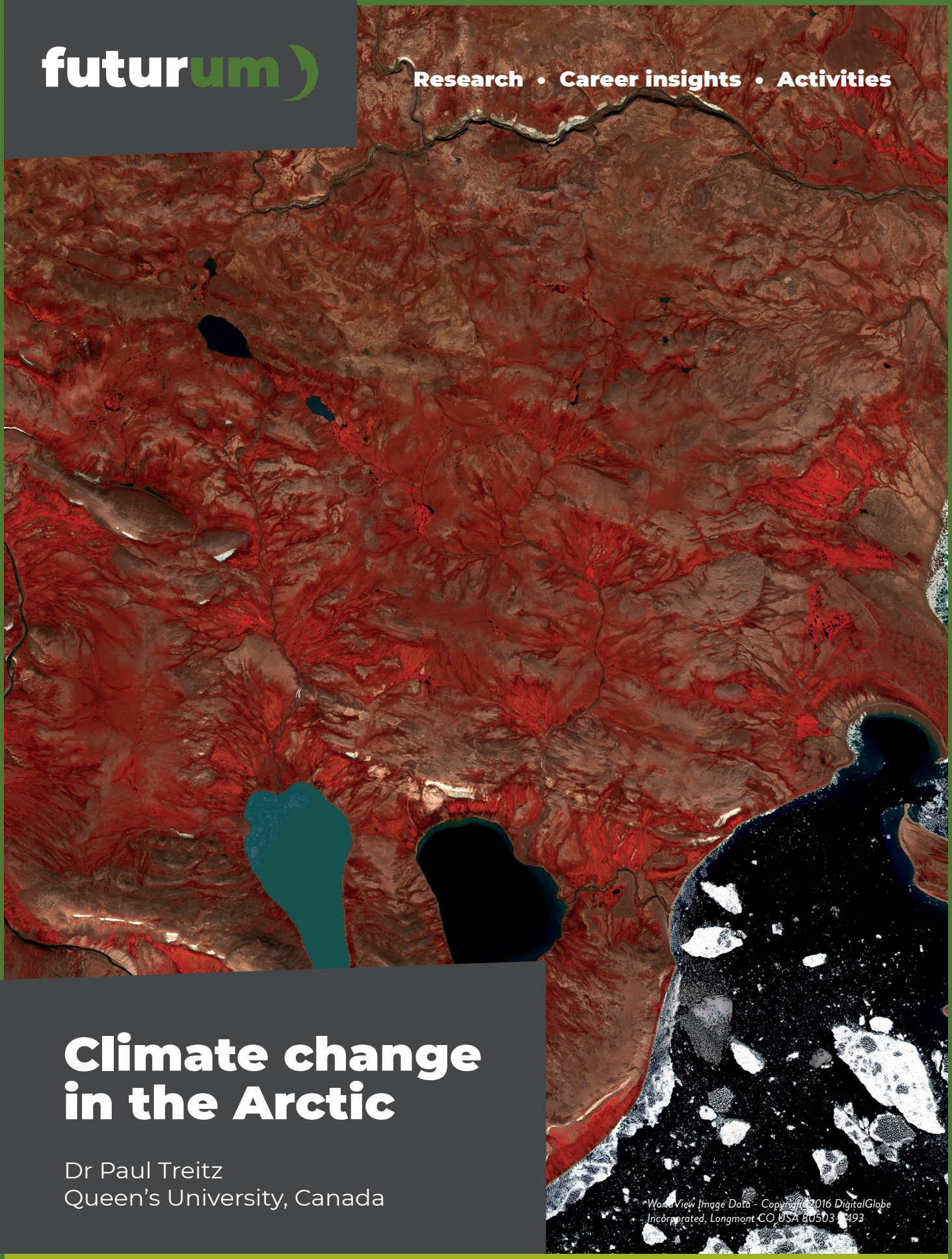

Climate change in the Arctic

Dr Paul Treitz
Queen's University, Canada

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Climate change in the Arctic

The impacts of climate change are all around us, but research in certain locations can provide particularly fascinating insights into this global issue. **Dr Paul Treitz**, based at **Queen's University** in Canada, is using remote sensing techniques and field measurements to investigate what vegetation in the Arctic can tell us about the effects of climate change.

Dr Paul Treitz

Professor Emeritus,
Department of Geography and Planning,
Queen's University, Canada

PROFILE

Fields of research
Geography, remote sensing, ecology

Research project
Remote sensing of vegetation types, and their productivity and change, in the Canadian High Arctic

Funder
Natural Sciences and Engineering Research Council (NSERC) of Canada

Talk like a ... geographer

Arctic — the regions around the North Pole

Canadian High Arctic — the regions of Canada, especially the northern islands, within the Arctic Circle

Carbon exchange — the continuous movement of carbon between various reservoirs, including the atmosphere, oceans, soil and living organisms

High Arctic — the regions of Canada that lie within the Arctic circle

Latitude — how far a place is north or south of the Equator

Permafrost — a layer of soil, regolith and bedrock that remains below freezing for at least two years

Plant photosynthesis — the process by which green plants convert light energy into chemical energy (and convert water and carbon dioxide into oxygen and carbohydrates)

Plant respiration — the production of carbon dioxide from plants when they break down nutrient molecules to release energy

Soil respiration — the release of carbon dioxide from soil organisms to the surrounding soil and atmosphere

Remote sensing — gathering information about something without making physical contact with it, usually done by using imaging sensors placed on aircraft or satellites

Spectral information — the information derived from the way in which electromagnetic energy (including visible light) interacts with materials

Vegetation greening — a significant increase in vegetation greenness associated with enhanced vegetation growth and productivity

Wet sedge — a grasslike plant that grows in wet places

Approximately 700 km north of mainland Canada lies Melville Island, an uninhabited island in the Arctic Archipelago. With an area of 42 thousand km^2, it is the 33rd largest island in the world, home to polar bears, Arctic wolves, muskoxen and Peary caribou. Uninhabited for most of the year, Melville Island only receives visitors in the summer months, when a scientific research group from Queen's University sets up a base there.

One of the researchers in this group is Dr Paul Treitz, whose work focuses on the effects of climate change. "The Arctic is warming at a rate three to four times faster than the global average," says Paul. "This enhanced warming at high latitudes makes the Arctic a critical region for studying the impacts of climate change, as the transformations occurring there provide early indicators of broader global changes."

What is the Cape Bounty Arctic Watershed Observatory?

Established in 2003, the Cape Bounty

The Cape Bounty Arctic Watershed Observatory (CBAWO) research base camp, looking southwest with West Lake (its unofficial name) in the background © Paul Treitz.

Arctic Watershed Observatory (CBAWO) is a research site on the south-central coast of Melville Island where Paul and his fellow researchers do their work.

At the CBAWO, Paul and his colleagues are investigating the relationship between the different types of vegetation at the site and the levels of carbon being sequestered (taken in) and produced. The ecological processes that vegetation ecosystems go through, such as photosynthesis and respiration, are important for exchanging carbon with the atmosphere, especially considering Arctic and sub-Arctic soils and permafrost store vast amounts of organic carbon. As permafrost thaws, soil organic carbon becomes available to microbes for decomposition and the subsequent release of CO_2 to the atmosphere.

While scientists know that the Arctic is warming, they are still unsure how this will affect the carbon exchange between vegetation ecosystems (which include soil microbes and organisms) and the atmosphere. "The warming of the Arctic might remove carbon from the atmosphere, through enhanced photosynthesis by plants, or it might add more carbon to the atmosphere, through enhanced soil respiration by organisms as permafrost thaws," explains Paul.

How does the team collect data?

Paul and his colleagues collect data in two ways – by using remote sensing data from satellites, and by measuring biogeophysical variables on the ground.

The remote sensing data from satellites is very useful, given the size and challenging environment of the Arctic, as it allows the team to examine vegetation changes over a large area. On the other hand, the field measurements collected on site can build a more detailed picture. "In addition to air and soil temperature, other biogeophysical variables that serve as controls on vegetation growth include soil moisture, available nutrients, topography (that is, the physical features of the land), microtopography, soil type and depth to permafrost," explains Paul.

To analyse the remote sensing satellite data, Paul and the team use an analytical tool called the Normalized Difference Vegetation Index (NDVI). This is a widely-used metric which measures the contrast between the red and near-infrared energy reflected by vegetation. NDVI generates values between -1 and +1. If there is nothing growing, the NDVI will be less than or equal to 0, and if the area has lots of healthy, dense vegetation, it will have an NDVI of somewhere between 0 and 1.

What does a typical day in the summer involve?

The team is based at its research site at Cape Bounty from late-June to early-August each year. Since Melville Island is so far north, the sun never sets while the team is there!

"Typically, after breakfast, we will head out for the day to our plots to collect field measurements or download measurements that are being collected automatically," explains Paul. "The days can be long, but we benefit from having 24 hours of daylight to collect our measurements."

What does a typical day in the winter involve?

At the end of the summer season, the team returns to its research lab at Queen's University to analyse the data collected from the field, alongside the remote sensing data received from satellites. "Much of this requires calculating statistical relationships between the field biogeophysical variables (collected at specific locations in the field) and the satellite spectral variables (which are continuous over space)," explains Paul. The team uses the spectral variables to model the biogeophysical variables over the whole landscape to get a complete idea of the vegetation across the entire area.

What has the team found so far?

"Although inconclusive, our CO_2 exchange data, averaged by vegetation type, seems to indicate that only the wet sedge vegetation type is a net consumer of CO_2 from the atmosphere during the summer months," says Paul. "It would also appear that the other vegetation types add more CO_2 to the atmosphere, through plant and microbial respiration, than they remove from the atmosphere."

The team has also found that there has been some vegetation greening in areas experiencing shrub expansion, correlating with warming temperatures. However, the team needs to collect more measurements at the CBAWO and other sites to confirm these results and see if they remain consistent over a larger area.

"I am hopeful that the methods and results of our research will be adopted by others working in the Arctic and elsewhere to conduct similar studies at other research sites," says Paul. "We need to better understand the trajectories of ecological processes as our Earth system continues to warm and respond."

About *geography*

Working as a geographer can take you to a vast range of places – from measuring soil temperatures in the High Arctic to working at a university desk developing models. "I expect that the next generation of geographers will be tasked with studying the impacts of climate change, responding to communities impacted by climate change, and developing adaptation and mitigation strategies to lessen those impacts," says Paul. "This could include developing better methods and policies for transitioning to cleaner energy, developing sustainable forestry and agricultural practices, improving public transportation options, developing more climate friendly waste management practices, and developing policy related to migration and food security. There is a role for everyone, no matter their interests, to apply geographic knowledge and skills to tackle these challenges."

What does being a geographer involve?

"The Arctic continues to be a frontier of discovery, hence research and field work in this environment is ground-breaking and exciting. In my role as a professor, I conduct fieldwork, explore analyses in the lab and teach and mentor undergraduate and graduate students. I have always loved working in the great outdoors, and being a geographer gets me to the field for extended periods of time in exciting and dynamic places. I then enjoy getting back to the lab to analyse the field data and work with computers to link those field measurements to satellite remote sensing measures. I also love teaching, from first-year undergraduate courses to graduate courses."

What are some of the challenges of geography research?

"The Arctic has a harsh climate," says Paul. "It is also sparsely populated, with limited infrastructure. For instance, the Canadian Arctic is approximately 4,000,000 km^2 (about 40% of Canada's landmass). However, it has a population of approximately 150,000, the population of a small to medium sized city. Road access is extremely limited, and many small communities are only accessible by air and/or by sea. Hence the logistics for conducting detailed scientific studies at remote locations is challenging and expensive."

Pathway from school to *geography*

"I recommend students keep their career options open by taking courses in English (you will be writing in whatever career you choose), maths (statistics, algebra, functions), sciences (biology, chemistry and physics) and, of course geography," says Paul.

At university, study geography or consider a combined joint-honours course such as geography and geology (Paul majored in geography and biology). "My interests in vegetation patterns led me to graduate school where I developed remote sensing tools to study forested environments," says Paul.

Read the Royal Geographical Society's tips on what to ask yourself before choosing your geography degree: **www.rgs.org/choose-geography/choose-geography-at-university/choosing-a-geography-course-at-university**

Paul encourages learning skills in analysing spatial data, through courses in geographic information systems (GIS), remote sensing, statistics and computer programming.

Explore careers in *geography*

The Canadian Association of Geographers website includes a fantastic section with detailed profiles of professional geographers and what their career path has involved: **cag-acg.ca/jobs-careers**

Paul recommends exploring the following websites to get an idea of the field and what it is like to work as a geographer: NASA Science (**science.nasa.gov/climate-change**), The Royal Geographical Society (**rgs.org**), The Royal Canadian Geographical Society (**rcgs.org**) and the American Association of Geographers (**aag.org/jobs-careers**)

According to Indeed, the average salary for a geographer in Canada is $60,000 CAD. However, this salary can vary significantly depending on education and experience.

"Geographers have a broad perspective and are suited to many careers not labelled 'geography'," says Paul. "They have skills that address issues in the social sciences, physical sciences and even health sciences."

Meet *Sandra*

Sandra Yaacoub
PhD Candidate, Queen's University, Canada

Fields of research
Geography, remote sensing

Funders
Natural Sciences and Engineering Research Council (NSERC) of Canada, Weston Family Foundation, Northern Scientific Training Program

I've always been interested in environmental issues, so working in geography and learning about remote sensing was appealing to me as it is a way in which environmental disturbances and changes can be assessed at broad scales. I wouldn't have gone down this path if it weren't for the supportive and passionate instructors and mentors who have inspired me along the way.

The most challenging part of field work for me is the unexpectedness of it. A lot of the time, schedules must be re-adjusted for weather, recovery and maintenance/ troubleshooting of equipment. However, field work is rewarding because it's truly a unique experience to be able to get to places and see parts of the world that not a lot of people get the chance to see. It's also most rewarding when those experiences are shared with locals as they can bring different perspectives to the work that make it more valuable.

I am proud of the connections I've been able to make along the way while pursuing this research, including involvement with NASA's Arctic Boreal Vulnerability Experiment (ABoVE) and spearheading a new student-led group called the Queen's Northern Research Network (QNRN).

In the future, I aim to be able to create tools that will help with managing disturbed landscapes and better understanding the changes that climate change may bring.

In my free time, you can find me rock climbing, hiking or pushing through a good workout! I also enjoy reading, journalling and learning new songs on the guitar.

Sandra's *top tips*

1. Be comfortable working alone so that you can build the mastery and expertise that will move the field forward.
2. Geography can be quite broad, so be sure to find your niche while being mindful of the various sub-disciplines.

Meet *Jacqueline*

Dr Jacqueline Hung
Research Scientist at Woodwell Climate Research Center (graduated with PhD from Queen's University in 2021)

Fields of research
Biogeochemistry, Arctic ecology

Funders
US National Science Foundation (NSF), Gordon and Betty Moore Foundation

As a young child, I enjoyed reading non-fiction accounts of travel and exploration in remote locations, including the Arctic. After my first exposure to Arctic research in Nunavut almost a decade ago, I was hooked.

I was feeling lost after the first semester of my master's programme and was contemplating a couple of changes in research avenues. Had I not reached out to who would ultimately become my master's advisor, I would never have been introduced to Arctic research. This eventually led me to my PhD advisors and my career in Arctic ecology.

Corporate summer jobs outside of my field of study helped me realise what I was good at, whilst also showing me what fields I found motivating (or not).

Rather than a single career achievement, I am proudest of the relationships with Indigenous community members, mentors and mentees that I've fostered throughout my time working on their traditional lands. Having long-lasting, meaningful friendships with Indigenous folks that I work with lets me know that my approach to science is respectful.

Attending conferences focused on ecological research is always a rewarding experience that leaves me inspired and motivated to build on my own research.

I hope to continue public outreach and education on the disproportionate impacts of climate warming on Indigenous and underserved communities.

Jacqueline's *top tip*

Don't be afraid to fail – falling short is part of the learning process, and growth comes from your response to difficult situations and shortcomings.

Geography

with Dr Paul Treitz

Talking *points*

Knowledge

1. Where is Melville Island, and where is Cape Bounty?
2. Which vegetation type does Paul think is a net consumer of carbon dioxide (at least during the summer months)?
3. What does NVDI stand for, and what does an NDVI value of 1 mean?

Comprehension

4. Which biogeophysical variables are used to assess vegetation growth?
5. What does a typical day in summer involve for Paul? What does his work involve in the winter?
6. Why is it so important to study the impacts of permafrost thaw in the context of climate change?

Application

7. How is studying climate change in the Arctic applicable and relevant to the rest of the world?

Analysis

8. Why does Paul need to combine both remote sensing data and field measurements? How does he manage to combine these two data types?
9. How could the warming of the Arctic potentially increase or decrease carbon in the atmosphere?

Evaluation

10. To what extent would you be interested in working in the Arctic, and why? What advantages and disadvantages would come with being in the Arctic for two months every year?
11. Of the top tips that Sandra and Jacqueline give, which is the most useful for you personally, and why?

Activities

1. Play GeoGuesser, an online game where you are dropped anywhere in the world and have to make your best guess at where you might be: **geoguessr.com**

See if you can improve the accuracy and speed of your guesses. What signs are you using to identity an area? Which areas are you struggling with, and why do you think this is? Which areas do you know most about, and why?

Once you have had a few practice rounds, challenge your friends to a game and see who is best. Are there any tips you can learn from each other to improve your guesses?

2. Choose a few of the quizzes from the Sporcle Geography quizzes list (**sporcle.com/games/category/geography/all**) – which range from quizzes on mountains around the world, to capital cities, to countries with the most airports – and create a tournament between your classmates, friends or family.

3. Choose an Arctic island (such as Melville Island) to research and create a poster about. Learn about the average temperatures there, the wildlife, plant life, and what period of the summer brings constant sunlight. How do scientific researchers get to your island (or how would they)? Include a map of your island, and research how climate change might affect the land and atmosphere there in the future.

More *resources*

- Visit the Cape Bounty Arctic Watershed Observatory's website to learn more about its research programme: **capebountyresearch.com**
- Read the team's research article 'Remote sensing of biogeophysical variables at the Cape Bounty Arctic Watershed Observatory, Melville Island, Nunavut, Canada,' online in Arctic Science: **doi.org/10.1139/as-2023-0043**
- Read about NDVI and how it works on the GIS Geography website: **gisgeography.com/ndvi-normalized-difference-vegetation-index**
- Take the BBC Bitesize quiz on photosynthesis and respiration to see how well you understand how plants produce and take in carbon from the atmosphere: **bbc.co.uk/bitesize/topics/zvrrd2p/articles/zjqfsk7**

Access to the CBAWO is by small aircraft or helicopter. Here, a twin otter landed on West Lake (unofficial name) on July 1 2019 to drop off Paul's research group © Paul Treitz

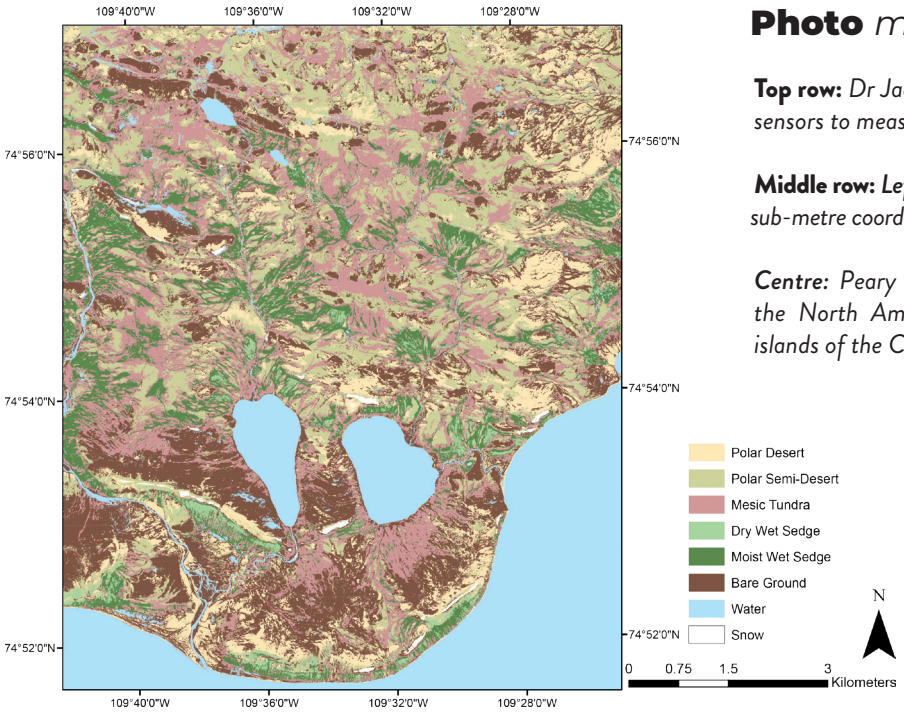

Photo *montage*

Top row: *Dr Jacqueline Hung wiring in electrical components and sensors to measure various environmental parameters*

Middle row: ***Left:*** *Sandra Yaacoub setting up a GNSS device to collect sub-metre coordinates of forest plots in Yukon*

Centre: *Peary Caribou (Rangifer arcticus pearyi) is the smallest of the North American caribou and are found on the northernmost islands of the Canadian Arctic Archipelago*

Right: *Dr Paul Treitz taking spectroradiometer measurements in a wet sedge meadow at the Cape Bounty Arctic Watershed Observatory © Janice Lange, Polar Continental Shelf Project, Natural Resources Canada*

Bottom: *Land-cover classification of the Cape Bounty Arctic Watershed Observatory (CBAWO) derived from 2016 WorldView-2 data and a topographic wetness index*

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