

## *Opinion*

# Science in the Changing North

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**Abstract:** In the last five years, northern science has been rejuvenated as national and international attention has been drawn to the Arctic. The principal forces driving the increased interest in the Canadian North are the worldwide demand for minerals and hydrocarbons, and the opening of the Northwest Passage as a result of climate change. The renewed scientific activity is taking place in a social context that has evolved, primarily as a result of land claims' settlements, so that local agencies require considerably more consultation regarding research projects than they did in the 1980s. Northerners aspire to have research conducted "in the North, for the North, and by the North," but it is likely that collaboration with outsiders will be necessary for some time before there is sufficient capacity in the North to set or fulfill a comprehensive research agenda. This phase in the development of a full northern research capacity requires scientists from outside to engage communities as partners, and to develop the research skills of the resident population.

### **Introduction**

This essay is a personal perspective on the evolving practice of environmental science research in northwest Canada. The paper draws on experience in the Yukon and Northwest Territories (NT), and so it is an account from a specific geographical context. It is also an account from a specific time, 1982 to 2008, during which research interest in the North declined before a renaissance leading to the International Polar Year, 2007–2009. The period has witnessed settlement of many land claims, devolution of responsibilities to territorial governments, and, particularly in the NT, resurgence in resource development. Climate change has become an international issue and its impacts on the North have been at the forefront of an evolving discussion.

Brief autobiographical details are presented next, in order to sketch the context from which this perspective has emerged. The three principal sections of the essay discuss the forces driving environmental research in northwest Canada, the changing context of fieldwork in the North, and

some reflections on the respective responsibilities of researchers and the communities they visit.

### *Autobiographical Context*

Our field research on permafrost began in the Yukon in 1982 and has been continuous there since then, with projects in the Mackenzie Delta area since 1987. In the Yukon, the fieldwork has been based at Mayo, where we have experienced great kindness, and in the western Arctic at the Aurora Research Institute, a critical logistical support centre. In the last few years, our investigations have extended to Old Crow, Dawson City, and Herschel Island, in the Yukon, and to Paulatuk in the NT. Throughout, I have been in the university system. I have always worked in a department of geography, a discipline which emphasizes human-environment relations at its core, and which stretches over, and sometimes tears at, the interface of the natural and social sciences.

My interest is primarily in the application of general physical principles to landscapes and landforms, or regional physical geography. My academic training bears the imprint of the guidance of Michael Smith through graduate school (e.g., Smith and Burn 1987; Burn and Smith 1990), and the subsequent mentorship of J. Ross Mackay (e.g., Mackay and Burn 2002, 2005). The research is primarily field based, but explanation of the observations usually requires analytical or numerical techniques.

Like most natural scientists, I am a critical realist. That is, I believe there is a reality external to and independent of ourselves, which we may interpret through reasoning. While such interpretation is subject to criticism, refinement, and improvement (e.g., Burn and Nelson 2006), useful interpretation will be rooted in and consistent with our observations of natural systems. In this context, I have benefited from conversations with holders of traditional knowledge because of the long-term observations and interpretations that they hold. Traditional knowledge is commonly associated with specific places and events, and, similarly, community members' interest in permafrost and the landscape is often through natural history. This is the approach we have used to convey our research results to local residents and visitors in central Yukon (Bleiler et al. 2006).

### **The Impetus for Science in the North**

The vast majority of financial support for science in Canada comes from the state, primarily through the federal government, but also from provincial and territorial agencies. Ultimately, this support must be justified in political terms. The scale of support is a relatively recent phenomenon, perhaps

originating from the massive investment during the Second World War. However, the roots of modern science and its culture stem largely from the work of men of independent means. This may be why many scientists regard independence as critical to their endeavour, and, certainly, it is difficult to legislate creativity. Today, science is broadly organized into three cultures: private science, conducted by industry, often on a proprietary basis; government science, conducted to address specific policy objectives; and university science, which is closest to the model of independence, but which still relies on state support. The state and other agencies may encourage or discourage particular areas of science by varying the support available, as is the experience of northern science.

Many northern scientists are motivated by an appreciation of our region as a national and global treasure. The North holds an essential place in the Canadian imagination and identity, but this is not always sufficient to ensure its prominence on the political agenda. Most recently in the 1990s, the peripheral location of the North in the Canadian body politic became evident as the federal government tightened its belt. A combination of factors has changed this position, but while romantics may emphasize the place of the North in our culture and dreams, and environmentalists the accelerating impacts of climate change in the Arctic, resource development projects, for minerals as well as oil and gas, attract far more government investment and attention, particularly through regulatory processes. The cost of fieldwork in the North, and the modest population, mean that the extent of scientific activity is tied to government interest, which waxes and wanes but may be more consistent in the presence of a fiduciary obligation such as the need to satisfy regulatory requirements for projects on crown land. The recent surge in energy prices and the growing demand from Asia for Canada's raw materials perhaps assure interest in the northern environmental science required for Environmental Impact Assessment (EIA) and licensing procedures. Climate change is now a formal consideration in EIA, and this will be one of the principal routes for climate change science to influence public policy in Canada.

#### *Science and Prediction*

The purpose of science is to develop our understanding of the world. We develop this understanding by constructing laws or general statements that describe aggregate behaviour, which are assembled into theories, and then tested against observations to evaluate their performance. However, there is a fine balance between observation and synthesis, because the ideas about general behaviour are commonly derived from repeated observations under

a variety of circumstances, rather than through abstract intuition. The state supports natural science because it enables prediction of environmental behaviour, and hence lets us harness the world for our purposes and helps us protect ourselves from the forces of nature. These tangible benefits are part of the reason financial support for research in natural science is generally greater than for social science and the humanities.

Science has achieved mythic status in our culture. The Concise Oxford Dictionary defines *myth* as a traditional narrative embodying popular ideas on natural or social phenomena. A myth is a system of knowledge or belief that is essentially seen to be true. Traditional knowledge is a myth because it is embedded in and trusted by Aboriginal culture. Contemporary science is a myth because over the last 300 years its acceptance by the public has steadily increased, and with it, its authority. It is now a privileged form of knowledge, superior in its domain to opinions and folklore. Science has achieved its status due to its ever-increasing success in prediction, such that our life today is quite different from conditions in 1907 or even 1957. It is the track record of success that ultimately gives science its credibility.

Much of the emphasis in environmental science today is on developing models, or theoretical structures, that describe how environmental systems behave. In the North there is some skepticism towards such models because the variety of landscapes in the North may defy generalization, and because of the extent of intuitive understanding of environmental conditions needed before formal explanations can be constructed with equations and formulae. As a result, much northern science is inductive, with emphasis on observation, measurement, and statistical analysis. It may be that a more deductive approach, arguing from theory, will dominate in time.

#### *Statutory Obligations*

Territorial governments have been responsible for regulations concerning wildlife for many years, but settlement of land claims has commonly led to co-management structures for policy development, and has necessitated the development of a cadre of northern regional biologists. These scientists are commonly involved with regional population surveys, and their work is of great local interest. These positions are best located in communities, rather than territorial capitals, and occupied by the same people for some time in order to develop the relationships envisioned for local co-management regimes. The territorial support for this area of science is assured by the fiduciary arrangements in land claims' settlements.

There is similar territorial interest in geoscience, especially in terms of regional surveys of mineral potential. In this case, however, the scientists

are located in the capitals, partly because surveys of a map area can be completed without need for repetition, and because geoscience has only recently become a territorial concern, as opposed to a federal responsibility. Nevertheless, geoscientists are a second cadre of scientists based in the North. The programs supported by these offices bear a clear link to the foresight of senior managers, as with the geohazard research conducted out of Whitehorse. Both of these groups, but especially the geoscientists, collaborate extensively with scientists from outside the North, exist to fulfill northern priorities, and can convey a northern agenda to southern researchers.

#### *Resource Development*

The opening of Canada's first diamond mine in 1998 at Ekati, near Lac de Gras, NT, was a turning point in the economy of northern Canada. The profitability of this industry has stimulated several other operations and reopened the North for mining. The current demand for Canadian raw materials has rejuvenated exploration across the region, and renewed interest in several mines that closed in the late 1980s. However, the legacy of several projects abandoned by their operators and assumed by the Crown, has prompted a more rigorous environmental assessment and monitoring regime. The recent referral to EIA of the proposed closure plans for the Giant Mine at Yellowknife, including the bulk immobilization of arsenic particles, indicates the scrutiny that the public requires of projects. Within individual corporations, however, environmental budgets are as subject to pressure as other areas, and it is not always evident that long-term environmental considerations are prominent given the need for short-term financial results. This increases the role of regulators in stimulating research. There is an expectation from regulatory boards that government will undertake the environmental monitoring of projects necessary to avoid unacceptable environmental impacts. In turn, government itself may initiate research to design monitoring programs, especially in the area of cumulative effects, which are poorly understood.

A second impetus for resource development is in the energy sector, with increasing continental and international demand for oil and natural gas. The most prominent research focus is associated with development of infrastructure, particularly pipelines, but there has also been considerable public investment in efforts to develop methods for extraction of energy from gas hydrate deposits. The Mackenzie Gas Project is seen as a basin-opening initiative, and if the main pipeline from the Mackenzie Delta to Alberta is built, other reserves in the Mackenzie Valley may be viably developed. Development of these resources has been declared as in the national interest

by several speeches from the throne, rejuvenating associated research in the western Arctic. The interest of industry in offshore resources and the prospects of increased shipping in the Arctic Ocean, as summer sea-ice extent decreases, mean that research efforts that may facilitate future regulatory applications will likely be maintained.

### *Sovereignty*

The dramatic reduction in the summer extent of sea ice in the Arctic Ocean has alerted Canadians to the potential for significant shipping through the Northwest Passage. While the bulk of such traffic will be cargo vessels travelling between Europe and Asia, a greater local impact will be created by cruise ships, each carrying hundreds of tourists, visiting our small Arctic communities and demanding significant local services. The environmental impact of such intermittent tourist populations and the risks presented by the vessels will need to be assumed by Canada, as all infrastructure for mitigation of such hazards will be built on ground that is indisputably ours. These tangible responsibilities are looming, but under international law a Canadian presence is also necessary to confirm our claim to resources beneath the Arctic Ocean. For the last fifty years, science has often been the rationale for offshore activities in the Arctic by Canadians. Indeed, under international law, an ongoing presence is the clearest claim to sovereignty, but such presence rarely occurs in an economic vacuum. Science can expect to ride on sovereignty's coat tails, both to demonstrate a Canadian presence, and to facilitate development.

### *Climate Change*

A large amount of current research in northern Canada is driven by a need to understand and adapt to climate change. This is one of the two themes of Canada's International Polar Year (IPY) program. Climate change research is an interface between contemporary science and traditional knowledge, because a record of change is held in some memories, and because many traditional Aboriginal activities take place outdoors where the impacts of climate change are observed. It is accepted that climate change is greatest in the polar regions and that its effects will be prominent. A great deal of current research is devoted to quantifying the magnitude of impacts that are to be anticipated, in terms of a longer season for growth of organisms, adjustments to the hydrologic cycle, and the effects of melting ice. Some of this research is conducted strictly on a regional basis, in anticipation of development, but international interest is focused on the Arctic Ocean and the effects a long open-water season may have on the general circulation

of the oceans and atmosphere. Human response to climate change is less studied, largely because climate is but one factor forcing changes to northern society, and because the sparse northern population is normally sheltered from the catastrophic effects of extreme weather events, unlike people in the densely populated tropics, where economic status is lower and municipal infrastructure less robust.

The North hosts two major environmental systems that will be critical in the global response to climate warming. The first is the circulation of the Arctic Ocean, particularly the outflow of cold water, which forms the bottom water of the Atlantic conveyor, allowing the surface North Atlantic Drift to warm Western Europe. If the volume of cold water leaving the Arctic Ocean declines, there will be a similar reduction in the warm water entering the Arctic and the reduced flow will change the climate of Europe, perhaps dramatically. The second concerns the dynamics of the carbon currently stored in permafrost. There may be about one hundred times as much carbon stored in permafrost than our current annual global industrial contribution to the atmosphere, which is about nine billion tones. As permafrost degrades, we fear this stored carbon may be released, either as carbon dioxide or methane, a more potent greenhouse gas, and our efforts to limit our own emissions may be of little consequence.

#### *Existing Scientific Infrastructure*

The first western science in the North was conducted in association with exploratory expeditions, and in many ways the refit of the Canadian Coastguard icebreaker CCGS *Amundsen* represents this tradition. The *Amundsen* is a platform to study areas that cannot otherwise be reached, and its maintenance and operation is a significant enterprise becoming ever more costly as the price of fuel increases. However, it is unlikely that the scientific institutions of Canada, having invested so much in the *Amundsen*, will not ensure its operation. The *Amundsen's* program, like most oceanographic research in the Arctic, is almost entirely conceived and developed in the South. There are other examples of established infrastructure, for example the Arctic Stratospheric Ozone Observatory at Eureka (Ellesmere Island), which operate in a similar fashion. The research stations with the closest coordination between research priorities established in the North and existing infrastructure are the Tundra Ecology Research Station at Daring Lake, a seasonal field station north of Yellowknife, and the research program of the Aurora Research Institute's staff at Inuvik.

Much of Canada's formal northern scientific infrastructure is dilapidated and in need of replacement if it is to serve research effectively. A principal



problem with such renewal is the complex nature of Canadian governance, especially when infrastructure is localized, while our interests cover a vast area. There are good cases to be made for investment throughout northern Canada as interest in the Arctic increases. Previously, scientists relied on the federal government to provide infrastructure, but there is now an opportunity for northern governments to demonstrate their commitment to science, perhaps as a sign of their growing maturity. This may become particularly apparent if federal investment, as with the *Amundsen*, identifies an overriding priority associated with sovereignty offshore.

The renewal of infrastructure is likely a requirement for development of northern science in the next decade, but not simply to keep up with technological change. The northern science community has traditionally been composed of relatively small research groups centered on individual field scientists. These groups have operated out of small research camps or with local logistical support developed over time. Increasingly, scientific research is conducted by multidisciplinary teams of collaborators. Large groups require infrastructure that can supply their diverse needs, tolerate multiple personalities, and cope with turnover in research personnel. More formal structures and arrangements for field research are likely to be a consequence of the changing sociology of science, and will be tied to the use of physical infrastructure.

### **The Context for Northern Field Investigations**

Northern field research commonly involves relatively complicated and expensive logistical support. Recently, cheap fuel and the relatively small research community have not constrained budgets or toughened the competition for support. Both of these factors are currently changing. First, fuel costs have escalated in 2008, although the impact on field operations has been delayed because of pre-existing contracts. From 2009 onwards the increased price of fuel will become a significant element in the scale of field investigations because science budgets are rarely indexed to such expenses. The greatest increases in absolute terms will be for aircraft use. This may lead to concentration of research projects closer to communities and roads. The research community tends to be less familiar with water transportation, so increased access by rivers and lakes may take time to develop, even though the introduction of four-stroke outboard motors has increased the efficiency of such travel.

Second, the International Polar Year has led to a substantial involvement of new students in northern research, many of whom aspire to develop their interest into a career. It is not clear whether the corps of professional northern



researchers will increase substantially, however, and many of these trainees may leave the field. No general expansion in the number of government or university personnel devoted to the North is currently contemplated, and the schedule for industry's shifting interests is unpredictable. However, given the priorities outlined above, opportunities for student research will likely flourish.

#### *Land Claims and Licensing*

One of the consequences of devolution and settlement of land claims has been an increase in local involvement in research licensing. Researchers in the three northern territories require an annual licence, which is the primary vehicle for recognizing the nature and extent of research activities in the region. During the 1990s, the attention given to research licences increased significantly, and the licence application process was recognized as an opportunity for local consultation regarding activities by visitors. The process has been used in a regulatory fashion by some groups and this has caused researchers some problems, not least because of the time and expense involved in developing an effective dialogue with communities often located a long way from the researcher's base. It is now routine for licence applications to be submitted to local agencies for comments, but not approval, and for a report on previous research to be submitted to these same agencies. Many researchers are unaccustomed to making their work accessible to the general public, but the importance of community consultation, and the potential benefits it may release, are increasingly recognized by Canadian northern scientists. These benefits not only include local knowledge that may be pertinent to research, but also the availability of field assistance, and, perhaps, the preparation of a welcome for visitors by the local population. It is important to recognize that in the terminology of Aboriginal governance, "consultation" does not simply entail a conversation, but also an expectation that there will be a response to, and accommodation of, legitimate concerns as a proposal is developed.

There has been some resistance to the increased communication required by northern agencies. Fundamentally, the problem centres on the question of for whom the research is being conducted. Most researchers operate in an administrative system that pays lip service, at most, to local engagement in research programs and projects. The costs of such engagement are commonly not considered part of a scientific budget, but the activities are not discouraged per se. The result is that most researchers do not regard local engagement as a critical part of their activities, which implies that the science is being conducted primarily for the scientific community. Ultimately, though, a primary justification of environmental science is for land and

water management, in which local involvement is increasing, and for which there are local expectations of researchers. Further, visitors are often noticed in small communities, where news travels fast and the intentions of visitors are matters of conversation. When this social context is combined with great cultural interest in the land, it is not surprising that communities want to know what researchers are up to, and expect to be consulted on planned activities. The development of local governments has formalized this process and facilitated the identification of appropriate agencies for such communication.

#### *Traditional Knowledge and Contemporary Science*

Canadian legislation has recognized that traditional knowledge (TK) must be considered during Environmental Impact Assessment, just as contemporary scientific knowledge is part of such deliberations. It is not difficult for contemporary scientists to recognize the importance of aspects of TK in their own research. In particular, TK pertaining to local environmental characteristics and behaviour is often a key to characterizing and understanding environmental systems in their regional context. Holders of TK normally acquire their local knowledge from observation and experience, and a fruitful dialogue can occur between such experts and scientists who have a similar awareness of observations and recent environmental history. It is much more difficult to engage in discussion when the TK concerns a distinctive political and social perspective and set of interests, rooted in the history of a First Nation. This is because holders of TK may also have well-developed ideas about the purpose of environmental systems. In contrast, contemporary science operates in a materialistic framework, answering questions about how environmental systems function as they do, not why they do. Contemporary science does not consider much more than what can be investigated in a repetitive and experimental way, and it does not, at present, investigate questions of meaning and purpose outside a material framework. This is a principal reason why TK is integral to resource management in the North. Management, after all, is about trying to create the world we want.

#### *Northern Research Capacity*

The capacity of northerners to create and fulfill a scientific agenda is a great challenge for the emerging North. Without such capacity, the relations of scientific production will remain as in the past, and the scientific agenda will be set outside. Aside from wildlife ecology and geoscience, there is capacity in but few areas. Remarkably, the capacity in surface earth science

and vegetation ecology is particularly small, even though EIA is conducted by local boards. The lack of capacity is apparent at public hearings, where numerous southern consultants appear as witnesses. Part of this deficit may be due to the separation between northern post-secondary educational institutions and the scientific activities of other branches of the territorial governments, but the fundamental reason is that the northern population is small and dispersed over a vast land area. Development of such capacity is a long-term project and involves a critical challenge, for as Aboriginal lifestyles change, with less time spent on the land, the transmission and development of TK will probably become more and more difficult. In the future, the availability of such capacity may well be tied to the existence of structured programs for environmental monitoring and fieldwork.

### **Neighbourhoods in the North**

The size of communities in the North places greater responsibilities on visitors arriving for professional purposes than what is encountered in larger, anonymous urban settings, for in the North, the visitor becomes an ambassador from the South. However, while the visitor may come from a relatively impersonal social context, a northern community is anything but impersonal. It is useful to consider the expectations of a scientist in the context of a visit to a community, and the expectations of the community towards the scientist. Most scientists are familiar with visiting their friends and relatives in other cities or communities, and the protocol for such a visit may be applied to the research context.

First, communities expect scientists to inform them when they are coming and when they propose to leave. As with a visit to friends, it may be necessary to change these dates if the hosts are otherwise occupied or if the hosts propose a better time to fulfill the purpose of the visit. Communities also expect scientists to inform them about what they intend to do and where they intend to do it, just as in the preparation for a social visit. The community may be able to suggest a better place for the investigation or advise if the location is inappropriate. Communities expect to know if local logistical resources will be required, and they do not expect scientists to be an encumbrance. Communities also expect the equivalent of a thank-you letter after the visit is over, including a preliminary report on the research undertaken. Later, the community expects a full report presented in an accessible fashion and it is commonly helpful if this can be displayed on a wall.

This summary of community expectations is presented informally, but for almost all projects there is a formal process, and for research involving humans the process may be quite detailed. The primary basis of consideration is of an evolving partnership, based on respect and, hopefully, an emerging interest in the research program. The partnership need not be of equals, but of complementary roles, as it is important to recognize that field research cannot occur in a vacuum. The expectations scientists may have of northern communities are similarly guided by experiences from visits to friends and relatives. First, the visitor, if arriving with proper advance notice, can expect a welcome, and then some clear guidance on the house rules. In this case, the researcher expects to be informed of local practices that may affect the field program, or any recent events that may upset the proposed activities. The researcher may also expect assistance with local arrangements, and, particularly, will expect any understandings reached before arrival in the community to be honoured. This applies especially to the hiring of local assistants.

### **Conclusion**

Scientists value independence and freedom, but the practice of science is becoming ever more collaborative as shown by the number of authors on most papers. Northern science is not only collaborative, but occurs in a context where inhabitants expect to be recognized and in some way included as partners in the research process. The engagement of others limits freedom, as in most social interactions, but these limits are accepted as they contribute to a greater common good, which is the slowly developing engagement of northerners with science.

Northerners strive for science “in the North, for the North, by the North.” Northern science always has a component “in the North.” Most programs have been justified in terms of “for the North,” but the agenda has rarely been set in the North, though northern views are now normally incorporated into discussions concerning relevant scientific initiatives. At present, the capacity for science “by the North” is limited, although significant in certain areas, and it will not develop further if science is treated as a solitary occupation. The development of science in the North can only progress through partnerships with southerners, a clear part of which must be to develop capacity through formal education and structured experience. In this context, science in the changing North will not simply affect material progress, but contribute directly to social development.

## Acknowledgements

I thank the *Northern Review* for the opportunity to publish material that has been the focus of various presentations during the last four years—in particular at the Science in the Changing North conferences held annually in Yellowknife, and the 2006 John Wiley Lecture to the Canadian Association of Geographers—and I am grateful to Deanna McLeod for careful editing of this paper. Our field research program has been supported principally by the Natural Sciences and Engineering Research Council of Canada, and the Polar Continental Shelf Project of Natural Resources Canada. Students working on our projects have been supported by the Northern Scientific Training Program, and the Water Resources Division of the federal Department of Indian Affairs and Northern Development (DIAND). Over the last twenty five years the research has also been supported by the Earth Physics Branch of Energy Mines and Resources Canada; the Atmospheric Environment Service of Environment Canada; the Northern Research Institute of Yukon College; and the Aurora Research Institute of Aurora College. We have received significant in-kind logistical support from: the Village of Mayo; the Na Cho Nyak Dun First Nation; J.V. Clark School, Mayo; the City of Dawson; the Northern Research Institute of Yukon College; the Vuntut Gwich'in First Nation; the Aurora Research Institute, Aurora College, Inuvik; Tuk Tuk Nogait National Park; Herschel Island (Qikiqtaruk) Territorial Park, Government of Yukon; and the Department of Environment, Government of Yukon. I gratefully acknowledge the encouragement and interest in our work of many northerners, particularly, in the community of Mayo, Jim and Shann Carmichael, Bruce MacGregor, Michael McGinnis, Mark O'Donoghue, and former resident and mayor Shanon Cooper; in Whitehorse, Charlie Roots, Peter and Mary Beattie, and former residents Scott Smith, Gary White, and Steve Morison; in Yellowknife, David Livingstone, Steve Kokelj, and Robert Jenkins; and in Inuvik, former resident Alan Fehr and Christian Bucher. We have received considerable assistance in the field from many people, but principally Douglas Esagok of Inuvik; Lee John Meyook of Aklavik; William Hummel, Ross Cooper, Michael Mason-Wood, and Ryan MacGregor of Mayo; and Ross Carroll, Karen and Diana White, Pierre Foisy, and Julie Cossette of Whitehorse. Several assistants have come from the South, and we have had special help from Alan Dufour, John Schilling, Todd Randall, and Andrew Burn. Finally, I would like to acknowledge with the deepest gratitude the continuing support of Joan Ramsay Burn, which began when we met in Mayo twenty-five years ago.

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