CLIMATE CHANGE AT ARCTIC'S EDGE

ARCTIC TEMPERATURES ON THE RISE

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Churchill, Manitoba, Canada — Up here, just south of the end of the world, people have a unique perception of the word "cold." In the summer months, temperatures range from -7˚ to 27˚C (20˚ to 80˚F), often in the space of an hour. By mid-winter, though, temperature becomes meaningless, and the bone-numbing cold is measured in degrees of wind chill — which can exceed -45˚C (-50˚F). Under these conditions, water turns to ice before you can spill it, and exposed skin freezes in seconds.

Yet even here, at the Arctic's edge, life thrives. More than 600 species of plants and thick clouds of insects support millions of migratory birds, as well as resident populations of caribou and moose. The waters of the Churchill River and Hudson Bay play host to beluga whales, seals, and thousands of fish species. It has just been determined that Churchill has the largest population of beluga whales in the world — 57,000, of which it is common to see 1,000 to 1,500 in the Churchill River estuary. And there are the polar bears. At nearly 700 kilograms (1,500 pounds), and taller than a grown person, polar bears are the largest terrestrial predators on Earth. The Western Hudson Bay population is estimated to be 1200 and they are very common in the Churchill region. Each winter, the bears head out on the newly-formed sea ice in search of their favorite food: seals. Seals, in turn, need ice to make their birth dens. Everything in the Arctic exists in relationship to the ice, and extreme cold is not an obstacle to life here, it's a requirement.

Unfortunately, the sea ice around Churchill is melting months earlier than normal, summer temperatures are rising, and polar bears could go hungry. The culprit? Global warming, and it threatens the entire Arctic **ecosystem**.

The key to understanding why is locked in a frozen layer of earth that starts within a meter of the surface. Within this permafrost lies a carbon-rich substance known as peat, which is concentrated in a broad strip around the entire globe at these latitudes. Peat is dead plant matter that fails to decompose, and it holds virtually all the carbon absorbed by an individual plant during its life. Our planet's peat deposits contain an estimated 450 gigatons of carbon-equal to 60 percent of the carbon in

DID YOU KNOW?

Churchill is known as both the Beluga Whale Capital of the World and the Polar Bear Capital of the World, and is ranked as one of the world's top ten bird watching locations. Churchill is also home to peoples from three Native American nations: the Inuit, Dené, and Cree. It's also one of the best places in the world to watch the northern lights.

Earth's atmosphere. In the north some of these deposits are over 40,000 years old. As long as the peat stays frozen, this vast store of carbon doesn't pose a problem. However, if rising Arctic temperatures allow the peat to thaw, the potential release of carbon (as carbon dioxide and methane, the two most damaging greenhouse gases) could lead to a sevenfold increase in warming. While this would be devastating to the Arctic, the potential consequences for the planet as a whole are catastrophic.

Or not. No one knows for sure whether we're facing manageable change or global disaster. This much is certain, though: Earth's climate is getting warmer, and the fragile Arctic ecosystem of which Churchill is a part is in the crosshairs. In the best case, the effects will only be felt locally, forcing animals and plants to either adapt quickly, migrate, or die out. At worst, warming temperatures at Churchill will trigger the release of thousands of tons of greenhouse gas into the atmosphere, setting the stage for a crisis affecting all life on the planet.

Either way, climate researchers are constantly aware of one thing: the vast concentration of carbon under Churchill is an ecological time bomb, and no one knows how fast it's ticking-or if there's any way to stop it.

THE SCIENCE OF CLIMATE CHANGE

In 1999, a collaborative research effort began with the goal of establishing a network of study areas representing the main ecosystems in the Hudson Bay lowlands. Since that time, the *Climate Change at Arctic's Edge* project, initially led by Dr. Peter Scott, of the University of Albert, has identified 11 study sites, spread out among three classes of ecosystem: natural, disturbed (by human or natural causes, such as gravel pads or fires), and **reclaimed**. Now, under the direction of the University of Alberta's Dr. Peter Kershaw, the research teams have started the project's main goal of identifying and measuring the environmental impact of climate change across the Churchill region.

To accomplish this, a number of short-term objectives must first be met, including complete vegetation and soil descriptions for each site in the study area to determine the soil composition, or how much of various elements, including carbon, are in the soil. The researchers are also live-trapping small mammals to determine the type, number, and movement of species, and are monitoring key environmental factors such as soil thaw depth, plant phenology, and plant growth. These tasks require the relative warmth of the summer and fall (thaw season) to be carried out.

During the winter, Kershaw and his team focus on the one thing available to them: snow. Specifically, they measure day-to-day differences in the **snowpack** at various locations throughout the study area, as well as region-wide snowpack variation from year to year. Kershaw has found that short-term variance is mostly due to differences in plant cover (trees versus no trees, for example) across the study area, while annual changes in the snowpack are a reaction to global climate change. Ultimately, Kershaw hopes to use data gathered through these efforts to accurately describe the current state of Churchill's ecosystem, determine which aspects of it are responding to local conditions and which are being affected by large-scale environmental changes, and set baselines against which future results can be measured.

GATHERING DATA IN THE SNOW AND PEAT

As this project covers many diverse components of the Arctic ecosystem, both living and non-living, and they all have their own particular characteristics, Kershaw's team has to use different methods for studying each aspect of the system.

For the soil study, pits are excavated at each site, and each individual layer of soil is described and a small sample of it is collected. Samples are then brought back to the lab where their **pH**, moisture content, and carbon levels are determined. They are also analyzed for their amounts of nitrogen, phosphorous, and potassium using a Hatch soil nutrient kit. Finally, at least three pits from each site are chosen for planned resampling (every five years).

Researchers also measure total **biomass** and carbon content of the vegetation at each site by clipping the aboveground plant cover, separating the clippings by species, and then

using the **loss-on-ignition** (weighing the plant matter, burning it at very high heat, and then weighing it again) method to determine carbon levels. At the white and black spruce forest plots, researchers measure and record the heights and diameters of all trees taller than two meters. They then take cores from a small subsample of this group for aging and **dendroclimatological** (studying climate from tree rings) analysis. Kershaw measures ring widths from these core samples to reconstruct past climate conditions over the age of the tree (in the range of 250 years for most sites).

In addition, Churchill Northern Studies Centre staff are monitoring several plant species each growing season to discover how the dates of plant development change over time. Kershaw's permanent climate stations will provide the micro-scale climate to help explain differences in these phonological changes from year to year. His research team is also using live trapping to mark and recapture small mammals within each study site, which should provide information on population size, species breakdown, and movement.

To determine how far down the soil thaws during the warm season, Kershaw uses **thermocouple** strings. Embedded in the ground, these strings measure soil temperature to at least 80 centimeters below the surface. They also extend above ground, though, and are used in winter to create snowpack temperature profiles. In mid-winter, the project team takes cores of the snowpack at 90 to 120 locations in each study site, measuring snowpack depth, density, and hardness. In areas where the thaw layer is thick ground-penetrating radar is used to measure the depth to the permafrost table.

GETTING RESULTS

Climate change is a particularly difficult area of science. It's a hotly-contested issue in the areas of politics and business, and in the everyday lives of ordinary people all over the globe. Most climate research scientists agree that both natural processes and human influence are contributing to the problem. The question is, how much? Estimates of our impact on warming range from 25 to 75 percent, so the actual value is still to be resolved. However, the facts are no longer in debate. Regardless of the cause, atmospheric carbon is increasing dramatically, and planet Earth is getting warmer. The *Climate Change at Arctic's Edge* study at Churchill is crucial in assessing the threat posed by warming locally, the resulting impact of Arctic warming on global climate, and the role played by human activity.

One of the reasons that Churchill is such an important location is that it sits at the Arctic treeline, straddling the border between northern **boreal** forest and treeless **tundra**. Such boundaries can be extremely susceptible to small environmental changes that often can have serious ecological impacts. Because areas like Churchill tend to respond quickly to disturbances in the environment, they often show the first indications of large-scale problems — the canary in the mine shaft. Churchill thus serves as an early-warning station for global climate change, and studies here can provide an invaluable first look at environmental changes that can be in store for the rest of us.

This project also gives Kershaw a set of baseline data to compare with future studies, providing a tool with which to measure changes to the Arctic ecosystem, identify their causes, and relate them to climate change as a whole. Using these data, the United States and Canadian governments can then make decisions about greenhouse gas emissions, oil and gas drilling, and fisheries and wildlife management with a better understanding of the consequences of their decisions. With Kershaw's data, people can also work towards creating a model of sustainable resource use in the Arctic.

BUILDING ON THE SCIENCE OF CLIMATE CHANGE

Results from *Climate Change at Arctic's Edge* project will help build a long-term monitoring network specifically designed to measure the ecological impact of global warming. This study is just one of hundreds around the world gathering data on the Earth's climate, past

TREE RINGS AND CLIMATE CHANGE

Tree rings are formed by cambium, the cells in a tree that become wood or bark. These cells grow in light layers in the late spring/early summer, forming "early wood," which grows rapidly. In late summer/early fall, tree growth slows down and is darker, forming a dark "late wood," ring. Each pair of rings — light and dark wood — constitutes a year.

Rings can be counted to tell the age of a tree, but the rings can tell scientists more than that. Depending on the thickness and colors of the ring, scientists can tell if a tree lived through a forest fire, drought, insect attack, or flood. By statistically comparing current tree ring growth with current climate conditions, scientists can create formulas that allow them to reconstruct past climate conditions.

Because trees can live hundred or even a thousand years, they are a valuable record of climate data. In the Churchill region the maximum age found so far is 250 years.

and present. Other studies include NASA's atmospheric aerosol monitoring study, the Canadian network for Ecological Monitoring and Assessment (EMAN) project, and the United States National Science Foundation's Long Term Ecological Research (LTER) sites.

While there are still skeptics who debate the science of global warming, the overwhelming majority of the climate-research scientific community not only agrees that the Earth's climate is warming, but also that the abnormal changes over the past 140 years are due to increases in atmospheric greenhouse gasses as a result of human activities. In 1997, the United Nations amended the United Nations Framework Convention on Climate Change, an international treaty on global warming, with the Kyoto Protocol. The Kyoto Protocol calls for countries to commit to reducing their emissions of carbon dioxide and five other greenhouse gases, or, if they cannot reduce, to trade emissions with other countries that have reduced. A total of 141 countries have ratified the agreement, with the notable exceptions of the United States, China, and Australia. The Kyoto Protocol came into effect on February 16, 2005.

If the goals of the Kyoto Protocol can be reached, there could be a reduction in the average global temperature by between 0.02˚C and 0.28˚C by the year 2050., This can be compared to the temperature increase of 1.4˚C to 4.8˚C predicted by the Intergovernmental Panel on Climate Change (*Nature*, October 2003).

GLOSSARY

biomass – plant material or vegetation.

boreal – of the north; northern.

dendroclimatology – the study of past climatic conditions by analysis of the annual growth rings of trees.

ecosystem – a system of relationships in a local environment between different organisms, and between organisms and the environment itself.

loss-on-ignition method – a scientifically-proven method of finding out the carbon content of plant matter. This involves burning the plant matter at very high temperatures, and comparing the weights before and after.

peat – dense turf made of poorly-decomposed dead plant tissue, saturated with water, often acidic.

permafrost – a layer of permanently frozen subsoil, found throughout most of the Arctic.

pH – a measure of acidity or alkalinity.

phenology – a branch of science dealing with the relationship between climate and regular occurrences in nature, such as bud formation and blooming.

reclaimed – to convert land from a contaminated or useless state to a useful condition.

snowpack – snow lying on the ground for a long period of time.

thermocouple – two conductors made of different metals and joined end-to-end. The junction between them, , produces an electric current that varies with temperature of the surrounding medium.

tundra – vast, level, treeless landscape in the Arctic or alpine.

FIND OUT MORE

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Key Words

Arctic, climate change, permafrost, thaw, greenhouse gas, peat, methane, carbon

Volunteers have joined this project through Earthwatch Institute. Read more about this study and other scientific field research at **www.earthwatch.org**.

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