SciencePages

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Arctic Adaptation

The Arctic is a vital part of Canada's history, economy, and more than 40 per cent of its land territory. About 100,000 Canadians call it home. It is rich with animal life, from large iconic species such as whales, caribou, polar bears and muskoxen, to fish, seals, birds, and tiny ocean plankton. Spectacular landscapes hold minerals, precious metals, as well oil and gas reserves.

Beyond its riches, the Arctic is an environmental bellwether, responding to climate warming three times faster than the world average. For example, the Canadian Arctic current summer ice extent is the lowest in at least 5,000 years. The Arctic's ecological sensitivities mean change from climate warming will be more pronounced there at first. Reliable monitoring data is an important tool for residents, scientists and industry to predict and prepare for changes, preserve the way of life of residents, maintain and build infrastructure and implement sustainable economic development for this changing environment.

ADAPTING TO A CHANGING LAND

One of the biggest effects of climate change in the Arctic will be thawing of the extensive permafrost. in many places this is already underway. Permafrost is ground that is frozen for at least two consecutive years, sometimes containing more ice than soil. Any construction on permafrost alters its temperature, often causing it to thaw and shift, thus threatening the stability of what is above. Current climate change trends exacerbate this by warming the ground and bringing permafrost closer to its thawing point. This presents particular engineering challenges for Arctic roads, buildings and airports.

The Arctic is rich with reserves of oil, gas and precious metals. All three of Canada's territories contain precious metals and minerals including gold, iron ore and silver.

Source: NRCan

Source: Martin Fortier/ ArcticNet

Twelve mines are awaiting regulatory permits while hundreds of sites are under exploration. Offshore discoveries in the Beaufort Sea and Mackenzie Delta area include more than 200 million barrels of oil and six trillion cubic feet of marketable gas, requiring infrastructure both on land and at sea. Developing these reserves require novel engineering approaches to deal with rapidly changing conditions.

New industrial infrastructure such as roads are being constructed and northern communities are expanding, both of which require understanding how permafrost thaw will affect structures. in the Northwest Territories, a new highway approved in March of 2013, will extend about 140 km from Inuvik to Tuktoyaktuk on the shore of the Arctic Ocean. The Inuvik-to-Tuktoyaktuk highway, costing the federal government $200 million, is built on land rich with permafrost, and was designed with this in mind, listing permafrost as one of the biggest risks to the project.

Long-term monitoring of the Norman Wells pipeline has yielded valuable data showing how industrial structures can affect permafrost. The pipeline was built in the early 1980s to carry crude oil from near the Arctic Circle in Northwestern Canada to southern markets. A collaboration between the Geological Survey of Canada and Enbridge, the pipeline's owner, allowed long-term monitoring along the pipeline. Results show disturbance of the permafrost from construction was more significant than from climate warming during the first 10 to 15 years of operation, but that climate warming gradually become more important. Designs for infrastructure meant to last for decades have to consider the effects of both environmental disturbance and of climate warming.

Shifting of the ground surface from thawing permafrost is usually detected by ground surveying and observing damage on structures. Researchers from Université Laval and the Geological Survey of Canada have developed a new way to determine structural risks before the damage happens. They tested it in the community of Salluit, Nunavik by analyzing time-lapse satellite radar images and using numerical modelling. They identified parts of the town where the ground has begun shifting at rates as low as 8mm/year, or only one-quarter the annual growth of human fingernails.

ADAPTING TO A CHANGING SEA

Record lows in the summer sea ice are opening the Arctic to more maritime shipping, tourism and oil and gas exploration. Commercial shipping distances between the Atlantic and Pacific Oceans can be cut by nearly one-third if ships go through the Arctic Ocean and the long-sought Northwest Passage. M'Clure Strait, the shortest route through the Passage, was open for the first time in 2007.

These formerly ice-blocked routes could be dependably open by mid-century, especially in the late summer. However, the routes have not been well charted and several ships have run aground in recent years. The risk of vessels colliding with sea ice will also rise as more vessels use the Passage. Researchers at Memorial University's Sustainable Technology for Polar Ships and Structures (STePS2) project are improving simulations of damage to ships colliding with sea ice. STePS2 creates computer models using technology developed for high-resolution videogame graphics. This lets the researchers create and analyze simulations in just seconds, when it once took days, sometimes months. This exponential jump in efficiency helps engineers strengthen Arctic ship designs for these new conditions.

Source: CBC/Paul Nagle

IQALUIT AIRPORT

Climate warming affecting the North has prompted worries about permafrost stability around the communities. Scientists investigating permafrost conditions under Iqaluit found that the airport was located on unstable ground.

The Iqaluit airport was built during the Second World War and its history has been punctuated by settling and frost-cracking problems giving rise to safety concerns. In addition to recent warming, airport use has grown rapidly since 1999, and aircraft takeoffs and landings are projected to climb from 20,000 in 2010 to as high as 37,000 in 2030. A major overhaul of the facility is planned for 2014, and ensuring ground stability in a changing climate is a priority.

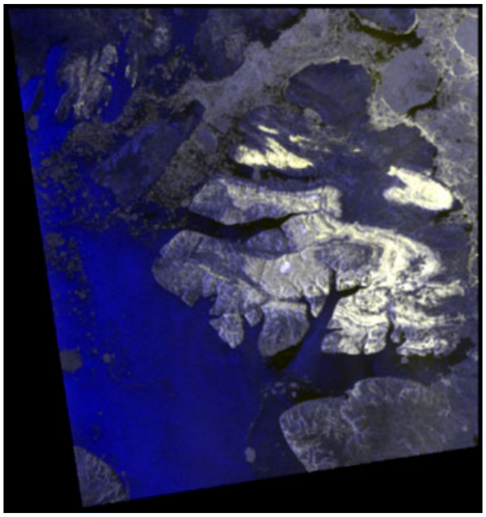
Over the last three years, scientists from Université Laval and the Geological Survey of Canada have been investigating permafrost conditions at the site. A combination of ground-penetrating radar, permafrost coring, deep temperature sensors, and numerical modelling has helped identify sensitive zones, map the depth of thawing under the runway and the tarmac, and forecast changes in permafrost based on changes at the surface. Scientists and engineers will collaborate on design modifications to keep the airport viable in the long term.

Source: Amy Tichwell

THE BEAVER CREEK EXPERIMENTAL HIGHWAY SECTION

A team of Canadian and U.S. researchers are operating an experiment on the Alaska Highway near Beaver Creek, Yukon, in an attempt to stabilize permafrost temperatures under roadways. They are trying to cool the ground under the pavement and prevent surface warming on 12 highway sections. Techniques include porous embankment material that allows air to flow under the road; changes in pavement to prevent heating by the sun in summer; and design strategies to keep insulating snow drifts away from the road. The site has hundreds of temperature and ground water sensors, and data is transmitted hourly by satellite to a central server in Whitehorse. Another approach, an air duct system using natural convection, raised the permafrost table by about one metre under the embankment.

Accessibility can also mean risk. While companies like Shell, Chevron and Statoil have launched exploration and drilling operations for oil and gas in the Arctic Ocean, Shell's project was halted this year after delays and accidents – including the grounding of an oil rig on the shores of Alaska – that showed, in part, how challenging the region can be.



Source: Radasat (MDA 2009)

REAL-TIME ARCTIC OCEAN OBSERVATORY

Fisheries and Oceans Canada created the Real-Time Arctic Ocean Observatory in the Barrow Strait of the Northwest Passage to collect data for adapting to the changing climate. The observatory is a seabed- moored array of instruments that gather and transmit data on ocean conditions via satellite directly to the department researchers.

As a result, the researchers were able to predict the date of the 2012 annual freeze-up weeks before it occurred. The accuracy of this information is vital for commercial and government vessels traversing the Passage. The observatory also collects data on the surrounding ocean ecosystem and its response to changing conditions.

Source: NASA/Reuters

LIVING IN A CHANGING WORLD

Food security, the "access to sufficient, safe, nutritious food to maintain a healthy and active life", is a problem in the North. A study of 150 Nunavut communities found that nearly 70 per cent of children were food insecure, seven times the average in the rest of Canada.

Creating sustainable and culturally appropriate strategies to ensure adequate food supply for northerners is one of the biggest hurdles in adapting to climate change. A third to more than half the households in the Arctic rely on traditional or "country" foods for their meat. Country food is more than simply filling the freezer. Harvesting large mammals is often a community social event with the meat shared in a way that strengthens cultural and social bonds.

But Inuit, Dene, and Métis communities that once sustained themselves on "country" foods like seal, narwhal, walrus, bowhead whale, caribou and fish such as Arctic char, Arctic cod and lake trout, are facing challenges to their traditional ways. Hunting and fishing grounds are becoming more unpredictable and dangerous as the warming climate melts sea ice, increases storms and winds, and shifts the migration patterns of animals and the movement of fish. Climate change has also been linked to an increased prevalence of parasites and other zoonotic diseases in "country" foods. Changes in sea ice — like thinning, unusual cracks, and shifts in the time of breakup and freezing — are being seen on a greater scale and are making conditions riskier for hunters and fishers. Though there are no definitive statistics on the number of

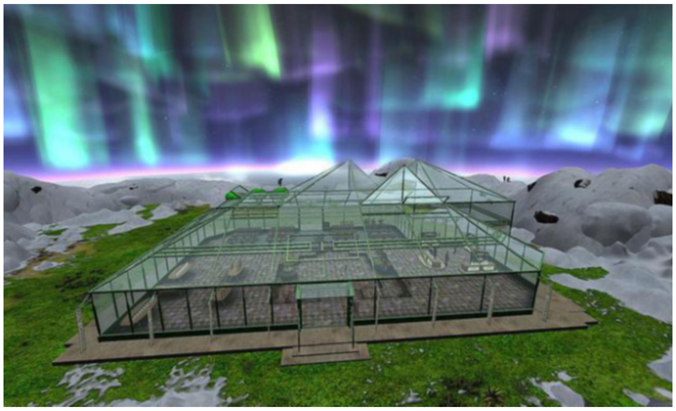
SAFE HUNTING — NAVIGATING A CHANGING LANDSCAPE

Integrating traditional knowledge with science is important to adaptation to climatic change in the North. Successful adaptation initiatives value and integrate Traditional Knowledge, rely on communities to identify the biggest issues affecting them and encourage youth involvement. For example, safe hunting and travel has been identified by many communities as a serious issue.

Health Canada is helping fund several projects with local hunters and fishers to set up ice monitoring stations along traditional hunting and fishing routes in two northeastern Labrador communities and in Nunavik. Community members monitored the stations weekly for average ice and snow depth. The information was shared through the local radio station, social networking sites and word of mouth, helping people in the community to plan safer hunting expeditions.

Recognizing that young hunters were not as familiar with traditional routes as their elders, Natural Resources Canada (NRCan) developed a pilot cartography project based on the knowledge passed down from community elders. The result was a comprehensive hunting map, complete with traditional names which included not only the routes, but the location of cabins that could be used if the hunters became stranded.

The Canadian Rangers Ocean Watch (CROW) initiative of Fisheries and Oceans Canada is putting science in the hands of the aboriginal community, giving them the tools to monitor ocean temperatures, ice thickness, snow depth and plant and animal movements. In one case, a hunter in Nunavut said that of the 71 seals he caught during the winter of 2009-10, all but two had shrimp in their stomachs instead of the expected capelin. This detailed data from local people is not only critical for early warning and monitoring, but helps engage and educate the community in the scientific approach to the environment, fisheries and oceanography.



Source:: Yukon College

GREENHOUSE PROJECT

An innovative 4.3 m x 7.3 m greenhouse project developed by Yukon College researchers and completed in 2012 is one attempt to bring fresh, inexpensive vegetables to northern communities year-round.

The challenges of growing crops in the North are obvious: cold weather, low/no light in winter (and 24 hours of light in summer), heating management and associated costs.

The Northern Greenhouse Research Project is using quadruple-pane windows, vacuum-insulated panels in the sliding door, plant beds heated by thermal storage instead of the air and automated systems triggered by temperature and humidity sensors to help reduce operating costs and maximize plant growth.

The greenhouse also uses a highly efficient 800-watt engine that combines both heat and power generation by using the temperature differential between the interior and exterior of the greenhouse. LED growing lights powered by the engine supplement sunlight during the dark winter. Shutters protect the plants from sun in summer. The greenhouse is so efficient that last winter, passive heating from solar energy and the engine kept the greenhouse sufficiently warm to grow plants. Their next step is to grow plants for 12 months, and adapt the greenhouse for local producers.

The Arctic's future will depend on how international interests, scientists and local communities work together. In May 2013, Canada will assume the chairmanship of the Arctic Council, an intergovernmental group, founded in 1998 that is a forum for research and debate on the Arctic.

The Arctic is already seeing a change to its climate. Those changes will continue to grow and spread southward. Lessons of adaptation learned in the Arctic will be important not only for other nations, but also for the rest of Canada as it faces a warming future.

ADDITIONAL RESOURCES:

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About SciencePages

SciencePages (www.sciencepages.ca) is an initiative of the Partnership Group for Science and Engineering (www.pagse.org) in collaboration with the Science Media Centre of Canada (www.sciencemediacentre.ca).

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It was prepared by Pascale Roy Léveillée, Simon Liem. and Cassie Williams,

For more information please write to us at: info@sciencepages.ca.

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