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A CASE FOR AIRSHIPS IN THE CANADIAN ARCTIC

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INTRODUCTION

It is evident for those of us undertaking research in the Arctic that extensive exploration is occurring and that the local affects of climate change are becoming more apparent.[1] It is also evident that costs for residents of basic everyday items like groceries and gasoline as well as building materials, snow machines, outboard motors and boats, are high. Given the recent trends in oil prices to over $60 a barrel, and with predictions of even higher costs for transportation, the cost of living will definitely increase. Combine these predictions with the fastest growing population in the country, concerns about Canadian sovereignty, and new wealth generation from non-renewable resources, and a need emerges for new and innovative long-term planning for northerners, and especially arctic communities.

There are three major forms of transportation in the Canadian North: sealift and barging during open water, fixed-wing aircraft throughout the year, and if permanent or winter roads are available, truck transport for bulk cargo. While the sealift is relatively economic it is limited to open water and may be affected by sea ice if warming trends continue, making some sea routes more hazardous over the short term (N. Mathur, personal communication). Furthermore, a late spring thaw or unpredicted shifting ice in a given year could mean that key construction equipment arrives too late by sealift to start work during the arctic summer, so that equipment is tied up for at least one more year. Fixed wing aircraft are expensive to operate and the recent bankruptcy of several air carriers indicates the impact that higher oil prices are having on the bottom line, even in areas of high population density. While fixed wing aircraft are unfortunately the only option for year-round travel and the delivery of crucial goods for residents of isolated northern communities, transportation and travel costs continue to increase.

The Canadian North and to a lesser extent the northern regions of most provinces have limited all-weather roads, in some regions supplemented by winter roads; about 70% of the Canadian land mass has no roads.[2] Figure 1 illustrates some of the existing and proposed winter roads in Canada today. Climate change has reduced the annual useable time of winter roads over the past decade[3] and has increased maintenance problems.[2] This, coupled with the absence of winter roads from many areas of the North and the tremendous construction costs of new permanent roads make it highly unlikely that the proposed roads will be built.

It is worth noting that many roads maintained by the forest and mining industries are not part of the provincial and territorial government transport inventories.

Canada

Consequently, the non-permanent road system in Canada is far more extensive than outlined in Figure 1* and the environmental impacts are high. Manitoba, northwestern Ontario, some sections of northern Saskatchewan, and the Northwest Territories (NWT) have extensive winter roads. Other areas of Canada such as the NWT, Nunavut and Nunavik have no road systems, except for a few kilometres in each community. Furthermore, new roads such as the Bathurst Inlet proposal (Figure 1) would primarily service new mining ventures and have little lasting value to northern communities. Another major proposed road along the west side of Hudson Bay would serve several communities and potential mining operations, but the estimated cost of $1.2 to 1.7 billion is prohibitive. It is unclear who would pay the construction and annual maintenance costs of these roads.[3]

Exploration, movement of heavy bulky equipment, basic research, environmental and resource management, and sovereignty issues require transportation that is cost effective (reduces the high cost of caching fuel), can move slowly over the landscape (oceanographic measurements, geological and geophysical surveys, global change surveys and wildlife census), has minimal environmental impact, is highly visible, and uses a vehicle that can move easily over rough ice, water and land.

Given the scenarios outlined above it is clear that other transportation options need to be considered. One of these is the use

* Information on winter roads from British Columbia and Quebec was unavailable and no winter roads exist in Nunavut.

Figure 1
Northern territorial and federal parks, bird sanctuaries, and existing and proposed winter roads in Northwest Territories, Nunavut, Alberta, Saskatchewan, Manitoba and Ontario.

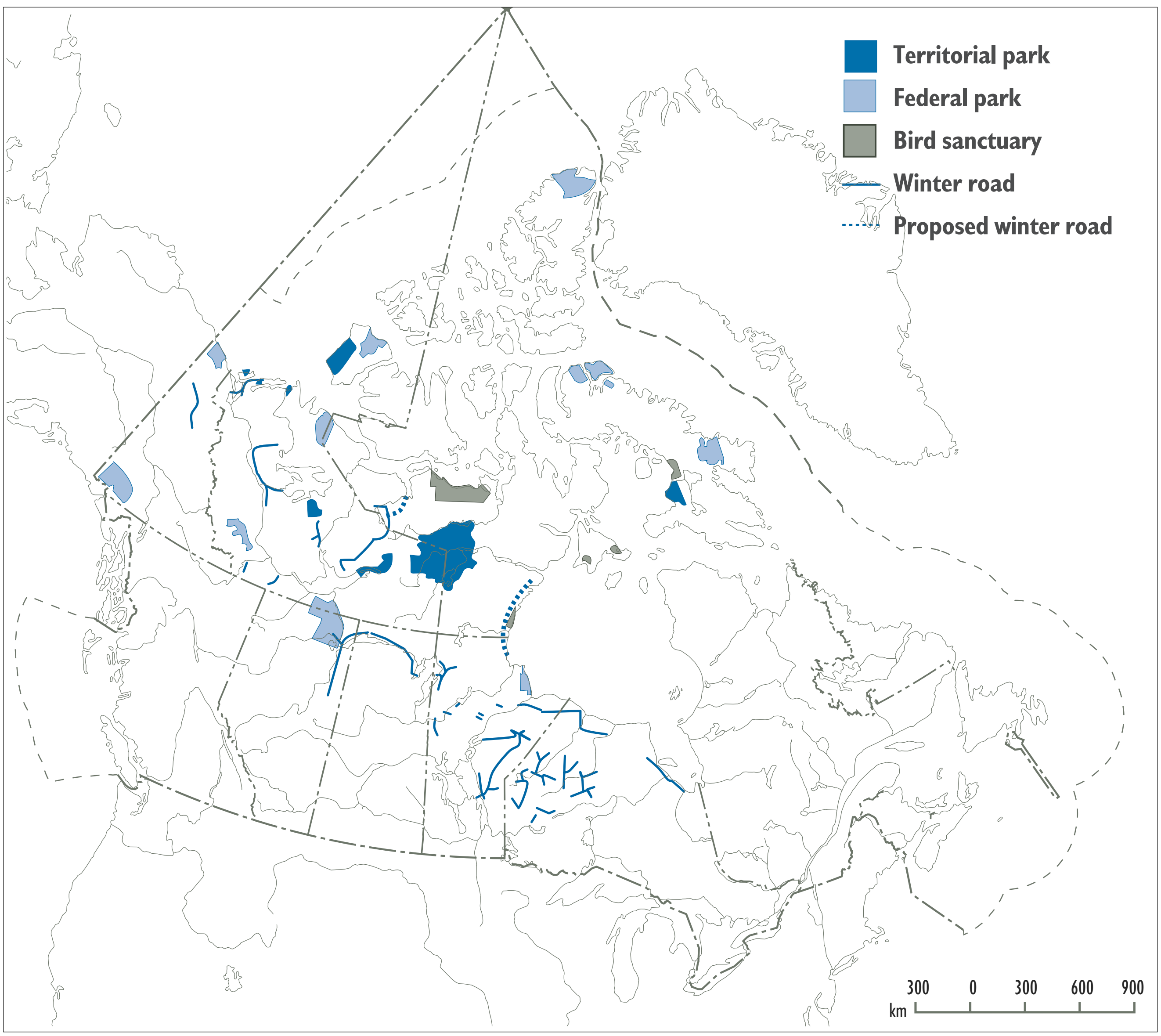

Figure 2
The spherical airship developed by 21st Century Airships of Newmarket, Ontario is suitable for diverse applications, has a quiet diesel-electric power system and can land and take off from water. Photo art: Eiko Emori using images from 21st Century Airships and Peter Johnson.

of airships. There are many skeptics concerning use of airships but most people agree that airships are light on infrastructure (the airships are the infrastructure), require little maintenance, and use comparatively little fuel. Some of the uneasiness with airships comes from the perception that they are unsafe, primarily based on the image of the burning *Hindenburg* and the use of hydrogen.

This article presents a historical perspective on arctic exploration using airships, some past and current technologies relating to airships, and a brief review of comparative cost of operations. We also discuss the potential benefits of airships to environmental research and natural resource management in the Arctic, and evaluate northern weather patterns as they relate to airship operations, as this is a consistent concern of those who question their use under the "harsh" arctic conditions.

EARLY EXPLORATION

Airships are not new to the Arctic. Over a century ago several explorers used balloons or airships for travel to the North Pole. The first, a hydrogen balloon attempt by the Swede Salmon August Andree (1856–1897), failed because of loss of gas through the fabric and the weight of mist and ice on the balloon.[4] An American, Walter Wellman (1858–1934) led five expeditions between 1894 and 1909, and in 1907 and 1908 used motorized airships in the Arctic.[4] An Italian airship piloted by Umberto Nobile sailed over the North Pole carrying the famous Norwegian explorer Roald Admundsen. Airships were used during both world wars as observational platforms and for anti-submarine surveillance, reaching their peak during the 1940s. The last US airship to cross the Arctic Circle did so in 1958, and shortly afterward the US navy phased out airships.

PAST AND PRESENT TECHNOLOGIES

Many airships were constructed during the early to mid 1900s. During World War I, for example, 300 British non-rigid airships protected allied convoys. The *Hindenburg,* constructed by the Zeppelin company and first flown in 1936, was the largest airship ever built and contained 7,062,000 cubic feet of hydrogen, giving it 242.2 tons of gross lift and a useful lift of 112.2 tons. Its design was novel even by today's standards, as passengers were located within the huge hull rather than in a protruding gondola. The Hindenburg met a fiery end even though its owners initially planned to use nonflammable helium.

Today there are twelve companies in ten countries with designs ranging from rigid to semi-rigid frames, and cigar-shaped to spherical. Modern composite materials designed for other uses are today being applied to airships. These new products include three-layer laminates consisting of a gas-tight layer, a polyester fabric layer to provide stability, and a polyurethane layer suitable for thermic welding that serves to connect the separate laminate panels. New computer-controlled engines adjust propeller vectors to maintain altitude with upward thrust, to allow hovering, and to angle the craft into the wind. Today helium is the gas of choice and since Canada is the third largest producer of helium at 2 billion m^3 per year, a shortage of helium is unlikely. The use of solar panels and fuel cells is being considered to further reduce energy costs. Two airships available today for cold weather testing and certification are the Zeppelin NT manufactured by Zeppelin Luftschifftechnik GmbH (ZLG) in Friedrichshafen, Germany and a spherical airship built by 21st Century Airship Inc. of Newmarket, Ontario, Canada.

ECONOMIC ASSESSMENT

The best economic assessment for airship use and comparisons with other forms of transportation has been done by Barry Prentice and his co-workers at the Transport Institute, University of Manitoba. The potential for cargo airships in the Arctic, using as an example the development of the Izok Lake mine (Bathurst Inlet road) in the Northwest Territories, is well documented.[5,6] A 265km all-weather road to the mine would cost $250 million; no roads are required for airships. Assuming 260 days per year of operation one airship with an 84 tonne capacity (the equivalent of two Super B tanker trucks) could carry 78 million litres of the mine's 180 million-litre annual fuel requirement. Cost of the airship was estimated at $60 million, depreciated over twenty years and including skin replacement in ten years (a very conservative estimate). Insurance was estimated at $1.75 million per year. Cost savings by reducing long term storage were estimated at $5 million annually. It was also estimated that a 10% return on investment would accrue after 245 days of airship operation and at 320 days of operation the mine would save an additional $4 million.[7]

Cost comparisons for the movement of goods by airship to small Northern Manitoba communities served by winter roads were also done.[7] The cost per tonne of goods only for a 30 tonne capacity airship was more than goods transported by road; if passengers were included the cost would be similar to truck transportation. Airships with a 150 tonne capacity were about 40% cheaper than trucks. While there are other variables to consider such as airspeed versus carrying capacity, distance travelled and fuel consumption, the above analysis indicates that airships would likely be competitive with contemporary winter road transportation systems. In much of the Arctic, where there are no winter roads, aircraft would not be able to compete with large airships.

ENVIRONMENTAL

Airships could be highly useful in wildlife management. National parks are widespread and often difficult and expensive to reach (Figure 1). Information from federal and provincial government internet sites indicates that the major mammal species managed in the North include grizzly bear, muskox, polar bear, caribou, Dall sheep, walrus, beluga whale, bowhead whale, harbor seal, ringed seal, hooded seal and harp seal. Much of northern Canada, including the northern portions of the provinces, is utilized by large mammal species (Figure 3). Even woodland caribou and moose in the Boreal regions could be studied using airships. Caribou herd migration and movements of polar bears, barren land grizzly, and whales could be plotted without direct intrusion into their habitats. Other marine mammal species widely distributed throughout the Arctic could be studied year round, even during ice breakup.

Airships could function as stationary

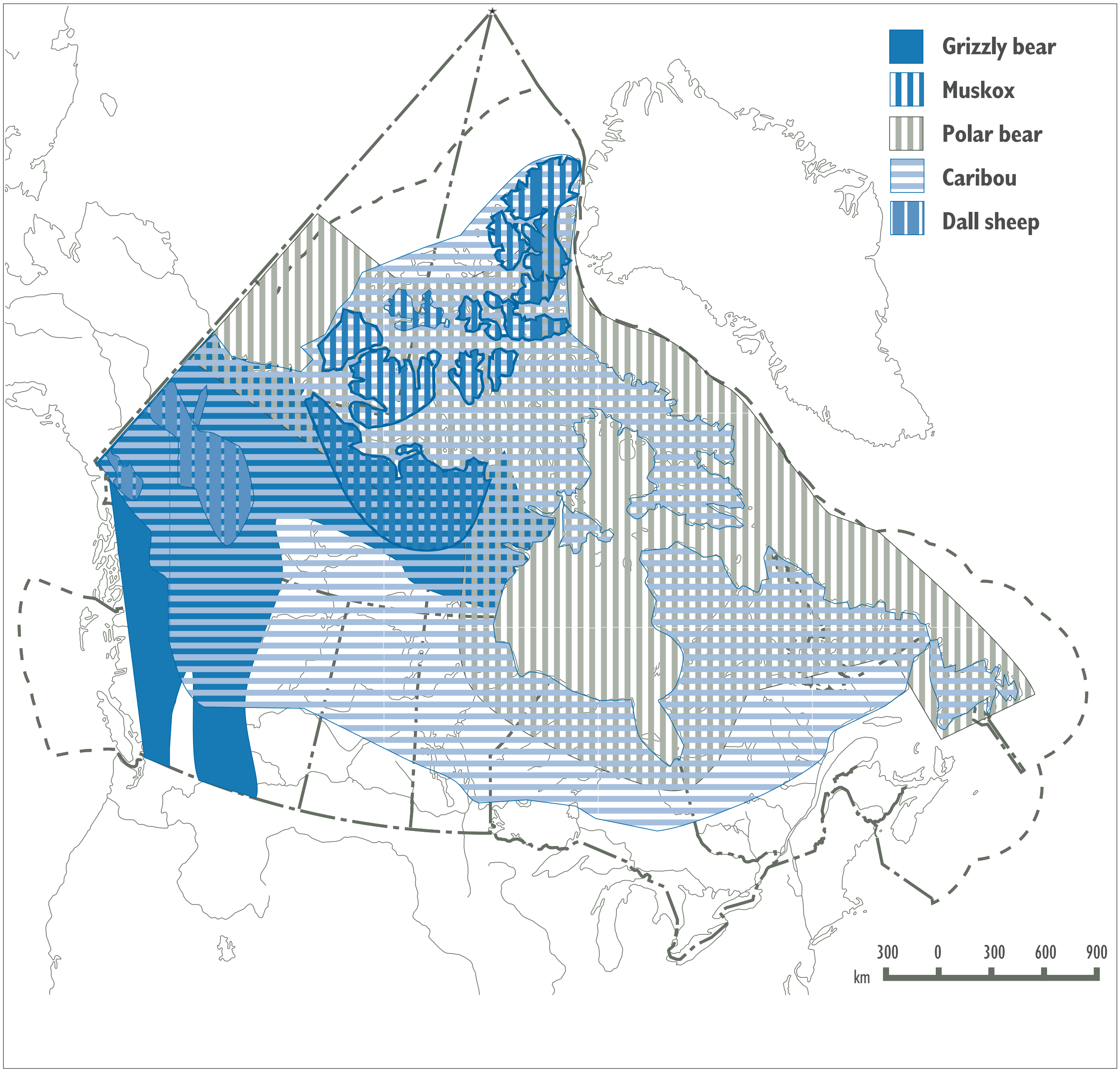

Figure 3
Canadian spatial distribution of grizzly bear, muskox, polar bear, caribou and Dall sheep.

platforms to document, by photography and other methods, species interactions at the ice edge. Animal movements could easily be recorded as they move from sea to ice to land with little or no disturbance to the animals or the environment. Surveying whales with Twin Otter aircraft requires refueling every six hours, and airspeeds of about 100 knots; but an airship can hover unobtrusively, offers a stable slow-moving platform for photography and can stay aloft much longer. Research data on animals could be collected where ice conditions are unsafe for surface transportation. In fact unstable ice conditions could be monitored continuously and airships would be available for rescue if needed during the peak hunting periods.

The distribution of species important to northern communities indicates that entire northern regions of Canada need to be accessible for census, harvesting and resource management. Airships would change how we view and manage arctic mammals and birds. Clearly airships could provide

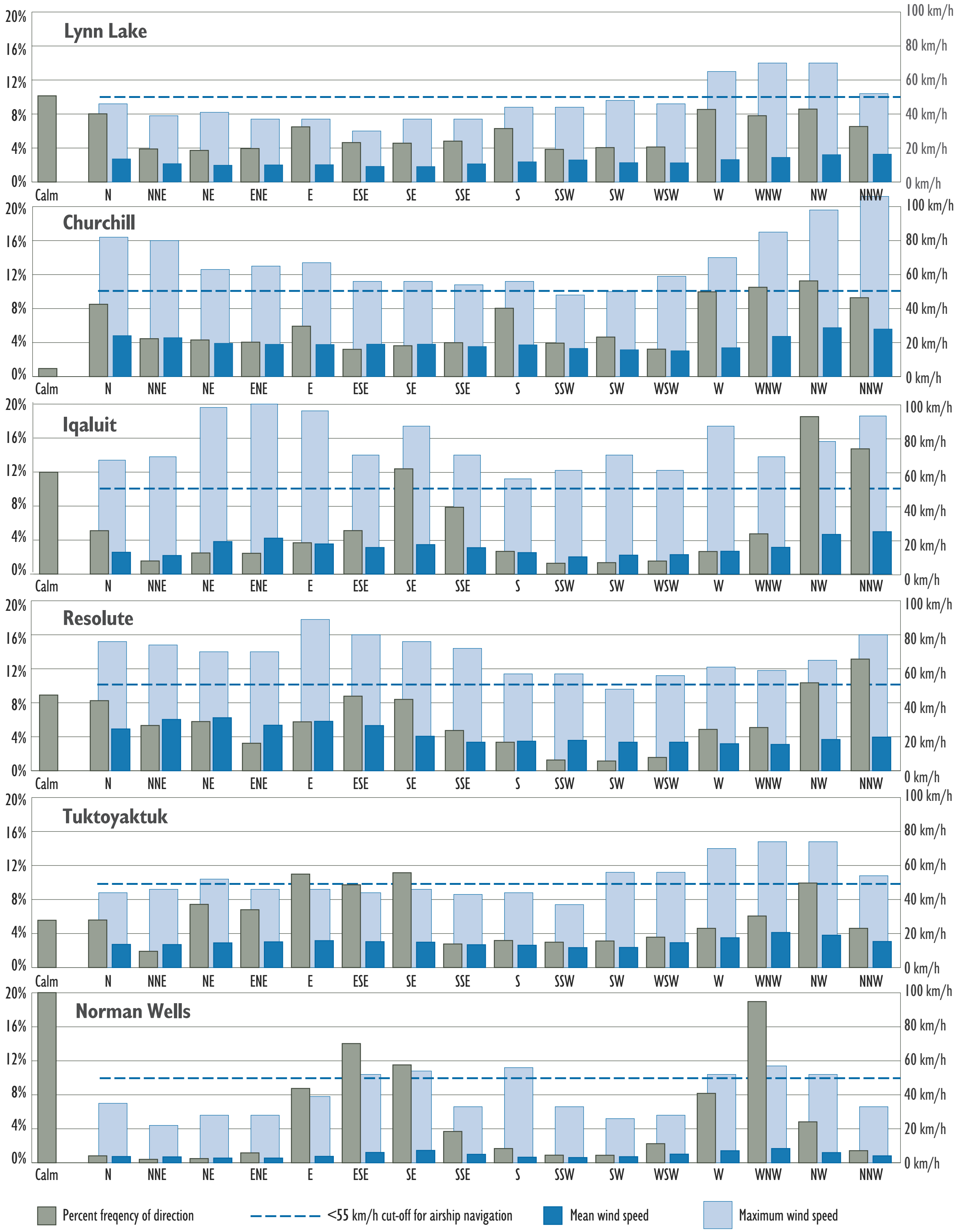

Figure 4

The percent frequency of wind direction and mean wind speeds from six Canadian Arctic communities between 1994 and 2004. Total number of days for which data was obtained is given in Figure 5.

economical year-round access to more remote areas and enable more accurate assessments. If subsistence travel and conservation hunting could be combined with resource management and ecotourism, airships could make vast areas of the North much more accessible, causing little environmental perturbation.

WEATHER PATTERNS

The North is viewed as an inhospitable environment and the harsh conditions are often suggested as a major barrier to the use of airships. To address some of these concerns hourly weather data (January 1, 1994 to December 31, 2004) from six northern Canadian sites (Lynn Lake and Churchill, Manitoba; Iqaluit and Resolute, Nunavut; Tuktoyaktuk and Norman Wells, Northwest Territories) were analyzed. Raw data was provided by Environment Canada's Meteorological services. The variables analyzed consisted of every possible combination of the following: drizzle, freezing drizzle, fog, freezing fog, ice crystals, ice fog, ice pellets, snow, blowing snow, snow grains, snow pellets, snow showers, and smoke.

The amount of days unsuitable for flight was the cumulative number of days between 1994 and 2004 with visibility under two kilometres and winds over 55 kilometres per hour; and the number of days when weather conditions included freezing fog, freezing rain or freezing drizzle. Prevailing wind directions and speeds for the same period were calculated for all locations (Figure 4). Of the entire suite of weather variables graphed for the category "unfavourable weather condition" (Figure 5) freezing fog, rain and drizzle accounted for most of the percentage.

The percent frequency of wind direction and mean wind speed for Lynn Lake, Churchill, Iqaluit, Resolute, Tuktoyaktuk and Norman Wells for the period 1994–2004 are given in Figure 4. Most airships can operate in winds up to 55km/h and from Figure 4 (see dotted lines) wind above 55km/h is relatively rare, except for Iqaluit and Resolute. The data clearly show that mean wind speeds are low for the six sites, but there are days when airships cannot fly due to excessive winds (Figure 5). Using the 55km/h cutoff it is evident from Figure 4 that high winds occur from all directions. With the exception of Resolute, with 14% of a total of 3997 days lost to airship operations, the percentage of days lost to poor weather was less than 8% of total days assessed for all weather variables (Figure 5). It appears that airships could operate much of the year in the Canadian Arctic, as weather does not appear to be a limiting factor. However, navigation systems that would allow night flying would be essential to maximize airship use, especially during the winter months.

While this review indicates that airships have a high probability of success in the Canadian North, several hurdles remain to be overcome. These include demonstrating that airships can transport goods and people on a regular basis; cold weather testing and certification; and the need to develop airships with greater lift capacity. The United States defense department has already started this process with two contracts for design of an airship able to carry 500 tonnes 12,000 nautical miles in seven days. Canadian needs are somewhat less but over the longer term airships with the capacity to transport 30 to 100 tonnes will likely be required.

WHAT CAN WE DO TO MAKE AIRSHIPS A REALITY FOR THE CANADIAN NORTH?

A first step is to give Canadians a place to focus their interests in airships. Iso Polar Research Inc., of Winnipeg, a non-profit organization, and the Northern Airship Advocacy Committee of the Nunavut Research Institute in Iqaluit promote the concept and the testing of airships in the Canadian North. Additional help is needed however, and could involve engaging industry, entrepreneurs, northern communities, politicians, governments and researchers in a national initiative. We need to determine how a transportation feasibility study on airships could be funded.

Perhaps some of the royalties generated from oil and gas and mining could be used to help develop a new and innovative transportation system for the North, or at the very least, to test the concept of airship technology in the Arctic. Perhaps some of the Kyoto funds could be used to fund the airship testing in the North and Arctic. After all, airships reduce greenhouse gas emissions, use much less fuel than conventional aircraft, and have a much smaller environmental footprint. Why not use some of the $2.6 billion the people of Canada received from the sale of Petro-Canada shares?[8] We could test the feasibility of airship transportation during the International Polar Year (2007–2008) when Canada is showcasing, to the world, its arctic heritage and its social and scientific initiatives and achievements in the North. What better symbol of sovereignty than airships the size of an ocean liner sailing 300–500m above the arctic surface with a 25m Canadian flag emblazoned on their sides, and at the same time reducing transportation cost, increasing accessibility and minimizing environmental impacts. We do not need to generate new funds to evaluate airships in the North but we do need the national will to take us into the 21st century in order to leave a transportation legacy for northerners after the non-renewable resources are depleted.

Terry Dick is a professor, and Colin Gallagher a technician, in the Department of Zoology, University of Manitoba. Terry

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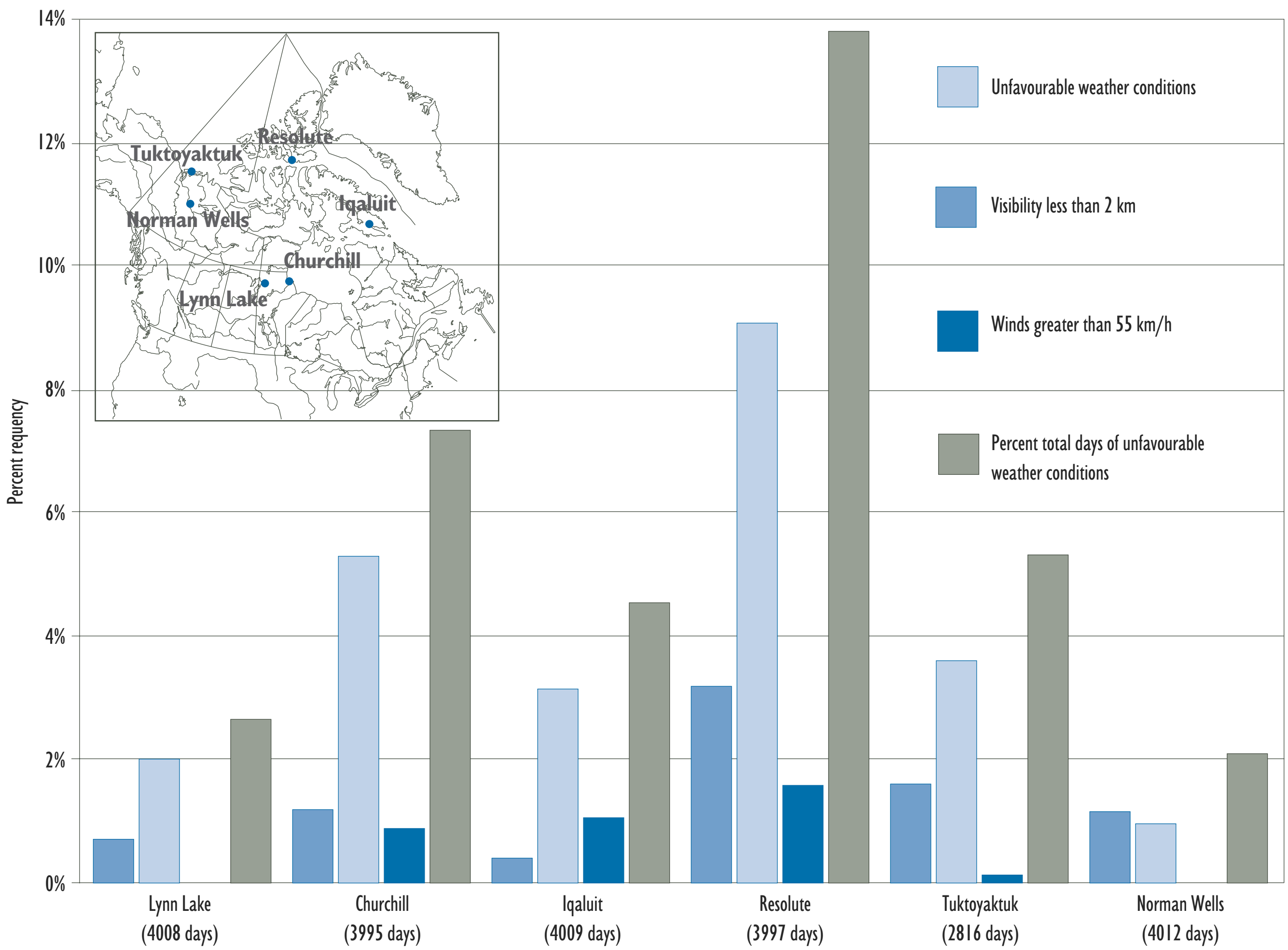
Figure 5
Percent frequency of days when conditions are unfavourable for airship flights.



CANADIAN ARCTIC INSECTS

Richard A. Ring

A convenient place to begin an article on the arctic insects of Canada is with the first Canadian Arctic Expedition of 1913–1918 led by Vilhjalmur Stefansson. This expedition was sponsored by the Canadian Government and thus most of the specimens collected (including insects and related arthropods) remain in Canada. Although there were numerous scientific and exploratory expeditions to the Arctic before this time, most of the biological specimens collected were returned to home countries such as the UK, many other European countries, and the USA. The report of the Canadian Arctic Expedition, published by AMS Press from 1919 on, has several sections that pertain to the insects and other invertebrates.

Further insect collecting expeditions from within Canada were carried out sporadically over the remainder of the first half of the 20th Century (1920–1950), but the halcyon days of Canadian arctic entomology began with the introduction of commercial air travel. Beginning in 1947, the Northern Biting Fly Survey followed by the Northern Insect Survey established the basis for more modern arctic insect studies. During the 1960s and 1970s, a wide variety of studies by groups and individuals was undertaken. What had started essentially as a program for obtaining and publishing information on the taxonomy and distribution of northern insects was by now diversifying into studies of morphology, behaviour, ecology at all levels (population, community, and ecosystem interactions), and eco-physiology. This body of work culminated in the publication of an invaluable book, *Arctic Arthropods: A review of systematics and ecology with particular reference to the North American fauna,* by Hugh Danks (1981). Since then, much attention has been focused on research devoted to insect adaptations in the North, although individual survey-type projects have also continued.

Arctic insect diversity follows the general trend in animal (and plant) biodiversity, that is, that animal diversity in terms of the number of species decreases as you move from the equator to the poles. However, Arctic Canada has a much greater diversity of insects when compared to similar latitudes in the Southern hemisphere. Over 6000 species of insects and related arthropods (*e.g.,* spiders and mites) have been collected, identified and named in Canada, and many more await (1) description and naming, and (2) discovery, I suspect.

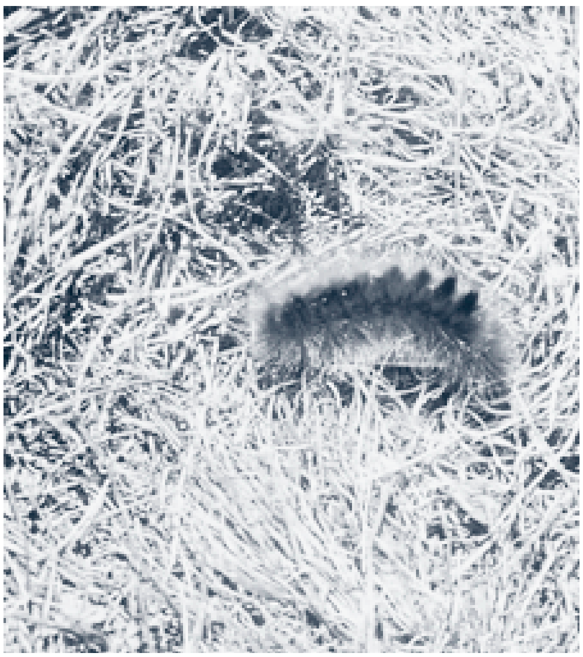
From the compiled lists, there are some interesting observations of an evolutionary nature that can be made. Compared to the same taxa in temperate and tropical regions, well known groups such as the mayflies (Order Ephemeroptera), dragonflies and damselflies (O. Odonata), and grasshoppers, crickets, etc. (O. Orthoptera) peter out towards the coniferous forest treeline, the transition zone between the northern boreal forest and the low arctic tundra. These orders of insects are diverse and abundant in temperate and tropical regions, especially the Orthoptera (think grasshoppers and locusts). Similarly, most social insects, for instance members of the Order Hymenoptera (ants, bees and wasps) are very rarely found above the treeline, with the rare exception of a few species of bumble bees (Family Apidae) which maintain small colonies even up into the High Arctic (*e.g.*, Ellesmere Island). It is difficult to explain, either intuitively or from an evolutionary perspective, why the mighty Order Coleoptera (beetles) – dominant in number of species in both temperate and tropical regions – is so depauperate in the Arctic. After all, beetles comprise over one third of all insect species, and insect species outnumber all other species of microbes, plants and animals combined! I will leave that problem to a more competent authority to explain.

In contrast, the Order Diptera (flies) rules supreme in the Arctic. Flies belong to one of the most diverse orders of living organisms, and have species that can be found in most terrestrial and aquatic ecosystems, including marine habitats. They represent several levels of trophic structure, and have, as members, herbivores, carnivores, detritivores, scavengers, decomposers, blood feeders, pollinators, parasitoids, and both ecto- and endo-parasites! Their dominance amongst the arctic fauna has important consequences for the plants, animals and peoples who live there. As pollinators, they have taken over a major role in the Arctic from the bees, butterflies, birds and others (but not the wind) in temperate and tropical

INTERNATIONAL POLAR YEAR FUNDING

The Honourable Anne McLellan, Deputy Prime Minister, announced on September 21st that the Government of Canada will provide $150 million in new funding over six years to carry out an innovative, interdisciplinary program for International Polar Year 2007–2008 in cooperation with our international partners.

regions. Over 50% of arctic flowers are insect pollinated, so theirs is a substantial contribution to insect pollination in the North. As decomposers and scavengers they are beyond compare, and as herbivores they play a very important role in insect/plant relationships. Indeed, some say (about insects as a whole) that they have about the same impact on plant populations as the large mammalian herbivores *i.e.,* caribou and muskoxen. However, it is the propensity for many families of Diptera to live as larvae in freshwater that makes this order of paramount importance. If you have been to the Arctic, then you know that much of the area is characterized by standing water (lakes, ponds, etc.) and slow-flowing streams and rivers, due largely to the underlying permafrost and other topographical features. Indeed, much of the arctic tundra seems to be composed of water with interspersed islands! This offers ideal habitat for the larvae of many dipteran families and genera. The result is that huge populations of aquatic larvae and pupae live and breed in the tundra, not only in numbers of individuals but also in numbers of species. No wonder that that many species and large flights of birds make this long, hazardous trip to the Arctic every year to take advantage of this natural, dependable food resource. Land mammals are also affected, but mainly in a deleterious way. Since many of these dipterans are biting flies as adults, they have profound effects on the behaviour of land-based mammals such as caribou and, even, the Inuit and other peoples of Arctic Canada. Caribou migration and behaviour are greatly influenced by biting flies and, especially, warble flies, those insidious endoparasites of caribou muscle tissue. The Inuit and other peoples of the Arctic (including visitors like southern entomologists!), too, are greatly influenced by biting flies, the omnipres-ent mosquitoes, black flies and deer flies ("bulldogs"). DEET is a good option if your skin can tolerate it! We have to be thankful, I suppose, that they do not transmit any arthropod-borne diseases (*e.g.*, arboviruses or other micro-organisms) as they do in most other parts of the world.



Arctic woolly bear caterpillar (*Gynaephora groenlandica*) at Alex Fiord. One of the most cold tolerant insects known. Photo: R. Ring.

Insects, therefore, occupy integral parts of all arctic terrestrial and freshwater habitats. They are found in everything from small ponds to large lakes, from small streams to large rivers, in marshy areas and in bogs. On land, they can be found in the soil, on and in plants (lichens, mosses, herbs, shrubs and trees), and in decomposing plant and animal remains. On live animals, they feed as blood feeders and as internal and external parasites; on other insects they live as parasitoids. In other words, they operate at many trophic (feeding) levels in arctic ecosystems. Finally, one should not forget their role as pollinators for many arctic flowers.

The main emphasis of my research program in arctic entomology has been on the adaptations of northern insects to the extreme environmental conditions of Arctic Canada. Such adaptations involve a suite of characteristics which include morphological, physiological, sensory, developmental and behavioral traits that can enhance the survival and reproductive success of the organism under these conditions. Two of the most obvious factors affecting the distribution and abundance of insects as poikilotherms in the North are the long, extremely cold winters and the short summers (growing seasons). Insects have adapted to these natural constraints in a number of ways: in their body structure (increased hairiness and melanism to conserve heat and protect against injurious UV radiation); in their metabolism (active at lower temperatures than their southern counterparts); and in their behaviour and life-cycle stratagems. The suite of adaptations that has occupied my interest for many years, however, is how insects have adapted to survive extremely low winter temperatures and the desiccating effects that accompany such exposure *i.e.*, the eco-physiology of insect cold hardiness. The Canadian Arctic is a "natural laboratory" for this type of study. Most arctic insects prepare for the onset of winter by selecting suitable overwintering sites (hibernacula) where winter conditions are likely to be less severe; for example, in the litter layer, under snow (the sub-niveal layer), in plant material, in crevices, or in small mammal burrows. Those living in water tend to be restricted to the non-frozen area or burrow into the substrate. Many species tend to choose locations that melt or heat up first in spring (south-facing aspects), thus allowing them a "head start" in development for the short growing season. Others, surprisingly, overwinter on rocks or in/on plant tissues that are above the snowline and exposed to ambient air temperatures!

Evidence from my laboratory, as well as many others, shows that arctic insects survive winter using one of two strategies: (1) "Freezing tolerance", in which the overwintering stages can survive a certain degree of freezing of tissue water, and (2) "Freezing intolerance", where insects avoid freezing and overwinter in the non-frozen but supercooled state. Their tissue fluids remain in the liquid phase throughout winter. Some species of arctic insects can survive in this way (supercooled) down to −55°C to −60°C! Both groups undergo a variety of physiological and biochemical changes in preparation to withstand such low temperatures, but one of the main features of these species is their ability to synthesize chemicals (cryoprotectants) such as the sugars glucose and trehalose, the sugar alcohols glycerol, sorbitol, mannitol, etc. and other compounds prior to the onset of deleterious winter conditions. Some of the other contributions to arctic entomology from my laboratory (myself, graduate students and research assistants), have been: (1) identification of a multi-cryoprotectant system in some arctic species whereby a "cocktail" of glucose, trehalose, glycerol, sorbitol and proteinaceous molecules are synthesized prior to overwintering, (2) the discovery of the lowest supercooling point ever for an insect, −61°C for the beetle *Pytho americanus* from the Western Arctic of Canada, and (3) identification of various anomalies in arctic and alpine insects where freezing tolerance can co-exist with very low supercooling points. There are several other anomalies that await elucidation among arctic insects, such as the winter survival of coccinellid beetles (ladybugs) in the absence of any known cryoprotectant substances.

Insect Cold Tolerance Strategies

Freezing Tolerant: Survive ice formation within the body, but usually only in the extracellular body fluids.

Freezing Susceptible: Avoid freezing by supercooling to varying degrees.

Protective Systems

Polyols: Glycerol, sorbitol, mannitol, dulcitol, threitol, erythritol, ribitol, arabitol, myo-inositol and ethylene glycol.
Sugars: Trehalose, sucrose, glucose, fructose and galactose.
Anti-Freeze: Proteins (thermal hysteresis proteins). Produce a lowering of the freezing point but NOT the melting point.
Nucleating Agents: Induce ice formation at relatively high sub-zero temperatures.

Several graduate student theses have been inspired by arctic insects. Lee Humble made an important attempt to tease apart the co-evolutionary problems of cold versus desiccation tolerance and/or resistance. In arctic willow sawflies of the low Western Arctic, he demonstrated that their abilities to survive low winter temperature and desiccation stress were co-adapted, that is they are overlapping adaptations. He also studied the overwintering behaviour and adaptations of the parasitoids of these willow sawflies. Neville Winchester studied the diversity and overwintering biology of the larvae (caddis larvae or case-building larvae) of the Order Trichoptera in the streams of the Tuktoyaktuk Peninsula. Dean Morewood studied the life history strategies and the temperature/development relationships of that most cold-hardy of all insects, the caterpillars of the arctic woolly bears (*Gynaephora* spp.: Lymantriidae). The location of this study was at that most magnificent High Arctic biological oasis, Alexandra Fiord, Ellesmere Island, Nunavut. During that period, another graduate student, Adrian DeBruyn, studied the overwintering behaviour and habitats of two species of diving beetles (*Hydroporus* spp.: Dytiscidae) that occupy the temporary pools at Alexandra Fiord. It was during that time that I became fascinated in and wished to collaborate with the plant ecologists who had established a Canadian site for the International Tundra Experiment (ITEX).

Woolly bear cocoon. Caterpillars spend most of the summer and all winter in these exposed cocoons. Photo: R. Ring.

ITEX (Canada) was established at Alexandra Fiord in 1990 by Dr. Greg Henry, a plant ecologist in the Geography Department at U.B.C. This was Canada's first response to an international meeting of tundra ecologists who were concerned about predictions that human-enhanced greenhouse warming on a global scale would occur earliest and to the greatest degree at the highest latitudes. This large scale field experiment in the Arctic was planned to be a long-term collaborative research program by scientists from nine countries working at 26 research sites to examine the effects of enhanced summer warming on tundra vegetation. Investigators agreed to use a common experimental design and a similar set of target species, and to monitor a common suite of parameters in each ecosystem.

Grids of small, translucent, fiberglass, open-top chambers (OTCs), covering almost 1m square of tundra surface area, were erected in each of the chosen localities. They have proved effective in raising the ambient air temperature within the OTCs by an average of 1°C to 3°C, close to what the Global Climate Change models were predicting at the time. This seemed to me to be an ideal opportunity to include an insect component in the ITEX protocols. After all, insects and plants have very close ecological relationships! The effects of OTCs on insects, therefore, have been studied for the last several years within the ITEX context at Alexandra Fiord. Insect, spider and mite specimens have been collected from six ecologically distinct plant communities, with the following three main emphases (1) comparison of the insect/arthropod fauna within and without (*i.e.*, controls) the OTCs using the standard yellow pitfall traps, (2) since OTCs have physical effects, such as excluding some flying insects many of which are known pollinators of arctic flowers, a comparison of the frequency of likely pollinators both within and without the OTCs was undertaken, and (3) an analysis of the direct effects of the OTCs on insect/arthropod development and phenology (mainly within the soil micro-arthropod fauna) was carried out.

Although a considerable amount of data have been collected to date, my compulsory retirement has been a major obstacle in the analyses of the data and publication of the results (I don't have a laboratory any longer). However, I continue to make this a major goal of my "retirement plans"! Other reasons to regret my forced retirement are the new attitudes that have recently emerged towards Northern research, and, in addition, the recognition that a continued research presence in the North is important for purposes of Canadian sovereignty. Furthermore, within the field of insect cryobiology new research is now being focused on exciting topics such as Rapid Cold Hardening (RCH). This can occur in insects within minutes or hours, and can occur within ecologically relevant cooling rates and thermoperiods, thus allowing the insects to continuously monitor and "fine tune" their physiological reponses and behaviour. The ability for RCH has been closely linked to the expression of stress proteins released within the insect during cold, heat and dehydration exposures; some of the *gene loci* that control the expression of these stress proteins have also recently been identified. This is likely to be a universal characteristic, moving such studies from the somewhat parochial field of entomology into the mainstream of biological experimentation. Similarly, the ability of some insects to denature their mitochondria in preparation for overwintering and then re-synthesize them in spring has recently been confirmed in species. This phenomenon was first described in the arctic woolly bear caterpillar by Dr. Olga Kukal and co-workers, and it may also be of widespread application among a variety of animals that overwinter in extreme environments. So, exciting things are happening in the field of insect cryobiology, but what vexes me most is the fact that I am the only entomologist in Canada working in this exciting, and nationally important, area of research. And there is no one ready to step into the breach!

There are many present and impending issues in the Arctic that will face the Canadian Government, northern peoples and scientists in the years that lie ahead. Global warming, with its effects on the landscape, indigenous peoples, plants and animals (which I have already alluded to) will be of paramount importance – but not the only one. The thinning of the ozone layer and increased UV radiation; the unpredictable effects of precipitation and cloud cover (or lack thereof), which will have immense effects on local temperatures at ground level, tundra lakes, rivers and streams, and the plants and animals that live in or on them; and the melting of glaciers, permafrost and sea ice, likewise. It is predicted that the melting of sea ice will be so advanced by the middle of this century (2050) that open sea will occur among the Canadian Arctic Archipelago, leading to marine routes from the North Atlantic to the North Pacific. This conjures up that nebulous but long-standing debate – Canadian sovereignty in the Arctic. There is no dispute about sovereignty over the Canadian arctic islands (not withstanding current issues with Denmark over Hans Island!), but the waterways between and among some of these islands in particular are another matter. The USA and Russia, for instance, are adamant that these are international waters. So further negotiations lie ahead. Let me make a proposal. Provide every scientific and exploratory expedition heading North with a Canadian flag and flagpole. Let the scientists fly the FLAG!

Dr Richard A. Ring is Professor Emeritus, Department of Biology, University of Victoria.

THE CHANGING TUNDRA – PALAEOECOLOGY IN THE HIGH ARCTIC

Christopher Ellis

Arctic terrestrial ecosystems have been an important theme in the development of global change biology. Given the expectation of pronounced climate warming in arctic regions, ecological studies during the last two decades have sought to understand the effect of human-induced change on the structure and function of tundra habitats. Perhaps the most well-known of these recent studies is the International Tundra Experiment (ITEX), which comprised the collaboration of ecologists from 12 countries working at 27 high-latitude circumpolar stations (www.itex-science.net). The ITEX approach sought to simulate climate change across these sites, and thereby understand the ecosystem response amongst contrasting vegetation-types. The simulation-experiment adopted by ITEX is a method used widely by research groups. Experiments have manipulated local factors that will change with climate, *i.e.,* temperature, soil moisture and levels of limiting nutrient, to demonstrate the direct effect of these interacting variables on the tundra vegetation (for a recent review see Wookey and Robinson, 1997).

Critically, recent experiments in tundra ecology are limited to relatively short time-scales, normally less than ten years. An experiment would be considered lengthy if it had continued for twenty years, though the vegetation-soil complex may respond over centuries. Consequently, attention has turned to the "scaling-up" of these short-term experiments, to understand how predicted climate change may affect tundra ecosystems over several decades or even centuries. An important part of this scaling-up process should utilise the palaeoecological record as a source of information about the long-term dynamics of an ecosystem. Palaeoecology has played a central role in confirming or refuting short-term observations over longer time-periods in lower-latitude ecosystems (*e.g.*, mires and forests in Temperate zones). Such research could be similarly used at high-latitudes, to establish whether the climatic sensitivity described by short-term studies may also control the development of tundra habitats over the long-term (*i.e.*, 100s–1000s of years). At present very little palaeoecological data is relevant to terrestrial tundra habitats, with the High Arctic particularly lacking. The sensitivity of tundra vegetation to climate warming, demonstrated by short-term experiments, therefore lacks essential long-term context. This article reports on one of only very few studies to examine the palaeoecology of a High Arctic terrestrial ecosystem.

BYLOT ISLAND AND THE WETLAND STUDY SITE

The study was carried out on Bylot Island (*ca.* 73°N, 80°W), which lies to the northeast of Baffin Island, within the Sirmilik

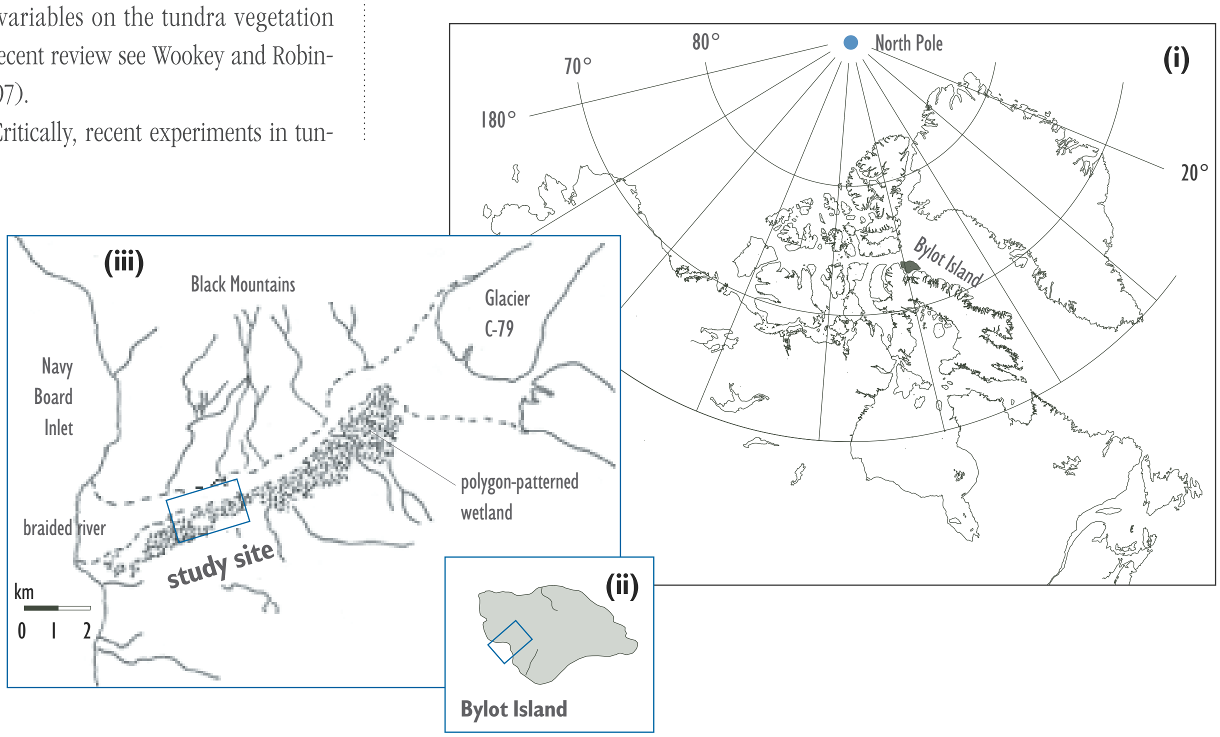


Figure 1
The position (i) of Bylot Island in the Canadian Arctic Archipelago, (ii) the Qunguliqtut Valley in western Bylot Island and (iii) the study site in the polygon-patterned wetland to the south of Qunguliqtut Valley.

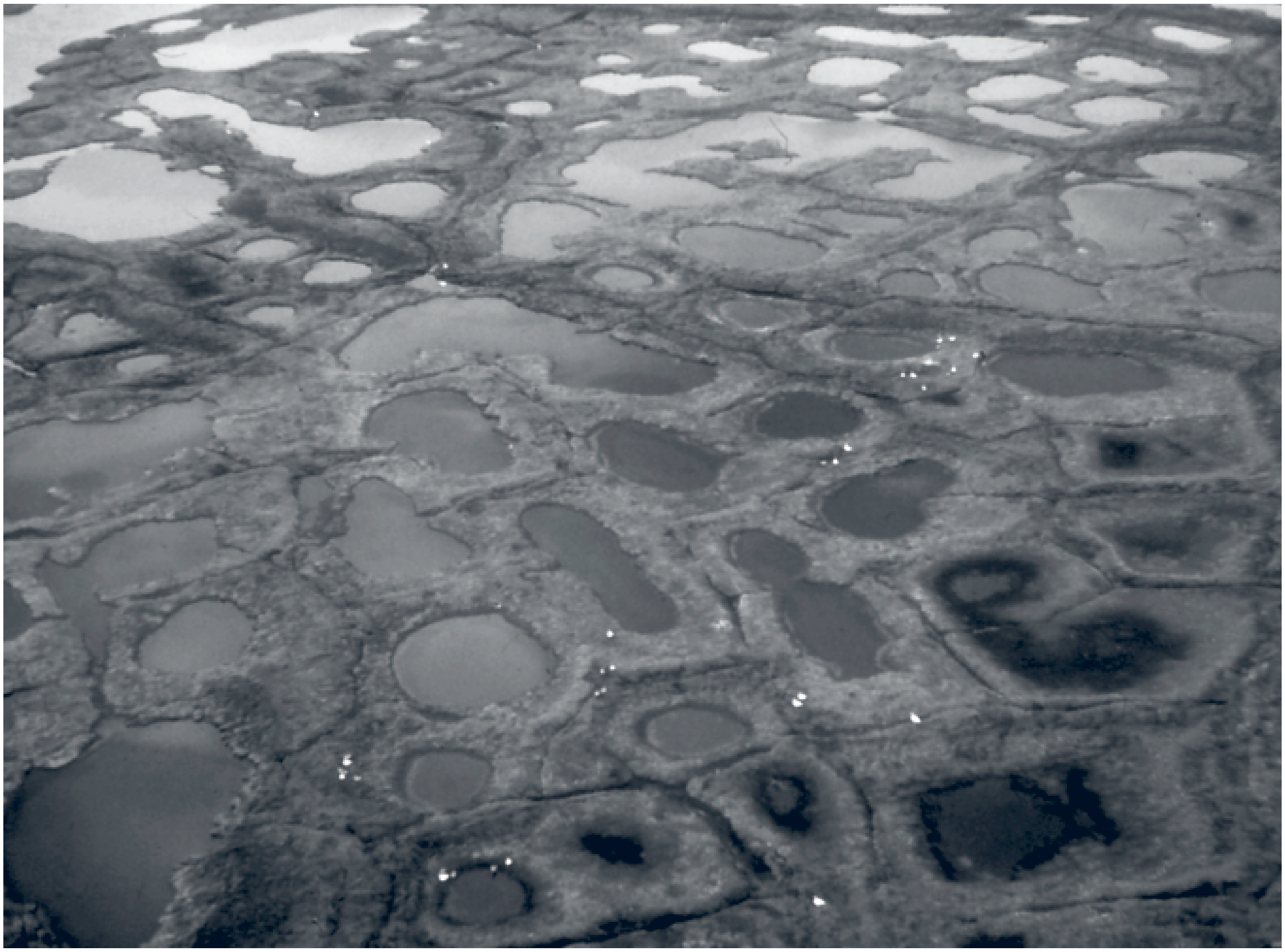


Figure 2
A low-centre-polygon complex inundated with spring melt-water. Notice that some low-centre polygons are wetter (mid-photograph) compared to others (drier polygons to the lower right). Difference in the wetness of adjacent low-centre polygons is a feature of the polygon complex.

National Park (Figure 1). Bylot Island comprises *ca.* 11,000 km^2, of which the majority is mountainous terrain (up to *ca.* 1600m), covered by a central ice cap and with radiating glaciers. The margin of the island includes a series of plateaux with sparsely vegetated polar desert. As the plateaux drop towards the sea the vegetation cover becomes more consistent, and at lower elevations is dominated by heath-tussock tundra. Wetlands develop in areas where spring melt-water accumulates. These wetlands are generally isolated patches on the lower plateaux, though in the glacial valley bottoms they form extensive ecosystems. Fed seasonally by water and nutrients from the surrounding higher ground and adjacent river systems, the lowland wetlands are "minerotrophic" mires, relatively productive and biologically diverse. The vegetation of such mires is dominated on Bylot Island by sedges (*e.g.*, *Carex aquatilis* var. *stans, Eriophorum scheuchzeri*), grasses (*e.g., Arctagrostis latifolium, Dupontia fischeri, Pleuropogon sabinei*) and fen mosses (*e.g., Drepanocladus* spp., *Aulocomnium* spp.), and they form essential summer habitat for migratory water-fowl. Beause of this richness they have been dubbed "polar oases".

Our study examined the long-term development of one such High Arctic wetland in the Qunguliqtut Valley, on western Bylot Island (Figure 1). The study site comprised a system of large terraces to the south of valley, raised above the channel of the adjacent river. The terraces are building through the accretion of aeolian sands and silts and the concurrent deposition of peat (Allard, 1996). A network of ice-wedges is developing during aggradation of the terraces, forming a complex polygon-patterned wetland (Figure 2). The development of these ice-wedges is critical to our methodology and the interpretation of results.

POLYGON-DEVELOPMENT AND PALAEOECOLOGICAL RECONSTRUCTION

The initiation of ice-wedges occurs where ground newly exposed to severe winter temperatures undergoes thermal contraction, cracking into a series of polygonal fissures

(Figure 3a). Melt-water entering the fissures during spring and summer thaw will subsequently refreeze, forming veins of ice (Figure 3b). Perennial cracking of the same ice veins, their inundation by melt-water and subsequent refreezing and fracture cause incremental addition and growth to form wedge shaped bodies of ground-ice. The progressive expansion of ice-wedges displaces surrounding cryosols (frozen soils), causing with the thermal expansion of adjacent ground the development of dry ridges, which thus surround lower and wetter polygon-centres – *i.e.*, low-centre polygons (Figure 3c). In depositional environments 'syngenetic' ice-wedges grow vertically as the permafrost table (*i.e.*, the top of the permafrost layer) rises with the accretion of sediments. Growth of syngenetic wedges is enabled by the long-term aggradation of peat-rich sediment, occurring under limiting conditions of slow, continuous sedimentation and repeated frost-cracking (Figure 3d and 3e). Thus, low-centre polygons at the Qunguliqtut study site will have developed upwards via syngentic ice-wedge growth as the sediments forming the terraces accumulated.

Our study examined the long-term development of five separate low-centre polygons. We extracted peat cores from the frozen centres of polygons using a machine driven corer (Figures 3e and 4). The collected sediment was examined to ensure that it was horizontally bedded and not disturbed by cryoturbation (mixing). Cores from the polygon surface to the mineral base of the sediment were between two and three metres deep. They comprised a mixture of undecomposed plant remains and aeolian silts, deposited over time as the polygons developed upwards. It was thought possible to reconstruct vegetation change during polygon development, by analysing undecomposed plant remains (mostly mosses), preserved in layer upon layer of the cored sediments (*cf.,* Figure 3e). The cores were

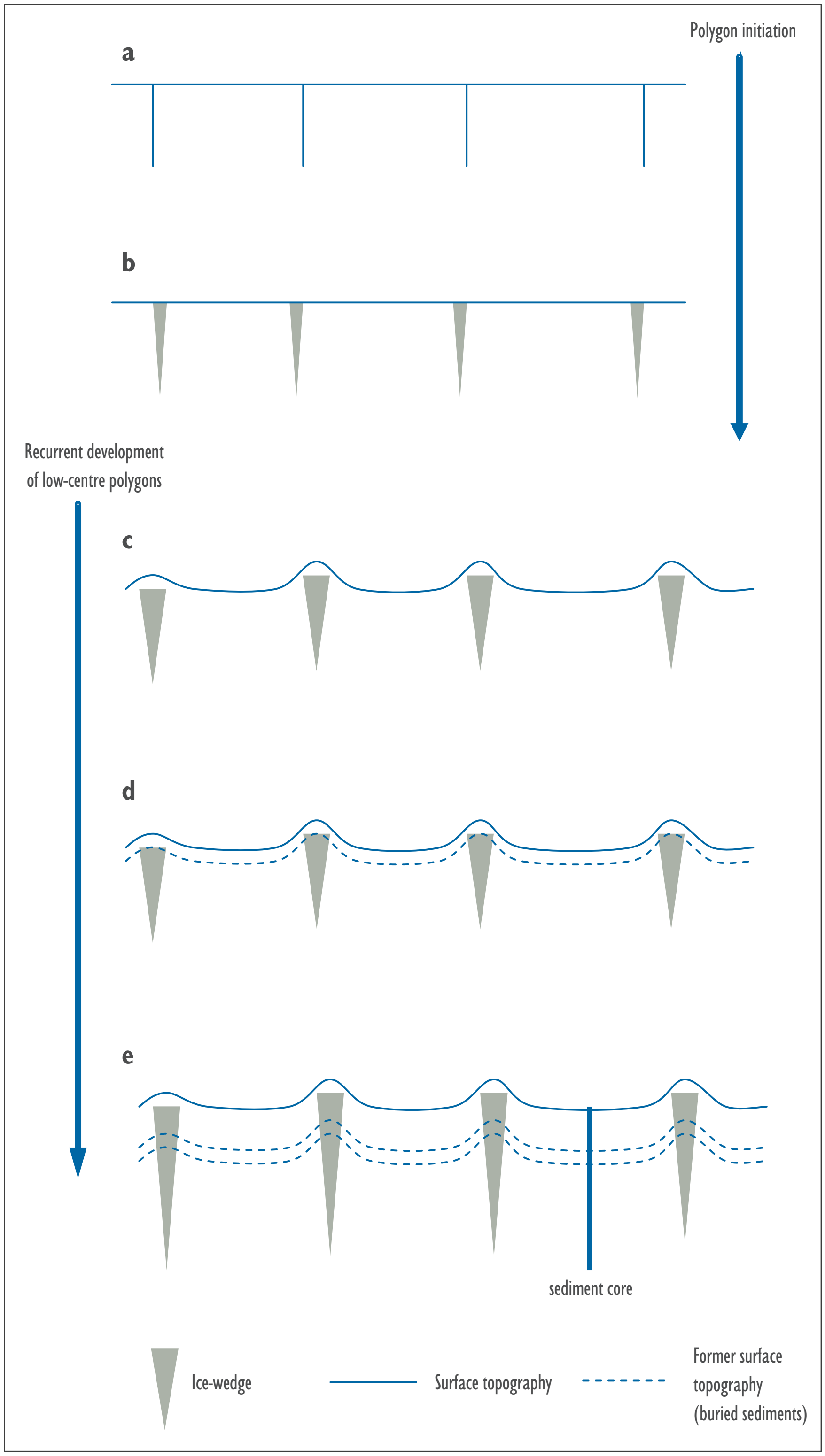


Figure 3
Scheme to summarise the initiation and recurrent development of low-centre polygons (see text, Polygon-development and palaeoecological reconstruction, for a process description).

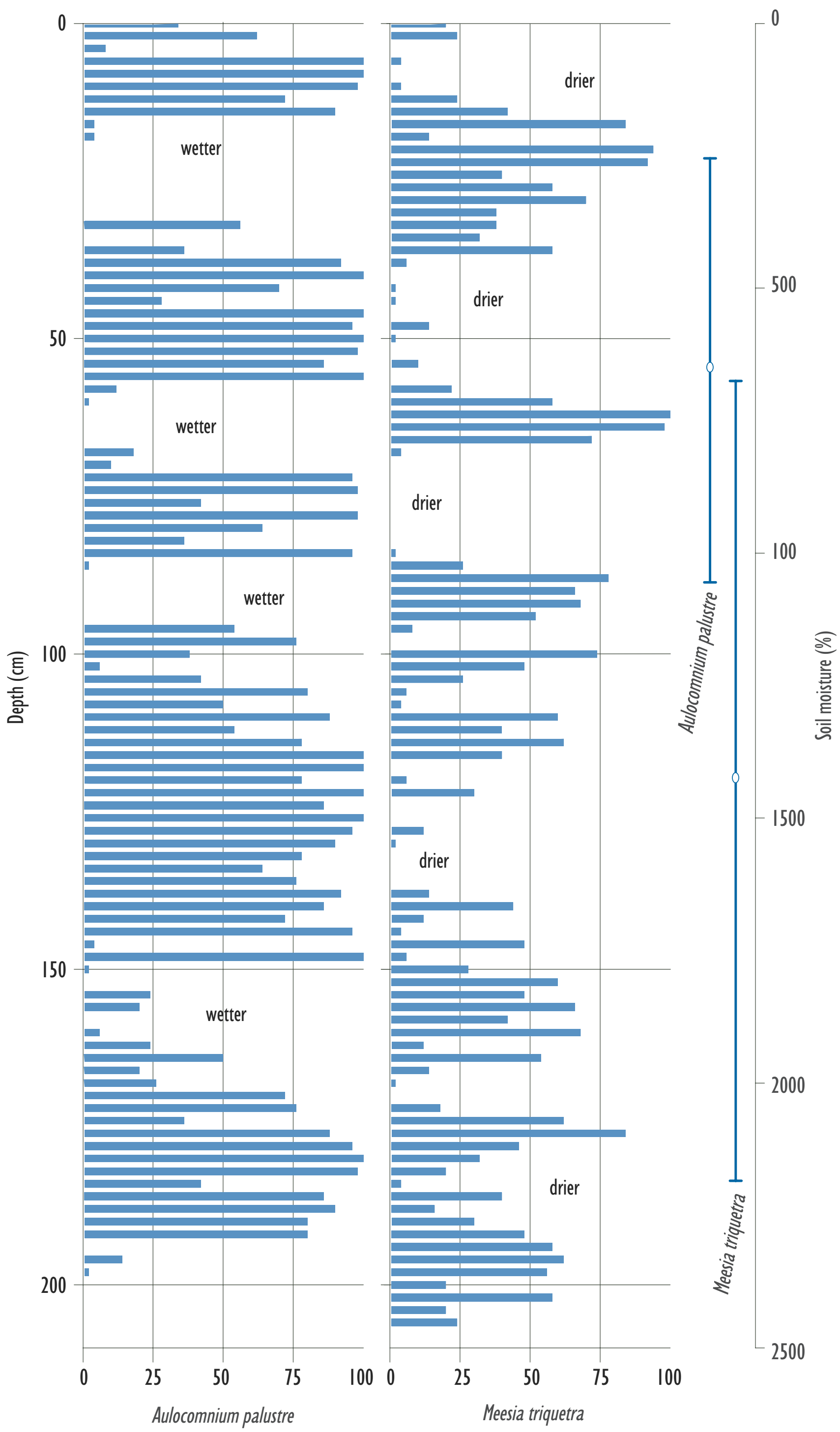


Figure 4

Summary palaeoecological record for two contrasting moss species: *Aulocomnium palustre* and *Meesia triquetra*. Ecological analysis demonstrated a clear difference in the soil moisture optima and tolerance range of each species. This information can be used to infer past changes in soil moisture during polygon development, *i.e.,* as sediments accumulated.

cut into 2cm slices and moss-remains were extracted and analysed from each slice (horizon). Small samples of moss were collected from different horizons and radiocarbon-dated, providing a time-frame for polygon development.

VEGETATION CHANGE DURING POLYGON DEVELOPMENT

The record of moss-remains demonstrated a striking variation in past vegetation during polygon development (Figure 4). The palaeoecological record was combined with ecological research to examine environmental factors controlling the distribution of mosses in the present-day polygon-complex. The ecological study demonstrated clear and predictable differences *spatially,* between moss species growing in communities representative of drier conditions (mesic species) and moss species growing in communities representative of wetter conditions (hydric species). However, the palaeoecological record suggested that for a site in the centre of an individual polygon, equivalent ecological differences had occurred *temporally,* during polygon development (Figure 4). Thus, the differences in moss species preserved in the sediments indicated recurrent shifts in polygon hydrology over time, as the polygon developed upwards and sediment accumulated.

CLIMATIC EFFECTS ON POLYGON DEVELOPMENT

We explored the possible effect of climate on polygon development by comparing the radiocarbon-dated vegetation record to independent palaeoclimatic proxies for the Eastern Arctic Archipelago (Bradley, 1990): five-year average values of percent melt in the stratigraphy of the Agassiz-84 ice core, Ellesmere Island (Koerner and Fisher, 1990) and five-year average values of $\delta^{18}O$ for the

Figure 5
Collecting a permafrost sediment core. The corer was custom built by Michel Allard (Université Laval), supervising (left), and is being operated by Daniel Fortier (to left) and Isabelle Duclos (to right). Photo: C. Ellis.

combined stratigraphies of two adjacent cores from the Devon Island ice cap (Paterson *et al.,* 1977). These provide proxies for past summer temperature (percent melt) and regional average annual temperature ($\delta^{18}O$).

We found that during one period only, leading up to and including the Little Ice Age (*ca.* 530–300 year BP), reconstructed vegetation and soil moisture change was pronounced and consistent across all the polygons examined, and correlated closely with ice core records of both percent melt and $\delta^{18}O$ (Ellis and Rochefort, 2004; Ellis and Rochefort, in press). In contrast, over the majority of the developmental period examined vegetation change was either (i) inconsistently related to proxy climate values or (ii) entirely unrelated to proxy climate values (Figure 6).

Figure 6
The strength of climate signals in the polygon palaeoecological records (compared to independent palaeoclimatic proxies; percent melt and $\delta^{18}O$). See Ellis and Rochefort (in press) for a complete analysis.

Strength of the climate signal	*Temporal occurrence across all cores*	*Period*
Shifts to drier or wetter palaeoecological conditions consistent across all polygon cores, associated with significantly higher/lower values of percent melt/$\delta^{18}O$, respectively	6% of the palaeoecological record (*ca.* 225 years)	Little Ice Age
Shifts to drier or wetter palaeoecological conditions not consistent across polygon cores, though associated with significantly higher or lower values of percent melt and $\delta^{18}O$	44% of the palaeoecological record (*ca.* 1710 years)	
No association between any of the polygon cores and the palaeoclimatic records	50% of the palaeoecological record (*ca.* 1950 years)	

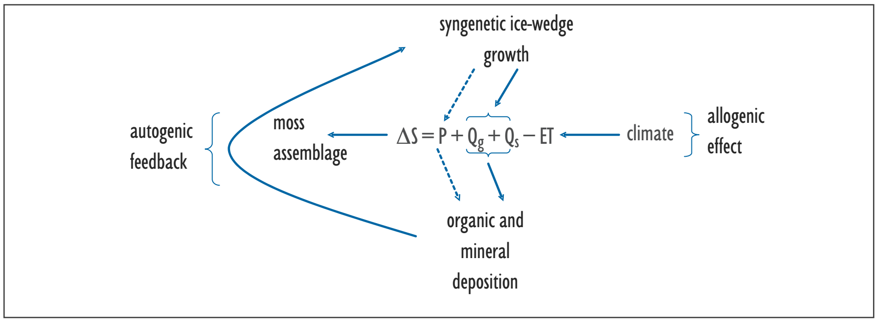


Figure 7
Diagram to show the effect of climate and geomorphology on the soil moisture of a plot within a wetland polygon. The hypothesised autogenic feedback effect between ice-wedge growth and sediment deposition is highlighted.

PERIGLACIAL GEOMORPHOLOGY AND POLYGON DEVELOPMENT

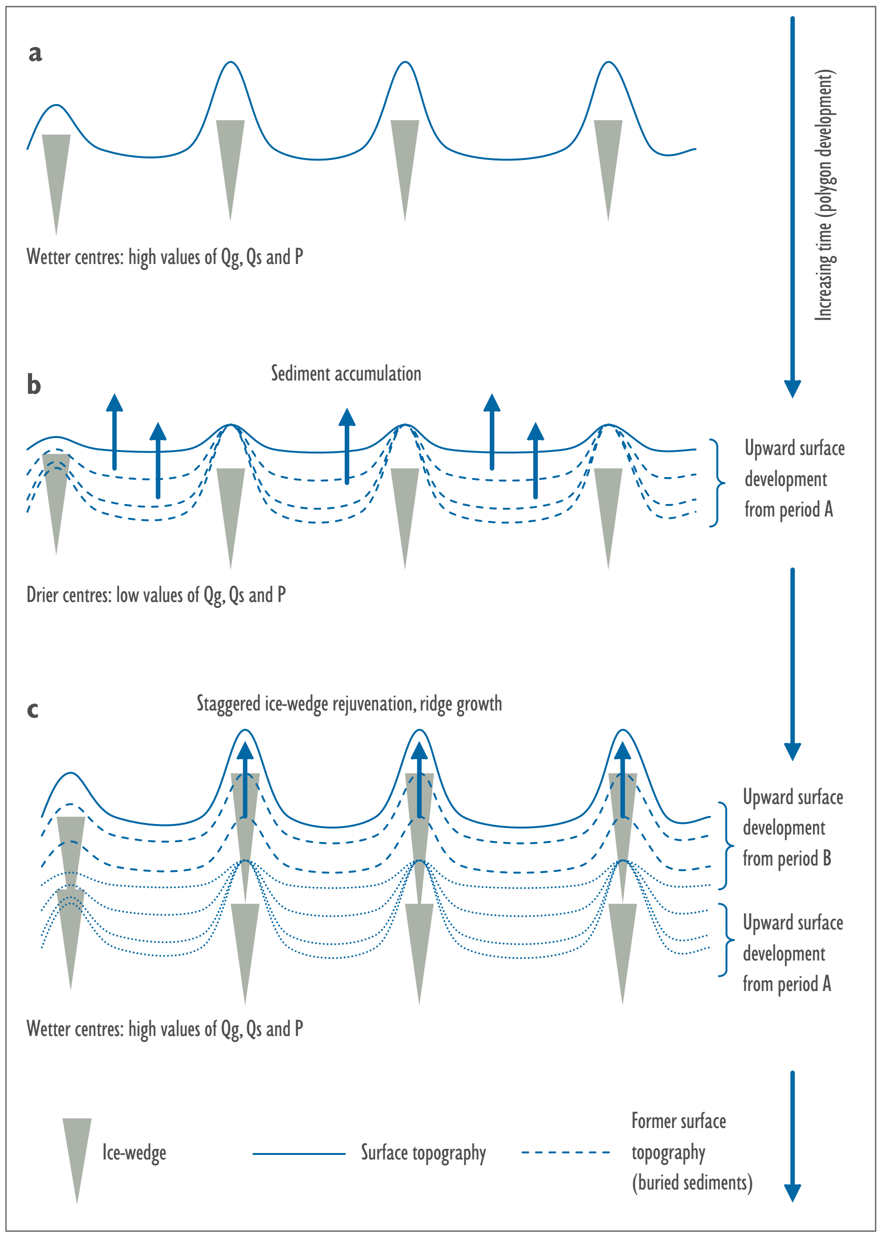
Periodic changes in reconstructed vegetation and soil moisture can be explained in the absence of a climatic influence (*ca*. 50% of the palaeoecological record [Figure 6]) by invoking the known mechanisms of periglacial geomorphology. Accordingly, the water balance (ΔS) of a plot within the centre of a given polygon can be approximated as:

$$\Delta S = P + Qg + Qs - ET \qquad (1)$$

attributable to the dual mechanisms of climatic control and/or geomorphology (Figure 7). Climatic effects include precipitation (P) and evapotranspiration (ET). Geomorphology (*i.e.*, polygon topography) will control groundwater and surface-water input & output (Qg and Qs) and modify inputs from precipitation (P) as deeper low-centre polygons will accumulate more snow in winter and shallower polygons will be blown clear (Rovansek *et al.*, 1996; Young *et al.*, 1997). However, climatic control may also be indirect, through the effect on topography of ice-wedge growth (Kasper and Allard, 2001) which will in turn affect soil moisture (P, Qg and Qs) (Rovansek *et al.*, 1996; Young *et al.*, 1997).

Alternating wetter and drier conditions during polygon development can be explained if the topography of a polygon changes during its development, comprising periods during which it is deeper (higher ridges and lower centre) and, therefore wetter, intercalated by periods during which it is shallower (lower ridges and higher centre) and drier. These changes can be explained by a feedback between sediment accumulation, controlled by the input of organic and mineral material, and the upward growth of ice-wedges, which is limited by the rate of sediment accumulation (Figures 7 and 8). If wetter conditions correspond to periods when the amplitude

Figure 8
Scheme to demonstrate how a feedback between ice-wedge growth and sedimentation may explain periodic changes in polygon soil moisture, independently of a climatic influence.



between a polygon's ridges and centre is relatively large (higher values for *Qg, Qs* and *P*) the upward growth of the syngenetic ice-wedges, and the continued development of ridges, will be limited during these wet periods by their height above the surrounding sediments (Figure 8a). Upward growth of ridges may slow or cease at a threshold height above the surrounding sediments, being rejuvenated only after a period during which sediments sufficient for continued ice-wedge growth have accumulated in the polygon centre. This intervening period of sediment accumulation will lower the amplitude between polygon ridges and centre, and, therefore, values of *Qg, Qs* and *P*, causing a shift to drier soil moisture conditions evident in the palaeoecological record as a dry moss community (Figure 8b). A process of staggered ice-wedge formation resulting in a chevron pattern of ice-wedge growth (demonstrated by field studies) might therefore explain recurrent shifts between wetter and drier conditions during the long-term development of low-centre polygons (Ellis and Rochefort, 2004).

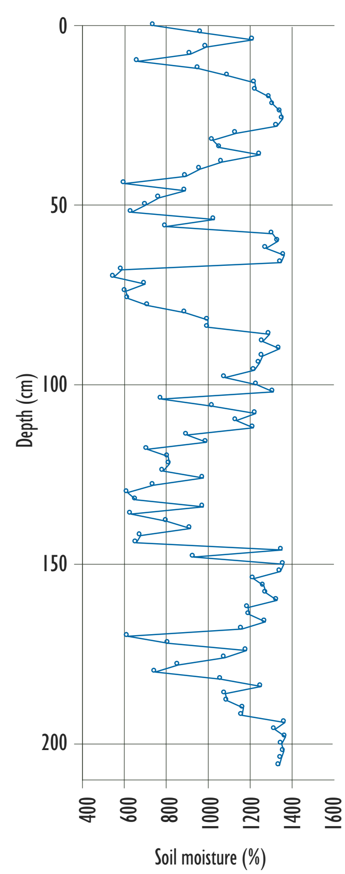
CLIMATIC RESPONSE MODIFIED BY LOCAL GEOMORPHOLOGY

Shifts to drier or wetter palaeoecological conditions are inconsistent between polygon cores over ca 44% of the palaeoecological record (Figure 4). During these periods wetter or drier conditions may be associated with contrasting higher or lower values of percent melt and $\delta^{18}O$ in adjacent polygons. Where a correspondence between palaeoecological and proxy-climatic records is contrasting across several cores it must be considered equivocal. Nevertheless, such a response may represent the modification of a regional climatic effect by local geomorphologic conditions. It is important to remember that past changes in soil moisture (dry-wet) explaining the periodic changes in moss communities (mesic-hydric) can be considered specific to individual polygons, *i.e.,* the ridges surrounding lower-centres are underlain by ice-wedges and act as a water-shed and barrier between adjacent polygons. Hence, if one polygon was in a dry state (*e.g.*, polygon b [Figure 8b] with lower ridges relative to and surrounding the polygon centre and low values of *Qg, Qs* and *P*) and one in a wet state (*e.g.*, polygon a [Figure 8a] with higher ridges relative to and surrounding the polygon centre and higher values of *Qg, Qs* and *P*) a shift to a wetter and cooler climate may be registered in polygon b though not in Polygon a, and *vice versa*. Thus, wetter and drier conditions in the palaeoecological record of soil moisture, which correspond between polygon cores to contrasting higher and lower palaeoclimatic proxy values, may point to an underlying long-term climatic influence, though modified where registered in individual cores by local geomorphologic conditions.

CONSEQUENCES OF PAST VEGETATION-HYDROLOGIC CHANGE

Several possible mechanisms have been presented to explain the observed changes in soil moisture during polygon development. Confirmation or refutation of these mechanisms, to establish their relative importance, is dependent on further palaeoecological study. However, regardless of the exact mechanism, there is little doubt that soil moisture conditions have changed dramatically during the development of the polygons, over decadal- to centennial-scales (Figure 9). These changes are important because soil moisture exerts a control on tundra ecophysiology through production, decomposition and nutrient cycling, regulating therefore the balance of CO_2 input and output. Experiments designed to explain the net effect of climate warming on soil moisture and the C-balance of tundra plots (Johnson *et al.*, 1996) support observational data demonstrating that a shift of soils from net C-input to C-output accompanies the recent drying of tundra habitats (Oechel *et al.,* 1993 and 1995; Weller *et al.*, 1995). A lowered water-table and increased thaw might be expected to accelerate the rate of soil decomposition (CO_2 source) over photosynthesis (CO_2 sink), so that the balance in tundra soils shifts from one of C-input or storage, to C-output, with a subsequent positive feedback effect on CO_2-induced global warming. The magnitude of change in reconstructed soil moisture during the development of the polygons is sufficient to infer variation in the functional role (CO_2 flux) of the wetland during its long-term development (Figure 9).

Figure 9
Soil moisture change during the development of a wetland polygon. The reconstruction is based on a weighted average regression of the moisture optima for 14 moss species (core BY-A, cf. Ellis and Rochefort 2004, in press).



CONCLUSIONS

Two major points are warranted by the results of our study:

1. Models to predict long-term change in the ecosystem function of terrestrial tundra habitats (including the effects of future global warming) may need to account for inherent variability during ecosystem development. Peat-rich soils associated with arctic wetlands have contributed a net sink for carbon during the Holocene and are estimated to store >97% of the tundra carbon reserve comprising *ca.* 180–190 × 10^{15}g of soil-C (Post *et al.*, 1982; Oechel and Vourtilis, 1994). Greater understanding of natural variability within and amongst arctic wetlands is essential to policy management of global carbon pools.
2. The mechanisms controlling soil moisture variation during polygon development, suggested by this study, should be confirmed or refuted. Our results suggest that short-term experiments may have neglected the important role of periglacial geomorphology in modifying the regional effect of climate at local scales. This is unusual, because vegetation patterns strongly related to geomorphology are an apparent feature of the tundra landscape. However, we also suggest that long-term polygon development may have been periodically impacted upon by pronounced climatic variability (*i.e.*, during the Little Ice Age). The corollary is that, given the expected magnitude of human-induced climate warming, even High Arctic ecosystems will be sensitive to future climate change. Nevertheless, predicting the effect of climate warming on High Arctic wetlands may require a greater understanding of the interaction between the vegetation-soil system and periglacial processes.

Christopher Ellis's main research interest is the structure and dynamics of ecological communities (especially mosses and lichens). Now based at Royal Botanic Garden Edinburgh (UK), Chris maintains close ties with Dr. Line Rochefort and her research group at Université Laval, Quebec.

Acknowledgements

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THE *QAUJIVALLIANIQ INUUSIRIJAUVALAUQTUNIK* SUICIDE FOLLOW-BACK STUDY

Jack Hicks, Laurence Kirmayer and Gustavo Turecki

Rising rates of suicide, particularly by Inuit in their teenage years and early 20s, became a major concern in the Central and Eastern Arctic in the last few decades (see Figures 1 and 2). While historically some adult Inuit would decide to take their lives for various reasons, the seemingly unexplainable deaths of young people by their own hands was a new and devastating phenomenon.

Not surprisingly, suicide in Nunavut and other Inuit communities has attracted considerable attention and generated much speculation about possible mechanisms accounting for the increasing rates. However, surprisingly little is known about suicide risk factors based on empirical data, and unfortunately there is a common misconception that considerable research focusing on Inuit suicide has been carried out with no tangible results on suicide prevalence. This is, however, not the case, and is based on assumptions that have been presented as facts.

In 2003 a Member of Nunavut's Legislative Assembly asked: "How come when a suicide happens in Correctional Centres, there is an inquiry that goes on? How come we do not do that to the other suicides that happen in the homes? Perhaps we should try and find out what the background was of that person who committed suicide."

Precisely to address these and other questions, this fall we began one of the most ambitious mental health research projects ever undertaken in the Arctic. The *Qaujivallianiq inuusirijauvalauqtunik* ("Learning from lives that have been lived") follow-back study will attempt to identify the risk and protective factors specific to the Inuit of Nunavut, as well as other data that can assist efforts to reduce the territory's tragically high suicide rate.

A follow-back study (often referred to as a 'psychological autopsy' study in the medical literature) is a way to learn more about the risk factors and preventive factors for suicide in different populations. Follow-back studies have been conducted in many different parts of the world, but never in northern Canada.

Since we cannot interview suicide victims themselves, we will conduct detailed and structured interviews with the victim's

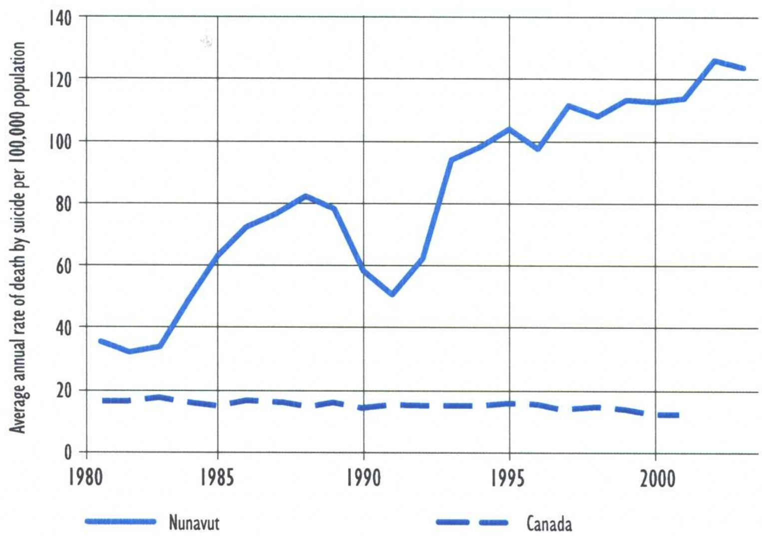
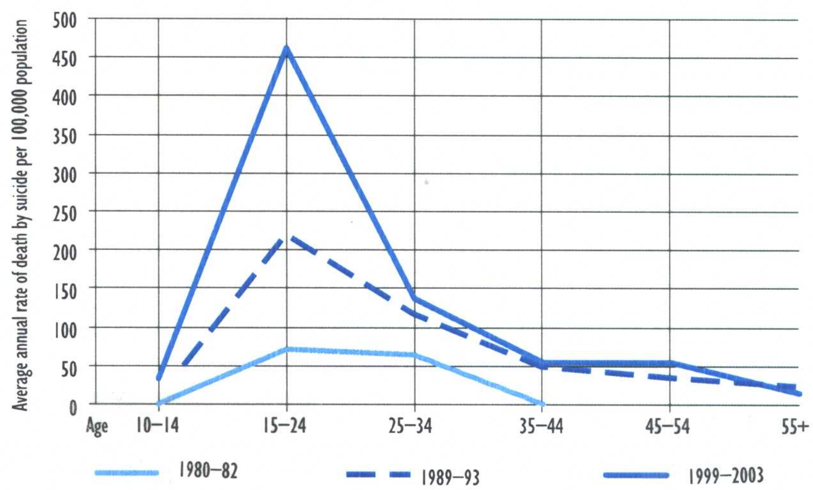


Figure 1
Average annual rate of death by suicide, Nunavut Inuit and Canada, 1981 to 2003. Source: Offices of the Chief Coroners of the Northwest Territories and Nunavut, and Statistics Canada.

Figure 2
Changes in suicide rates by age cohort from 1980 to 2003. Source: Offices of the Chief Coroners of the Northwest Territories and Nunavut, and Statistics Canada.



family and friends to understand the details of his or her life – from birth to death. We will also ask about family and individual life stories in great detail. We will ask about such things as family history, medical history, experiences at school and work, relationship history, alcohol and drug use, traumatic life events, previous suicide attempts, etc. We have tried to include everything that has been mentioned as possibly contributing to suicide in Nunavut.

When we look at the details of many lives that were cut short by suicide, we can begin to notice patterns. This information can help us to design more effective suicide prevention and intervention programs. In Finland, for example, the results of a major follow-back study resulted in the development of a national suicide prevention strategy consisting of a range of targeted initiatives as well as strategies for more effective inter-agency efforts. The significant decrease in death by suicide over the past decade in Finland may well be attributable to this strategy, and to the research on which it was based.

Our research team will interview people who have attempted suicide in the past, but who are still alive – and also their family and friends. This will help us learn more about the factors that make a difference in peoples' lives after they attempt suicide. We will also be conducting the same types of interviews with Nunavummiut who have never attempted suicide, and their family and friends, for comparison purposes.

Participation in the study is completely voluntary. A letter of consent signed by both the interviewer and each individual participant will confirm the participant's informed consent to be interviewed and provide a written guarantee of the confidentiality of the interview results.

The *Isaksimagit Inuusirmi Katujjiqatigiit* (Nunavut's "Embrace Life Council"), the Government of Nunavut, Nunavut Tunngavik Inc., the Royal Canadian Mounted Police, and the Chief Coroner of Nunavut all strongly support this study, which has been approved by an Ethics Review Board and granted a scientific research license by the Nunavut Research Institute (NRI).

The study is being conducted by researchers from Nunavut working with the McGill Group for Suicide Studies (MGSS), one of Canada's leading suicide research bodies. The MGSS recently completed a follow-back study of all suicides in New Brunswick during a one-year period, and the results have resulted in the provincial government strengthening aspects of its mental health services.

Funding for this study has been provided by the Canadian Institutes of Health Research, an arms-length granting agency of the Government of Canada, through a special grant competition focused on Aboriginal suicide.

The study began in 2005, and is expected to take four to five years to complete. Some preliminary results will be available before then.

The progress of the study will be reviewed in a quarterly newsletter, and on the MGSS website. The conclusions of the study will be distributed widely throughout Nunavut, in particular to partner organizations and to all Nunavummiut who agreed to be interviewed.

Jack Hicks is the Nunavut Follow Back Study Project Manager; Laurence Kirmayer, MD, is the Director of the Division of Social and Transcultural Psychiatry at McGill University; Gustavo Turecki, MD, PhD, is the Director of the McGill Group for Suicide Studies.

BOOK REVIEW

Susan Rowley

Do Glaciers Listen? Local Knowledge, Colonial Encounters, and Social Imagination, by Julie Cruikshank. Vancouver: University of British Columbia Press, 2005.

The Glaciers of the Mount St. Elias range are, without doubt, one of the most remarkable natural features of the world. They surge and retreat with exultant, unanticipated rapidity, tearing across the landscape and altering it with abandon and total disregard for humans.

These glaciers are the stage for Julie Cruikshank's new work, which examines the differing perceptions and constructions of the natural world by indigenous peoples, explorers and scientists. It is a philosophical treatise on the nature of knowledge and the ability of one culture to understand another.

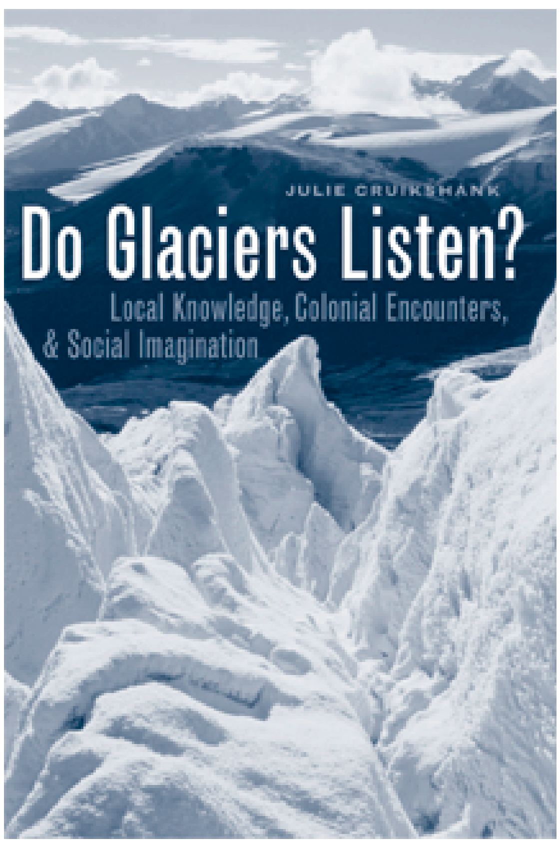
Glaciers are used as a metaphor for the constantly changing history of this region. The glaciers' comings and goings form an important part of the story but they are not as crucial as the comings and goings of people, their interactions and the way that they, through their actions, alter the social and political landscape of the region.

Do Glaciers Listen? is divided into three parts: Matters of Locality; Practices of Exploration; and Scientific Research in Sentient Places. In Matters of Locality the reader is introduced to the time before the industrial revolution when western cultures were more attuned to nature and viewed glaciers as prescient beings meting out justice to social transgressors. Recent events have shown that the need to find meaning behind seemingly inexplicable events has by no means disappeared: consider the view expressed by some that the ravages of Hurricane Katrina on New Orleans were a punishment inflicted by an angered God on a city of sin. It appears that, even in the 21st century, western science does not in fact permeate very deeply into the fabric of our culture.

Practices of Exploration looks at the contact zone between the aboriginal inhabitants of the region and visitors from outside. Cruikshank delves into the differences and her argument is convincing as she examines the colliding worldviews which come so close to mutual understanding at times and yet are driven apart at others. How profoundly is a worldview shaken when outsiders arrive, act in ways contrary to local belief systems, and yet escape unscathed? What realignments are made and what new realities constructed to adjust to these new circumstances?

Scientific Research into Sentient Places is the third and final section of this volume. In the last chapter the author poses the question of how proximate – and yet how distant – the worldviews of today are. She also explores the difficult issues of integrating local knowledge with scientific knowledge that are highlighted by today's rapidly melting glaciers. Finally, Cruikshank warns against the pitfalls of attempting to integrate different kinds of knowledge into a blend that is not satisfying to either.

Do Glaciers Listen? is an amalgamation of previously published pieces and chapters written for this book. Such works almost inevitably suffer from their very nature as stitched together pieces where the warps and wefts may not always align to create a clear picture. This is not the case here. What may at first glance appear an interesting digression turns out to be central to the thesis. One example is the strange tale of "Edward James Glave, the Alsek and the Congo", a story so fascinating you can't help but forgive the author this apparent indulgence. And yet, while the intriguing question of Glave's possible influence on Joseph Conrad's seminal work *Heart of Darkness* is an aside, the central theme of the article – the way external forces inevitably shape and reshape outsiders' perceptions – lies at the very heart of this book.



NEW BOARD MEMBERS AT THE POLAR COMMISSION

The Canadian Polar Commission thanks outgoing Board members Peter Johnson, Michael Robinson, and Richard Binder for their many contributions over the past six years. The Commission also extends a warm welcome to new members Tom Hutchinson (Chair) Ron Macnab, Susan Rowley, and François Trudel (Vice Chair).

Perhaps the crucial word in the title is "Listen". The reader must listen carefully to the words as spoken by others in this beautifully crafted book. Cruikshank, as in her earlier works, allows aboriginal people's words to speak for them, and avoids covering them with her own interpretations. However, this is not the case for the words of outsiders such as explorers, around whom the author carefully constructs a context within which to interpret their words. This is one of the few imbalances in the book.

Do Glaciers Listen? is a fascinating read. Cruikshank's discussion of how encounters shape and create perceptions of the world, and how layers of meaning are forced onto landscapes by peoples is thoroughly thought provoking. This book is highly recommended for scientists, anthropologists, historians, and everyone with an interest in the social construction of landscapes.

Susan Rowley is Curator of Public Archaeology at U.B.C.'s Museum of Anthropology and assistant professor in the Department of Anthropology and Sociology. She is also a member of the Board of Directors of the Canadian Polar Commission.

HORIZON

Arctic Science Summit Week
March 22–29, 2006
Postdam, Germany
www.iasc.no/

Arctic Change and Coastal Communities
August 12–18, 2006
Tuktoyaktuk, Northwest Territories
www.czc06.ca/e/home.html

The 15th International Inuit Studies Conference: Orality in the 21st century. Inuit discourse and practices
October 26–28, 2006
Musée du Quai Branly, Paris, France
Organized by: National Institute for Oriental Languages and Civilizations (INALCO) and National Center for Scientific Research (CNRS)
Michèle Therrien (michele.therrien@inalco.fr)

NEW BOOKS

Arctic Clothing, *by J.C.H. King, Birgit Pauksztat, and Robert Storrie. Natives, anthropologists, and historians look at contemporary and traditional clothing in the north. McGill-Queens University Press (ISBN 0773530088).*

In the Arctic, sea and land animals provide the raw materials for garments that allow people to hunt and survive in the world's harshest conditions. Arctic Clothing, developed from a conference held at the British Museum, showcases the work of native artists and skin sewers in an exploration of the ways in which clothing connects native societies to the environment and the continuing importance of animals, birds, and fish to these communities.

J.C.H. King is responsible for the North American collection, Department of Ethnography, the British Museum Birgit Pauksztat is the Thaw Special Assistant, department of Ethnography, the British Museum. Robert Storrie is a former assistant in the Department of Ethnography, the British Museum.

– McGill-Queens University Press

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