Studying and restoring Canada's peatlands and their carbon storage superpower

Healthy peatlands capture and store a huge amount of carbon, helping to mitigate climate change. However, industrial activities, such as oil and gas exploration and mining, threaten this storage potential. At the **University of Waterloo** in Canada, **Professor Maria Strack** is investigating how disturbance affects peatlands' ability to store carbon – and how effective restoration efforts can help degraded ecosystems regain this essential function.

Professor Maria Strack

Department of Geography and Environmental Management, University of Waterloo, Canada

PROFILE

Fields of research
Physical geography, environmental management

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Measuring the effects of disturbance and restoration on the ability of peatlands to sequester carbon

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Website
uwaterloo.ca/wetland-soils-and-greenhouse-gas-exchange-lab

Talk like a ...

physical geographer

Carbon sequestration — the process of removing carbon dioxide from the atmosphere and storing it

Climate change — large-scale shifts in climate patterns, principally due to increased atmospheric carbon dioxide

Greenhouse gas — any gas that traps heat in the atmosphere, such as carbon dioxide and methane

Horticulture — the science and art of growing plants that are used by humans for food, medicine and decoration

Indigenous Peoples — ethnic groups who are descended from, or identify with, the original inhabitants of a region or territory

Peatland — a wetland ecosystem where wet conditions prevent plant material from fully decomposing, forming peat

Seismic line — a linear clearing through a forest that is cut to aid the search for new oil and gas deposits

Winter road — a linear clearing through a forest or another habitat that is frozen in the winter to create roads

At a glance, you may not consider peatlands to be the most inspiring landscapes: flat, boggy and exceedingly damp. However, they are vital ecosystems for a variety of reasons, including their remarkable ability to combat climate change. "Even though peatlands only cover 3% of the Earth's surface, they store about 600 billion tonnes of carbon," says Professor Maria Strack, a physical geographer from the University of Waterloo. "That's more than the carbon stored in all the world's forests combined." Climate change is largely driven by the release of carbon dioxide into the atmosphere, so ensuring that this carbon remains locked away is vital.

"A peatland is a type of wetland with a thick layer of organic matter – peat – as its soil," explains Maria. "Peat is made up of partially decomposed plants, which are approximately 50% carbon." The boggy nature of peatlands is critical for long-term carbon storage. "Healthy peatlands have wet soils," says Maria. "This limits the availability of oxygen for the microbes that would normally break down the plant material and release carbon into the atmosphere as carbon dioxide." This dramatically slows the rate of decomposition and allows the build-up of carbon-rich soils over thousands of years.

Too wet, too dry

Human activities can significantly

Maria and a team of researchers walk through a type of peatland called a fen.

alter peatlands and, consequently, affect their ability to release or sequester greenhouse gases. For instance, because it holds a high volume of water, peat is a highly desired medium for the horticulture industry. "To extract peat for horticulture, the peatland is drained and all its vegetation is removed," says Maria. "This dries out the peat, exposing it to oxygen and leading to the carbon it contains being released into the atmosphere as carbon dioxide."

On the other end of the spectrum, peat can also become overly wet when it is disturbed. Canada's western regions are petroleum-rich, making them a tempting target for oil and gas companies. "Mapping these deposits involves cutting long clearings, called seismic lines, through the forests to move equipment and personnel," says Maria. "Once petroleum extraction begins, companies build winter roads to access their infrastructure, and many of these roads and clearings cross peatlands." The movement of heavy machinery along these roads compresses the peat and makes the peatlands wetter.

While a moderate level of wetness is good for peatlands, too much can be a bad thing. "Being wet allows peatlands to store a lot of carbon, but it also means that any organic matter decomposition is happening without oxygen," explains Maria. "Decomposition under these conditions can produce methane, a potent greenhouse gas."

In undisturbed peatlands, the carbon sequestration rates are high enough that, even with methane emissions, they have an overall net climate cooling effect - but this is a fine balance that can be easily disrupted. "It's vital to investigate how these greenhouse gas exchanges work so that they can be accounted for in peatland management decisions," says Maria. "For example, there are proposals to excavate peatlands to access the minerals beneath for use in clean energy technologies such as batteries – but if this disturbance releases significant greenhouse gases in the process, it may not be a viable climate solution."

Restoration research

With this in mind, Maria's work examines how different types of disturbance affect greenhouse gas flows in peatlands. "My research involves taking measurements at peatland study sites, experimenting in greenhouses and the lab, creating computer simulations, and analysing data," she says. For example, in the field, Maria measures the amount of carbon stored in peatlands by comparing the carbon content of plant and peat samples to plant biomass and peat depth. In other experiments, she calculates greenhouse gas exchange by measuring how gas concentrations change over time in closed chambers containing plant communities, or through specialised towers that measure gas concentrations and atmospheric turbulence.

Maria's team is particularly interested in the power of peatland restoration to repair functions such as carbon sequestration. "Restoration methods depend on how the peatland was disturbed, but the goal is always to restore the peatland plant community and original wetness levels," explains Maria. "If these conditions can be achieved, the peatland can start to store carbon again." Restoration can involve reintroducing key species, like sphagnum mosses, or reversing the processes that originally drained or overwetted the peatland.

The Can-Peat project

Maria leads a Canada-wide project, Can-Peat, which is building understanding about how effective peatland management can help reduce greenhouse gas emissions. "Canadian peatlands store globally important amounts of carbon, but we don't always have the information needed to support climate-friendly management decisions," says Maria. "Can-Peat aims to bring together research and knowledge about our peatlands through network building, data compilation and collaboration." This knowledge can help advance models of greenhouse gas exchange in peatlands, which will help to inform decisions on how to manage Canada's peatlands in the future. "We also aim to advance Indigenous control over peatland data, by making it accessible to communities and organisations, and co-creating research priorities," says Maria.

The Can-Peat project and Maria's ongoing research aim to help Canada manage its precious peatlands more effectively. "For example, we are exploring better methods for re-growing trees following oil exploration operations, while protecting carbon storage," says Maria. In other research, Maria intends to examine how disturbance by agriculture affects peatlands' carbon emissions, and how these areas can best be restored. Peatlands are complex environments, but with the right knowledge and practices in place, they can be a critical ally in tackling climate change.

About *physical geography*

Physical geography is a broad discipline that involves the study of natural processes and features, and the interactions between them. This can involve studying the atmosphere, water cycles, ecosystems and geology. Physical geography is one of two main branches of geography; the other is human geography, which involves the study of human populations. Maria explains more about her field:

"I love systems thinking – considering how many different factors are interrelated. In my line of work, this involves considering how soil, water, plants and people all interact with each other. Physical geography involves exploring these connections at a range of space and time scales.

"The complexity of these systems leads to fun collaborations. To understand peatland carbon cycling, we need to understand microbes in the peat, plants on the surface, and water supply and how it varies over time. To factor all this in, I collaborate with experts in microbial ecology, DNA sequencing, remote sensing, hydrology and Earth systems modelling. This means I learn new things every day.

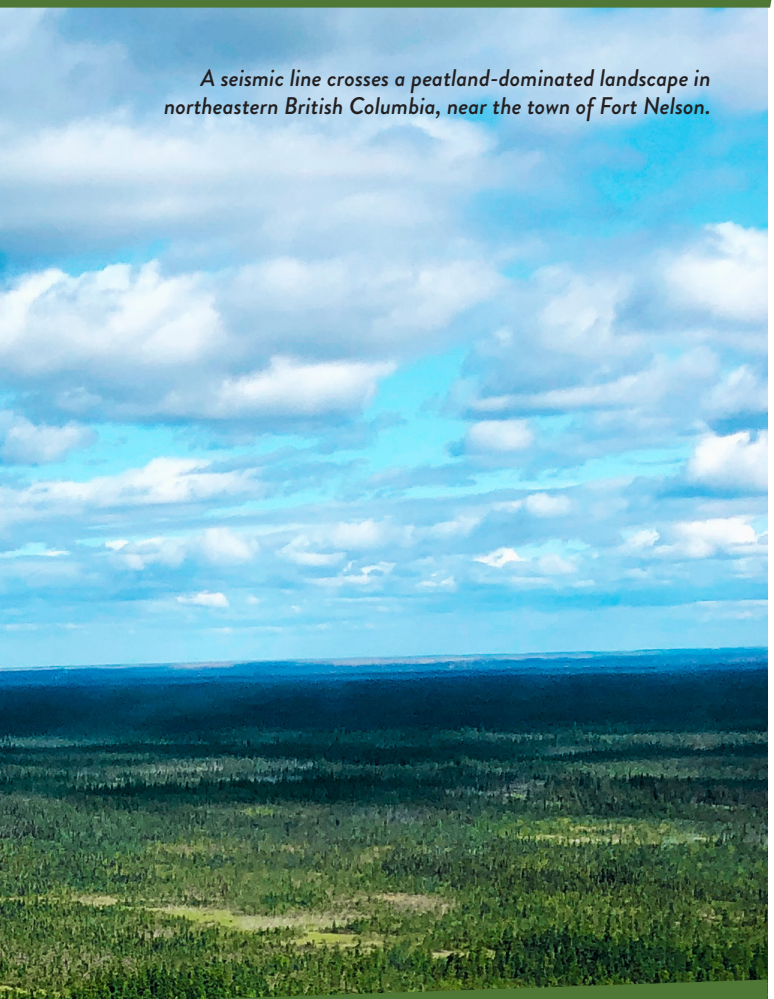
"Fieldwork can be fun and exciting, but also challenging. The places we travel to may require specific training and equipment, as well as spending time away from home. I have an excellent team of graduate students and collaborators who work across our large number of research sites, and I work hard to support them in their requirements for safe fieldwork.

"Canada is all Indigenous land. As natural scientists, we are always considering how to best conduct research that supports reconciliation with Indigenous Peoples. In my research programme, I work to build relationships with Indigenous communities and organisations near our field sites to understand the history of the sites and people's connections to the landscape, and whether our research can be of use to them. We also recognise the rights of Indigenous Peoples to determine priorities and strategies for the use and development of their lands, including research conducted upon it."

Pathway from school to *physical geography*

At school, Maria recommends pursuing science subjects, alongside a solid foundation in mathematics to help you analyse data.

At university, Maria suggests courses in geography and environmental science as good introductions to systems thinking. Opportunities related to language and public speaking can also be useful to build communication skills.



A seismic line crosses a peatland-dominated landscape in northeastern British Columbia, near the town of Fort Nelson.

Explore careers in *physical geography*

There is a wide range of careers available to physical geographers. Maria's students have gone on to work as environmental consultants, ecosystem restoration practitioners, government scientists, laboratory and field technicians, university professors, science communicators, and specialists in geospatial data, policy or conservation. The University of Waterloo website provides a handy overview of potential career paths for geography graduates: **uwaterloo.ca/future-students/programs/geography-and-environmental-management#careers**

Maria suggests participating in outdoor clubs or environmental competitions, volunteering for an environmental organisation, or finding work placements with research groups to get a taste of the discipline. For Ontario high schools, Maria recommends the Envirothon, a hands-on, environmentally-themed competition that includes networking and careers advice: **forestsontario.ca/en/program/ontario-envirothon**

The University of Waterloo runs a variety of outreach programmes relevant for high schoolers – for example, their annual Geographic Information Systems (GIS) Day introduces the public to the various usages of GIS: **uwaterloo.ca/environment-technology-instructional-support/gis-day**

Meet *Maria*

As a teenager, I loved reading, science and spending time outside. I also liked turtles – maybe that helped build my interest in wetlands! At high school, I started learning about the interactions between water, plants and soil, which excited me.

When I entered university, I wasn't sure what career I wanted. I decided to take a science course that allowed me to study a broad range of topics, enabling me to explore my interests. I eventually chose to focus on ecology. In my second year, I applied for a summer research position working on wetlands, and I was hooked.

Visiting a restored peatland is always a privilege. Having had some role in the planning or research supporting that restoration is a source of pride. It's exciting to see how previously-disturbed ecosystems can develop and recover over time.

I'm very proud of the people I have trained throughout my career. I love working with students and seeing their love of science grow. It's so exciting to see them go on to careers in areas like peatland protection or restoration, helping build new understanding about these ecosystems.

My curiosity has helped keep me excited about science. I am also a natural mediator, which has helped me maintain relationships with a wide range of collaborators, even when we don't agree on the next step.

Even when not in the field, I love to spend time outside. I often go for long hikes, usually accompanied by my golden retriever, Quigley. I also enjoy spending time with my kids and playing sports like pickleball, disc golf or volleyball. I also knit, and always have a sweater or two on the go.

Maria's *top tips*

1. If you're not sure what you want to do, start by thinking about things that you really don't want to do and cross them off the list. Then pursue things that make you happy.
2. Skills and experiences are largely transferable across fields, so nothing that you're learning will be a waste.
3. It's likely you will change paths many times throughout your life, so don't be afraid to follow your passions.