Fifth Theme:
Science and Technology Application in the North

Opportunities and Barriers to Housing Research in the North – Two Sides of the Same Coin*

Aleta Fowler

The Canadian North is generally thought of as the area north of the 60th parallel. The reality is that the Canadian North is a cultural and demographic area which includes the traditional Northern populations such as the Inuit, Innu, Gwich'in, Dene, Dogrib, etc. It is the collective cultures of the North, along with the characteristic geography and climate which have shaped it, and must continue to shape it. In this way, the Canadian North is more a part of a circumpolar community than of any one nation.

A defining feature of this circumpolar community is its remoteness. There are few roads. Air and sea access are weather-dependent. Telecommunications are just beginning to emerge, as are "southern" style economies and lifestyles. Herein lies both the opportunity and the barrier to northern housing technology research.

The opportunities for housing technology research in the Canadian North are quite straight-forward. The North is virtually a clean slate, with the traditional culture still persisting as a starting point. Early "southern" approaches brought to the North (ventilation systems, building envelope designs, building siting, etc.) failed so rapidly that Northern self-determination began to merit consideration and respect.

This absence of development offers a unique opportunity to see issues clearly and to pursue solutions "outside the box", as large investments in infrastructure have yet to be made. Mistakes made in the South do not need to be repeated. Rather, opportunities developed in the South can be re-evaluated for applicability in the North.

The barriers in the Canadian North arise from the same attributes. There is little economic base and there is enormous need. What "southern" influences there are continue to erode the strength and sustenance of the traditional cultures (i.e. "southern" concepts of "home" as a stationary base; concepts of land ownership and control; product marketing through southern television; etc.). Remoteness, harsh weather, and lack of equipment and skilled labour thwart expeditious action.

The key to housing technology research is the ability to develop self-determination within the Northern communities. These communities were largely created as the result of settlement enforced nearly four decades ago. Since that time, the Canadian North has solidified into a network of over 100 communities in Labrador, Nunavik, Nunavut, Northwest Territories and Yukon. "Imposition" of housing and housing technology has not been entirely successful. Each community is unique and each is worthy of making choice regarding unique approach to its needs and opportunities.

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The first opportunity/barrier in the Canadian North is education and capacity. Education and capacity have two sides in the North. "Southern" style education is needed to facilitate interaction with the southern marketplaces and policy makers. But the retention of traditional knowledge is the key to survival and continuity. These two kinds of knowledge must be melded before key decisions can be made. This is the important step being made in this new era of Northern housing technical research. This may be the step which results in the development of uniquely Northern economic opportunities.

The second opportunity/barrier is money. There is little local money, limited opportunity for economic growth, and few outside funding sources to assist communities. A direct result is a paucity of housing, which creates over-crowding, with all its disastrous social ramifications. However, the existence of these problems may provide a (very small) benefit. In the North there is a tremendous drive toward achieving housing solutions without preconceptions about what constitutes appropriate building technology. Thus, indigenous culture can continue to play a formative role in housing design, and each community stands a chance of remaining unique.

Other obstacles in the North are obvious, and include: challenges of cold climate performance; lack of local maintenance; high transportation costs; high utility costs; durability; social acceptance; affordability; environmental impact; lack of local equipment and expertise; short building season; limited access; difficulty of obtaining replacement parts; etc. But given that Northerners have always faced these challenges, these barriers may be relatively insignificant and may be overcome if self-determination is respected and if financial means are made available.

From a purely technical standpoint, providers of Northern housing are likely to target ways in which to make housing more readily available, more durable, more easily maintainable, more responsive to the occupant's lifestyle and more affordable. At a community level, they would likely target infrastructure - the provision of utilities, access to homes, and preservation of the landscape to preserve the built environment. But when it comes to applying these "solutions", however, the opportunities/barriers inherent in Northern culture and geography will demand to be taken into account – and each community will need to choose its approach.

In the past two years, the way CMHC has approached the line which separates pure technical research from community self-determination has been through an objective investigation of possibilities. The first undertaking was a "Client Consultation" where over 130 individuals, businesses and agencies were asked what opportunities and obstacles were uniquely present in the North. CMHC also co-hosted two Circumpolar Housing Fora where over 200 community representatives from the Circumpolar North participated in discussions regarding housing technologies.

From these client consultation activities arose a research agenda. As a direct result, studies in foundation system options, ventilation system options, soil and flora restoration, alternative energy sources, provision of water and sewer, and the costs of infrastructure and construction are underway. For each study, each Northern community's conditions are outlined to determine what the possibilities are and what it takes to introduce new technologies. In this way, each community can assess a technology and its local suitability for cost, performance, durability, and ease of maintenance. Access to up-to-date information about each technology is supported by publications which are available through the Canadian Housing Information Centre, CMHC offices, Northern libraries and on the worldwide web.

A second step was taken this year when CMHC provided funding for a Northern demonstration project. This initiative was not intended to "impose" solutions, but rather to offer a venue by which Northern communities could observe new technologies in order to facilitate the making of informed decisions. This demonstration project is a continuation of CMHC's program in "Healthy Housing". The "Healthy House" is not a defined structure, or even a component list, but rather it is a design program. It challenges communities to determine the best means

to address critical issues such as occupant health, energy efficiency, resource efficiency, environmental responsibility, and affordability and economic viability. Launched nearly a decade ago in the South, Healthy House has spurred dozens of new technologies which can now be re-evaluated for Northern use and observation.

Housing technology researchers in the North have not been overly successful in making production of housing affordable. However, in examining total housing costs, we have determined that it is the affiliated, ongoing costs of utilities and infrastructure provision, rather than the actual construction costs, which are particularly damning. Perhaps by controlling these seemingly peripheral costs, we do stand a chance of making housing more affordable. One recent housing technology success story illustrates an opportunity to not only bring down utility costs, but also to make housing infrastructure more durable, less environmentally threatening and more socially acceptable.

While the South has a water and sewer infrastructure in place with components which need to be amortized over a 50 year life span, the North has primarily trucked services, amortized over 7 years or less. Nearly a decade ago, as part of CMHC's Healthy House challenge, a technology was devised which would cleanse household gray and black water to purification levels equivalent to that allowed by Health Canada for swimming pool use. The technology is termed an "on-site wastewater reclamation microsystem".

This 'microsystem' technology was developed by the private sector, and numerous governmental groups at all levels have participated in bringing this to the North at the behest of the communities involved. The first communities to adopt 'microsystems' are the Yellowknives Dene communities of N'Dilo and Dettah. Provision of water and sewer is the single largest household utility cost in these communities, comprising an average of 43% of the monthly bill (in 1995/96 this was $298.37 per household per month in these communities at the unsubsidised rate). In contrast, electricity is 36% of monthly utility costs.

The five microsystems will service CAPut!' households via utilidette systems. The purchase and installation cost of the microsystems, the structures to house the systems, and the utilidette system is $130,000, or $6,842.11 per household. The reclaimed water is presently used only for laundry and toilet flushing, (approximately 62% of household use according to recent monitoring of a microsystem in N'Dilo). Therefore, less than half of the total household water will need to be purchased from an external source. This reduces monthly water costs to under $150. At this rate, the microsystems will pay for themselves between years 3 and 4, and the water and sewer costs savings are permanent to the household and the community. In Grise Fiord, where monthly costs are $936.81, the payback period would be about 14 months.

This example illustrates how the perceived obstacle of a lack of infrastructure and high cost has resulted in a unique benefit. Because of the compelling need to address affordability in a community setting, and the fact that there is little infrastructure, an affordable solution, with ancillary benefits was readily pursued by the community. As a footnote, the family who has patiently endured the two years of monitoring of their test microsystem love it. Many of us in the North are hoping this technology will eventually alleviate the extreme environmental impact of sewage lagoons which we presently face.

The North is a place which has wide-open opportunity for unique solutions if creative people are willing to put aside any preconceived ideas and begin their work by starting from the culture and the community. Because of this "clean slate" it is even possible that examples developed in the North may lead to technical solutions that are eventually adopted by Southern communities – to the economic benefit of the North.

Towards a Stronger North with New Technologies and New Forms of Virtuality*

Jaana Kuula

Manufacturing industries in the North suffer from distant location, unfavourable logistics and high production costs. This affects the economy of the area, which in turn causes unemployment and depopulation. Recently, the speed of depopulation in rural areas has, in Finland at least, become even greater, and it is especially young and educated people who move away from the area.

With some new technologies, the chances of Northern industries can be improved. In this context, the new media business, digital content production and e-commerce are discussed as real opportunities for the North. They are not only creating a new, rapidly growing field of industry, but also improving the international competitiveness of the basic industries.

The opportunities for the new media business in the North lie in its cultural heritage, traditions, high level of education, fascinating nature, security, good telecommunications infrastructures, and in the logistics of non-material production. In turn, the new chances for basic industries are to be found in improved international marketing through electronic marketing channels, in the high quality of niche products, and in the flexible and on-demand production that is enabled by modern production technologies. The simple application of new technologies does not, however, directly lead to industrial growth, since much needs to be done for international marketing, and for creating strong and internationally networked production units.

The New Media Business and Digital Content Production in the North

International decentralization - an opportunity for the North

As the increasing diffusion of digital-tv's, mobile phones and home computers is exponentially increasing the demand for digital content products and services all over the world, there is strong pressure to create new production in this field. Products and services are needed in all sectors of our daily life, especially in the fields of entertainment and leisure time services, communication, education, health and social services, government and other public services, transportation, commerce, industrial design, tourism, etc.

Currently, digital businesses are centered only in certain major cities of the world, where there are severe problems with living conditions, high wages, and the quality and loyalty of trained personnel. Also, as the product is directed to the world market, centralized production does not always meet the tastes and values of local audiences in this culture intensive field. By decentralizing international production and moving it into new regions, variety in production could be increased, and products better accepted interna-

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tionally. Also, if local producers were able to take part in the international production, the disadvantages of, and resistance towards, globalization would be diminished.

In the North, chances to create new production in this field are good because of the North's great cultural heritage, its high standard of education, and good information technology skills and infrastructures. Also the location for this kind of production is favourable, because wages are relatively low, and due to the non-physical nature of the product, geographical distances do not weaken industrial competitiveness in the same way as they do for ordinary manufacturing industries. Instead, these products can be delivered to the market through telecommunication networks, and there will be no increase in delivery times or in prices due to distant locations.

Environmental issues go hand in hand with the new media industries

In connection with industrialization and environmental issues in the North, it can be said that digital content production and other software industries are remarkably well fitted to the situation. As the production is totally intellectual, it will cause no pollution, and yet its influence on the economy may be higher than the influence of manufacturing industries. Also, this kind of production will not require any factory buildings, or construction in wilderness areas.

International cooperation and incubator programs are needed

For making these new industries bloom and succeed, small Northern countries and regions need investment and incubator programs, venture capital, networking and international cooperation. By joining forces, they can make a new and interesting production area in this field, and also a new international market with a new kind of bargaining power.

Finnish Lapland leads the way

In Finnish Lapland the challenge of the new media business and digital content production is taken seriously, and the area intends to become an internationally recognized center for R&D and production in this field. In Lapland, approximately 400 new students each year are taken in to study information technology and new media subjects at the university and in other schools. The laboratories in these schools are specialized in 3D programming, real time immersive environments, filmmaking, animation, virtual stage sceneries, 3D industrial design and automated prototyping, and 3D textile design. The birth of new companies is boosted by an incubator program and, additionally, businesses from other locations are invited to the area. International cooperation with companies in the Silicon Valley and Hollywood areas in California help ensure the same level of technology and know how for beginning companies, as well as providing local representation in the core business areas. The national technology development center in Finland, Tekes, has an office in Silicon Valley, and it assists the entry of the Lappish new technology companies into the US market as well.

The Influence of E-commerce in the North

There are three dimensions to e-commerce in the North: First, local consumers and industries buy consumer products and materials from the world market through the Internet. Second, locally produced commodities, industrial products and travelling services are sold through electronic networks to the international market. Third, virtual products and services are sold and delivered through electronic networks to the world market.

Buying from the net weakens the local economy

When the idea of e-commerce was first introduced, it was generally assumed that it would improve the volume and quality of services available in rural areas. Instead, as the experiences in Finnish Lapland show, buying through electronic networks has a negative influence on the local economy. As the money flows directly to areas outside, less and less of the local income is left in the region. And at the same time as the local demand is decreasing, the local ser-

vices are also being pulled down. The negative influence is strengthened by the fact that it is mainly the wealthiest part of the population that is buying from the net, while the poorer part is left to live with the weakening services.

This does not mean that buying from the net should be limited to protect local economies, but only that people should be aware of the consequences of their actions. Certainly, local retail stores need to find new ways of offering better services, and for competing against their virtual rivals.

Being on the net does not automatically mean business

For the local production, whether it is consumer products or industrial production, e-commerce means improved marketing and better international recognition. However, also in this aspect, the original expectations of e-commerce have proved overestimated, thus being on the net does not automatically mean being on the market. Small firms and small countries' offerings are not found in the net, and, even if they are found, it does not automatically mean business. Also, if the small company's products are found interesting, the logistic problems and transportation costs still remain, and the firm needs to overcome them with an unique design, technological expertise, World leading quality, absolutely reliable deliveries, or with some other critical arguments. Also a good brand will help selling, but it is not an easy task to make an unknown product into an internationally known trademark.

Virtual consumer markets are not ready yet

Marketing non-material products through electronic networks means, so far at least, future markets: there is not, as yet, much supply, and additionally, the electronic delivery chains from the producers to the consumers are not yet ready. The supply of digital consumer products is expected to grow, but it is difficult to make any reliable forecasts concerning which products and services consumers will buy. For example, there are presently various widely used services which have been built on the GSM mobile phones by using the SMS technique, even though only two to three years ago no one could imagine that SMS would generate any business at all. Service suppliers also seem to be hesitant in offering new services until the better stabilization of the media environment.

On the consumer market, most expectations in the beginning were on the adoption of home computers and Internet access. Currently, however, there are doubts as to whether it will be the main home media at all. First, the unexpectedly fast diffusion of mobile phones, together with the growth of short messaging and the possible offerings of WAP services, started to threaten the position of home computers. After that, the fast development of digital-tv technology started to change the balance between the three main media, and it looks now as if it is the interactive television with built-in Internet access that will become the major interactive media and service channel at home. The third generation mobile phones may still have some effect on the situation, but they will probably remain as the first media for travel, but only the second media at home.

Conclusions

In the future, the international economy will be built on both traditional manufacturing industries and on the new non-material industries. Northern areas can preserve and create successful production in both fields, but in the manufacturing industries the disadvantages of distant location still remain. These may be overcome with outstanding quality and service, specialized production and better international recognition, but that requires a lot of effort and cooperation, both locally and internationally. In the new media business, which includes software production both for industrial and for consumer markets, the North has a good chance to become important and innovative production area, and a sophisticated testing area and market for future products. That position would give the Northern regions a new kind of bargaining power in the international economy, but for making that happen, these regions need wise strategic goal setting, and international cooperation in R&D, production and marketing.

Consciously Confronting the Uncomfortable*

Richard Langlais

This paper takes the circumpolar Arctic, loosely defined, as its context. As its focus, it discusses a specific effort to construct a new institution there—namely, the University of the Arctic (hereafter referred to as UArctic). The intention of the paper is to reflect on how to move forward with efforts in cooperation, both in the particular case of the UArctic and, more generally, with other circumarctic and even more broadly-based initiatives on a global scale.

In a ten-year perspective, the Arctic has experienced remarkable growth in institution-building. This is here understood as everything from intergovernmental organizations such as the Arctic Council and non-governmental organizations such as Bellona and WWF-Arctic, to scientific cooperation efforts such as the International Arctic Science Committee and indigenous peoples' organizations such as the Inuit Circumpolar Conference. The list is really quite enormous and these are only a very few illustrative examples. In fact, the real size of such a list is something I am only guessing at and is based on the fact that already-existing lists – such as those maintained by ADD, the International Arctic Environment Data Directory – while in themselves justifiably impressive, are by their own admission far from being comprehensive. (This is not meant as a negative criticism, but is simply to point out how we all have much more work to do!) These phenomenal developments have surely been achieved as the result of conscious decisions to pursue cooperation in the circumpolar Arctic region.

While the Arctic in some ways still bears the burden of not only cooperation, but also of conflict, reflecting the seminal description achieved by G. Osherenko and O. Young in their work *The Age of the Arctic: Hot Conflicts and Cold Realities* (1989), that world of slightly more than ten years ago has now changed so profoundly that we must understand cooperation in the Arctic as having the lead on conflict. Yet, at the same time that cooperation dominates, it is fair to assume that every such cooperative step taken still bears within it the demands imposed by conflict: in goals, methods, process, timing and planning, among others. The additional fact that a great many of the institutions that have now been created did not even exist in the beginning of the 1990s, must also by implication mean that a great deal of conflict has been resolved, which is in turn impressive. Consequently, another objective for any program of research on Arctic society must be to tell the story of how such new entities evolved, in order to better understand how the balance between cooperation and conflict has been transformed in each case and, at least as importantly, in interaction between the cases. The examples are numerous, indeed.

At this point, the UArctic initiative can serve as a case-in-point. It has been underway for three-and-a-

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half years and is interesting in that it illustrates a number of particular aspects related to cooperation in the area of institution building. In the way that it appears to illustrate the strong elements of tension between the role of the individual and that of the collective, it can serve as an example in the sociological debate with regard to just that topic (and could be used there to support the views of Anthony Giddens and his colleagues). As an initiative inspired by the presence and interaction of different kinds of knowledge traditions, cultures and languages, it is also useful in the light of studies on interdisciplinarity, such as the completely fresh PhD dissertation, *Epistemic Encounters: Intra- and Interdisciplinary Analyses of Human Action, Planning Practices and Technological Change,* defended so recently as 20 October, 2000, at Göteborg University, by Henrik Bruun. For me, it has been especially relevant in the light of the work, *The Evolution of Cooperation* (1984), by Robert Axelrod, on game theory and organization studies, where his crystallization of a number of elemental guidelines for cooperation activities has served not only as a platform for enquiry, but as a constant guide and inspiration. It is the latter that will take up the rest of this brief paper.

Before taking the next step in that effort, though, it is necessary to say just a little more about why having a "constant guide and inspiration" has been felt at all. The reason is that, even though cooperation in the Arctic has made great strides and attained much diversity, the Arctic itself is nevertheless only newly-emerging as a region. As a zone of cooperation, there are few examples (although there are some) that predate the 1990s on an Arctic-wide basis. There is much learning taking place about cooperation and this, by definition, means that it is not always easy, to put it mildly. The idea of cooperation on any initiative may often be in jeopardy as mistakes are made and many things are being attempted for the first time. The degree of discomfort caused by different sorts of difficulties has at times had concrete effects, including the withdrawal of partners, encouraging decisions to not become involved at all, the creation of too great a sense of political risk, and so on.

In the daily practice of having worked with the UArctic since its initial phases, there is a particular formulation by Axelrod that has proved particularly useful in consciously overcoming the influence of feeling uncomfortable at continuing on with cooperation. In truly difficult moments in working with the UArctic initiative, a quick recollection of them has been strengthening, indeed, even pivotal, in helping one to avoid despair. They almost resemble a mantra for an approach to cooperation:

> Do not be envious of the other player's success;
> do not be the first to defect;
> reciprocate both cooperation and defection;
> and do not be too clever.

In the following, there is a brief reflection on each of the four lines, with particular regard to their relevance for the UArctic, and in that sense they serve as section headings. The reflections are my own departures and constructions from the four lines above.

Do not Be Eenvious of the Other Player's Success

The UArctic initiative, at the same time as it can be experienced as a constant challenge and struggle for survival, nevertheless occasionally experiences "successes." Things considered successes may actually even be quite trivial, but still play an incremental role in the process. In this, there are at least four internal (that is to say, within the UArctic community) levels of interaction on which success can be measured: the individual's own sense of achievement, a success for an individual member institution, a success at the level of a particular country, and a success for the circumpolar, international UArctic as a whole, which of course includes the other three levels. Each of these could be dwelt on at length, but space is lacking.

In terms of the security of the entire UArctic initiative, it would be threatening and damaging for it if, within any level of success, envy arose over the success of others (within, or even between, the levels.) Whenever one institution or group of institutions gets funding or acclaim for a particular UArctic activity, it must be recalled that, and it must be handled so

that it remains completely transparent and obvious, that any such success is ultimately a success for the whole inititiative and for everybody in it. If the initiative is to endure as a cooperative effort, then eventually there will be—indeed, there will *have* to be—enough to go around for everybody. The best chance for getting there is if conscious efforts are made to keep this insight uppermost, to keep reminding ourselves of this. Actually feeling envy is, of course, natural at times, which means, in turn, that the degree of alertness to its potential negative effects must be as intentional as possible at all times.

Do not Be the First to Defect

Precisely because the degree of learning in a newly-developing initiative and in a newly-emerging region is so high, the degree of uncertainty may end up being at least as high; and such uncertainty may, in turn, also prove to be so uncomfortable as to make leaving the initiative appear necessary. Cooperation can only exist, though, if there are cooperators, so leaving the cooperation means that cooperation is by definition annulled. If the goal of cooperation is the result of a solid commitment, however, then the meaning of the cooperation, at its most fundamental level, is to provide access to more than one's own resources in dealing with reality as it emerges. Even if that reality is plagued with problems, the cooperation provides the possibility, for example, that additional responses may be provided by the other players. The cooperation needs players and, even when everything appears to be at its most uncomfortable, being there alone, or being there as part of a cooperation, provide two distinct scenarios to choose from. The point of cooperation is to be in it, so stay in it. No matter how attractive it may appear to leave it, as long as one, or others, stay with it, the cooperation can grow.

The flip side of this lies in suspecting that others are about to leave the cooperation, which in turn might make one think that it's better to leave soon, rather than later. If everyone thought like this, the cooperation would end instantly. The most basic way of avoiding a situation where everyone thinks like that is to not think like that oneself. If everyone decides to avoid thinking like that, then no one will be thinking of leaving the cooperation, and the cooperation will (barring other circumstances) be what it wants to be: the cooperation will be a cooperation. In other words, to strengthen the cooperation, everyone should assume that everyone else *wants to be* in the cooperation. This decreases suspicion and paranoia, as well as lowering the tendency towards envy as discussed above.

The UArctic has certainly not been free of these tendencies and it has had a certain share of defections, which leaves a question concerning how many defections the cooperation in developing the initiative can endure before becoming unbearably weakened.

Reciprocate Both Cooperation and Defection

This is perhaps the most difficult guideline to deal with. Its first part is straightforward: cooperation thrives on cooperation. The second part, though, appears to require sensitivity and much good judgement. This is because, in its most straightforward way, more defection is less cooperation, and adding defection to defection is even less cooperation (except perhaps that a new kind of cooperation emerges: the players now cooperate in defecting!) The key question here would seem to be: When is an action actually a defection? Many things that look like defections may actually be ploys for achieving other aims within the cooperation. It is clear that the idea of reciprocating true defection is in order to avoid having a forced cooperation. This would be a cooperation that would ultimately fail, and which no one would want in any case. Forcing the cooperation can result in many unpleasant consequences.

As in the case of the UArctic, the rationale of "needing" the cooperation is essential. But in this kind of defection scenario, that would disappear. Maintaining the cooperation in a non-constructive environment might also result in its being considered too costly to participate in, or not worth the cost of doing so, even if it were thought to be needed. Other

unhealthy results might be an aura of appeasement, which would not be a situation of cooperation, but more of concession. Should a particular goal of cooperation be achieved at any cost? Not everything needs to succeed, and, indeed, even the attempt at succeeding in cooperation can lead to highly enriching social learning for many, or even all, of those concerned.

A suitable way to reduce the possibility of experiencing defections that are of a massively harmful character might be to divide the cooperation into several distinct areas of cooperation that are linked at some other overarching, or underlying, level. This would dissipate some of the danger that a defection was necessarily conclusive, and perhaps allow a defector to remain interested in at least part of the cooperation, to an extent that was still good for the cooperation.

And Do not Be too Clever

Perhaps in this brief essay I am following this advice too closely. Much of the above must be seen as only scratching the surface of a specific case like the UArctic, rather than considering it in any detail. In cooperation, being too clever would mean deviousness and less-than-total transparency, which would then have a negative impact on confidence-building ambitions and a lessening of the all-important sense of trust that cooperation thrives on. Cooperation is about sharing the same vision and values to some extent – even if only to a minimal degree (as in the case of minimal cooperation) – the same burdens, the same returns and advantages, and the same outcomes.

The active cooperation that permeates the University of the Arctic has been the primary driving force in propelling it thus far. The will to keep cooperating in spite of the difficulties has outweighed any discomforts felt by the players during almost four years of effort. In my opinion, the degree to which we consciously choose to stay with it – even when the way ahead seems most uncomfortable – and the degree to which we face that discomfort openly, will be the key factors in giving the University of the Arctic the best chance of reaping the benefits of solid and meaningful cooperation in the circumpolar north, together.

Northern Science and Technology: The Canadian Scene

David G. Malcolm

Northern Science and Technology activities in Canada extend to over 50% of Canada's land mass. Although the primary focus is on the three territories, i.e., Yukon, Northwest Territories (NWT) and Nunavut, there are also substantial programs and activities associated with the northern areas of Canada's provinces. The three territories are diverse in their present circumstances and ethnic composition.

The Yukon Territory (YT) comprises a population of approximately 30,000 people, of which about 25% are of Aboriginal descent. YT has a well developed road network and a relatively diversified economy, but has suffered recently in economic terms through the closure of major mines.

The population of NWT is approximately 40,000, of which about 50% are of Aboriginal descent. The diverse ethnic mix in NWT makes consensus decision-making a challenging task when dealing with governance, social and economic development, and policy generation. Many exciting projects are under way in NWT in such areas as diamond mining and processing, and hydrocarbon development. Capacity building is a serious issue in NWT, and there are concerns about the capacity to stimulate, manage and benefit from economic development.

The new Nunavut Territory (NT) comprises a population of approximately 25,000 people, of which about 85% are Inuit. The government of NT is facing many challenges in policy development and in developing the capacity to govern. NT is the most underdeveloped of the three territories in terms of both knowledge and infrastructure bases.

Canada's northern peoples are more concerned about technology development than about scientific research, although they welcome research in the social sciences which may enable them to tackle the many socio-economic challenges of the North. The following sections discuss the science and technology programs and activities which are funded by Canada's federal government, and present an introduction to some of the technology development activities which have great impact on the economies of all of the northern regions.

Northern Science and Technology in Canada: Federal Framework and Research Plan April 1, 2000 - March 31, 2002

The Northern Science and Technology in Canada: Federal Framework and Research Plan (ISBN: 0-662-65049-2) has been prepared under the auspices of the Interdepartmental Committee on Northern Science and Technology of the Government of Canada. The

overall goal and objective of the Plan is to maximize, in partnership with governments, universities, colleges and northern peoples and institutions, the return on federal investment in science and technology so that activities and results contribute to sustainable development, the advancement of knowledge, and the improved quality of life and environment in the Canadian North. The Framework and Research Plan has been developed to ensure that federally funded science and technology (S&T) continues to improve the quality of life and the environment, social and economic wellbeing, and the advancement of knowledge in northern Canada.

Recent years have seen dramatic changes in the North. The Territory of Nunavut has been established, new northernbased administrative and management institutions have been created, and northern Aboriginal people throughout Canada have proceeded with land claim settlements and regional selfgovernment. At the international level, Canada has joined with other Arctic states to form the Arctic Council and new ties have been forged with nongovernmental organizations concerned about Arctic issues. Recently, the federal government strengthened Canada's foreign policy by developing the *Northern Dimension of Canada's Foreign Policy.*

Canada's northern regions are part of a circumpolar world that shares physical and environmental characteristics, as well as challenges and opportunities. Understanding those characteristics, meeting those challenges and exploiting those opportunities require cooperation and information sharing. In order for Canada to meet its S&T needs and responsibilities in the North, we need to be able to draw on the global pool of knowledge. Implicit in drawing on this pool is the moral obligation to contribute to it.

Canada established its prominent place in the family of circumpolar nations as a founding member of the Arctic Council. Participating in such international organizations, maintaining diplomatic and scientific relations with our neighbours, and keeping Canada's place in the leading group of industrialized nations often requires the support of Northern S&T activities. The Framework and Research Plan details the Northern S&T activities of federal departments and agencies. While these address Canada's needs and interests, many of them also represent Canada's contribution to the global pool of knowledge about the circumpolar world.

Many federal departments support Northern S&T; each has priorities related to its mandate. The Framework and Research Plan will assist in setting priorities for Northern S&T on an interdepartmental basis. It represents a coordinated federal basis for the promotion and enhancement of Canadian Northern S&T cooperation, as well as partnership and international linkages throughout the circumpolar region.

The report is divided into two parts. The Framework outlines the guiding principles and objectives, as well as the key issues. The Research Plan describes the implementation of federal Northern S&T activities, from April 1, 2000 to March 31, 2002, to support the Framework. In order to address the key issues, the Plan includes a section on interagency collaborative activities, and sections on the activities of each individual department and agency. Please refer to the report directly for details of these interagency and individual agency activities, including approximate expenditures for the 1999 fiscal year.

Canada's Northern Affairs Program

The Northern Affairs Program (NAP) of the Department of Indian Affairs and Northern Development (DIAND) is tasked with regulating industrial development activities in the North. DIAND is a major client for research conducted by science-based departments and agencies as well as outside agencies. DIAND requires research results in Northern S&T to carry out its federal mandate, including the formulation of policy and regulations, for:

- supporting northern political development
- supporting sustainable development in the North through various management and regulation processes
- advising on circumpolar issues

NAP administers the Northern Scientific Training Program (NSTP), which has contributed to the research efforts of university students in Canada's north for almost four decades. Approximately 245 students are supported each year under the program. NAP also contributes to the support of the Association of Canadian Universities for Northern Studies (ACUNS). ACUNS actively promotes northern scholarship and research through its growing membership of approximately 36 Canadian universities and colleges.

Northern Technology Development

Economic Impacts

As in other jurisdictions, technology development in northern regions has a dramatic effect on economic development. Cost/benefit analysis can be performed to compare the benefits accruing from changes in technology with the costs of the technology investment. Every northern community requires *leadership and vision* in order to ensure that technology development is based upon an appropriate strategy, goals and objectives. Northern research and technology development activities should lead to large „social rates of return" on investment, as well as the conventional financial rates of return.

Traditional Knowledge

Traditional Knowledge (TK) plays a very important role in Northern S&T activities. On the science education side, there are several projects either completed or in progress where TK is taken from the knowledge of elders or from formal Land Claims Agreements and used to develop curriculum for primary and secondary schools in the North. In this way the importance of TK is emphasized in the educational system. TK is becoming very important for supporting the Environmental Impact Assessment of proposed industrial projects as well as research programs. TK is becoming very important in studies of climate change impacts and adaptation. Permafrost melting effects on roads, infrastructure, housing and wildlife habitat can all be well informed by the TK of elders and long time northern residents. One example is a video tape, produced in 2000 by the International Institute for Sustainable Development in Winnipeg, Canada, *Inuit Observations on Climate Change in Sachs Harbour, NWT.*

Examples of Northern Technology Development

The following examples represent a small sample of the projects that are under way in northern Canada. The examples presented concern appropriate technology development in the housing and food industries of the North. There are many other technology development projects, including fibreglass manufacturing and projects which utilize renewable energy sources such as solar and wind energy.

Housing

The Canadian Mortgage and Housing Corporation (CMHC) carries out very interesting research and demonstration projects in the area of housing for northern regions. CMHC concentrates on research that improves the technical, economic, environmental and social aspects of housing. The design efforts concentrate on flexible housing and housing which emphasizes occupant health and resource efficiency along with economic viability. CMHC also has a technology development program for waste water treatment for northern housing. The systems being developed are referred to as „On-Site Wastewater Recycling Microsystems". They reduce water needs in remote northern communities and community infrastructure costs. They provide for 75% of home water requirements, i.e., for all water usage except for drinking water.

The Industrial Research Assistance Program (IRAP) of Canada's National Research Council funds small projects in private industry in Canada's northern territories in the area of energy efficient house design. IRAP assistance has been instrumental in assisting many entrepreneurs in the North to bring products to market.

Food Industries

Food industry examples of technology development in northern Canada include:

- Carbon dioxide production for small soft drink bottling plants
- Harvesting and processing of kelp for health food use
- Musk ox meat packing plants
- Community greenhouse operations in summer with plentiful solar energy (Inuvik and Norman Wells) to produce high quality fruits and vegetables in the Arctic under organic growing conditions.

Science and Technology Application in the North*

Egor Petrov

Yakutia is the largest region in the planetary north. Its resources potentially influence the progress of the world economy. According to the explored reserves and predicted potential resources of diamonds, coal, gold, oil and gas, non-ferrous and rare metals, iron and other natural resources, Yakutia will occupy one of the dominant positions in the world economy in the 21st century.

Compounded by the climatic peculiarities, development of the Sakha Republic (Yakutia) has been constrained by the following objective and subjective factors:

- Due to the location of the Republic in the permafrost zone and a short summer period, the development of agriculture, which is the main occupation of native people, is constrained. Production of the Republic's agricultural complex is not competitive, either on the Russian or on the world market.
- During the last 50-70 years, development in the Republic has been accounted for only by the mining industry. That has caused ecological problems: mining regions now resemble „moon landscapes"; the area of agriculturally cultivated lands has been reduced.
- There are no developed transport communications, road systems for automobiles, railroads, or central energy supply system in Yakutia.
- Ecological problems caused by the mining-industrial complex, relative overpopulation in the north – all create overpressure on the northern environment, as due to permafrost and the severe climatic conditions of the region, the regeneration of the landscape and nature is quite slow.
- Native people do not usually participate in mining, and the visiting experts do not look at or treat the northern nature as if it were their own. Laws about environmental protection do not work.
- Natural resources development and industrial and agricultural development are being held by traditional methods without appropriate scientific and technological support. We lack new technologies and approaches for addressing northern problems.

In connection with these problems, in theory and in practice, we need to concentrate on rational use of nature. We speak here of the system of activities which would provide rational and economically profitable exploitation of natural resources, regeneration of these resources for the development of the economy, and protection of the health of the population and future generations. To address these tasks we need a new, complex approach which would take into account experience of indigenous, environmentally friendly economic activities and resource saving techniques and technologies. In that way, we would be able to preserve the natural bases of our culture, to provide for the Republic's national security, and to contribute to the world's sustainable development in the 21st century.

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On the other hand, the major contribution of Yakut science has been to the mining industry. I would like to mention two examples of large-scale scientific projects in the diamond-mining industry. The kimberlite pipe „Mir" was mined by the open-cast method. That resulted in the opening up of an underpermafrost water-bearing complex and the emergence of inflows of more than 50 m^3/hour. During reconstruction of the open cast, a lake with the volume of 3.5 million m3 was formed there, containing water with high levels of mineralization. The evacuation of these brines was made through the pipe-lines run along the bottom of the open cast which broke down due to the margin's instability. Scientists from the University and the Yakut Scientific Centre managed to reinforce the sides of the open cast with polyurethane foam. An area of 4000m^2 under the pipe-lines have been insulated; this provided non-stop work for 4 years and allowed for the brines exhaustion from the open cast. Such large-scale application of thermal insulation in order to increase stability of the rocks is unique.

The first underground diamond mine of the Republic was opened in 1999. The mine head-frame of the cage trunk is set on a foundation which lacks strength when thawing. Its stability, however, is supported with the help of a freezing system designed and constructed according to the recommendations of the scientists at the University and the members of the Scientific Centre. This technology is also unique.

On the other hand, diamonds and gold have been mined in four northern regions for 40 years. At the beginning of the exploitation of these deposits, there were not enough techniques and technologies which could be applied in this region. At that time the leaders of the country demanded great output, and a „barbaric" method of mining was practiced for many years. As a result, hollow landscapes appeared, reindeer breeding started to disappear, and many rivers were polluted.

There is a lot of scientific research in the development and introduction of new technologies, which are economically and ecologically attractive for ore mining and processing, affording a high degree of metal extraction and an increase of work efficiency. Of course, we cannot solve the ecological problems by introducing new technologies and techniques. The thick layer of ice and surrounding rocks do not allow for any kind of restoration works. For the present we have only one way out – a transfer to underground ore development.

As I mentioned above, the native population is not involved in this industry. To solve this problem, in many industrial towns new schools have been opened. In these schools the local population can take preparatory courses in relevant specialized fields. A network of local branches of the main educational institution of the Sakha Republic, Yakutsk State University, is being developed. For instance, there is a polytechnic institute which was opened in Mirny, in order to prepare specialists in geologic profiling and energetics, and branches of the University were opened in Lensk, Udachny, Niurba, and Tiksi. All of these educational institutions have access to the Internet, making contacts with modern 'global' society easier and aiding the acquisition of necessary techniques and knowledge.

The system of transport which exists in Yakutia right now is considered to be extremely unsatisfactory: not only is it very expensive, but also it is not developed enough to satisfy all the needs of the population. The President of the Republic set the task of reviving the Northern Sea Route and making it a transcontinental traverse line, in the interests of the Russian Federation, the countries of the Asia-Pacific region, and Western Europe. The Northern Sea Route which is the shortest sea way, would provide highly effective transit transportation in the Arctic. It would improve transport service in arctic regions, support their stable development and also provide for production expansion.

We can solve these problems if we cooperate with other countries, especially Arctic ones, by working together to bring new lands into cultivation, in education and in science, and in the transfer of scientific technologies under mutually profitable conditions.

Technological Change and Economic Development in the North – Observations*

Boris Segerståhl

I want to start with two important observations on the interaction between and character of technology and economy and one observation on the regional characteristics of technology and economic systems.

My first observation is that technological change and economic development are two sides of the same coin. It is not possible to separate one from the other. It is not possible to say that changes in one of them are caused by incentives and driving forces emanating from the other. Technology and economy participate in a complicated coevolutionary process in which neither one of them can be understood and studied without taking into consideration the characteristics of the other one. Both technology and economy create forces and incentives impacting the other partner in this complicated pas de deux of what is called development.

My second observation concerns the interaction between technology and economy on one hand and regional structures on the other. The impact of technological development is a two-edged sword. On the one hand, it creates new opportunities for prosperity and well-being in Northern regions. On the other hand, it tends to move societies toward stronger concentration of populations and resources. This development is driven by sometimes rather single-minded efforts to maximise short-term efficiency. It has often been said that with the emergence of new communication technologies, especially the internet, the center-periphery issue will disappear and every region will have the same opportunities to share in the global growth of prosperity. This development has, however, not yet been seen.

One of the challenges for politicians, planners, industry, and scientists is to find a common understanding of how science, technology and economic development should be used in such a way that the justified demands of all regions are met. This is a challenge only if we accept as a starting point for our idea that populations in peripheries have the same right to a good life as those living in the centers of economic systems.

My third observation concerns the fundamental characteristics of economic and technological systems in the South and in the North. One of the slogans of modern development is that we are becoming „information societies". In many countries a major part of growth in GNP comes from the information technology sector. This trend is made clear by the fact that in many countries enormous sums are paid for rights to use certain radio frequencies for mobile telecommunication. This suddenly emerging „information resource" has a market value based not on its present use but on future expectations. The situation in the North is different. I quote a national review of the importance of various regions: „The

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North is extremely rich in various natural resources…." The question is now: how should we take care of this northern resource society in the global context of an information society? We should, of course, at the same time doubt the validity of this simple dichotomy.

Implications

The three observations were: 1) coevolution of technology and economy; 2) technological and economic development create prosperity but can at the same time cause greater inequality between regions; 3) the North is perceived as being a resource economy within the global information society.

The immediate implications are not that obvious. This is due to the fact that the system exhibits so many degrees of freedom that there is room to create, and not only to accept, a reasonable future for northern regions. We should not assume that information technology will lead to a more even distribution of development and prosperity.

What it will probably lead to is a new concept of distance where the traditional diffusion theories have to be replaced by jumps in geographical space. It can, in a certain sense, be true that the distance between Reykjavik and London is shorter than the distance between these cities and the surrounding rural areas. A challenge to science is consequently the need to study the structures of these new time-space systems so that policy instruments and development efforts are supportive of these new modes of interaction and collaboration.

Inequality between regions is not a static state but a process undergoing continuous change. The process will cause, and is caused, by distribution of economic power, distribution of productive capacity and by mobility in the population. Access to and control of natural resources is of diminishing importance in these processes. The implication of this statement is that regional inequality is not a problem that can be solved but a process that has to be managed through systematic implementation of a counterprocess. The second challenge to science is to learn more about the main characteristics of strong local communities and about the driving forces leading to positive or negative changes in these communities. Based on this understanding, policy instruments can be developed that try to support positive development while containing and limiting the impact of negative development.

The resource based economies in the North are sensitive to the modes of exploitation implemented in different economic spheres. Resource extraction alone can not support a good regional societal structure. A broadening of the sphere of economic activities and better control of the natural resources in the region would be needed in order to build a strong fundament for future development. These goals are not easy to achieve. In many cases the resources are controlled by economic interests far away from the region and treated as cash cow providing resources that can be invested in activities in other regions. One reason for this is that the North is not seen as an attractive environment for investments outside the resource sector. This can change only if these regions can support logistic services required by modern enterprises, provide access to a well trained work force, develop a local environment that is attractive to professionals and guarantee health care, education, culture and education on a level that will meet the standards expected by professionals and workers in corporate environments.

The use of natural resources in the North is a continuous challenge. No local development effects can be expected if the raw resources are exported without value added. A positive example is the way Iceland is trying to develop industries based on the catches from the fishing industry. In other cases it might be much more difficult to develop local and regional activities because of the economies of scale. The oil and gas industry does not invest in petrochemical plants and the production of plastics and other oil-based products in the North. For them it is more efficient to ship out the crude oil to refineries in other regions.
The bottom line is that developing the North is a never-ending process that will require continuous

efforts. Success cannot be achieved by trying to stop technological and economic development in the region. Success cannot be achieved by using existing technological and economic solutions without adapting them to the local environments. We might have to teach technology and economies to speak local dialects so that interaction between the regions and these two forces can be based on a common language.

Northern Science: Status, Tendencies and Integration*

Vladimir N. Vasiliev

At the junction of two centuries and two millennia, the world examines critically the way passed by mankind and determines ways for further development of civilization. Northern science, where the tendency toward internationalization has been evident, is no exception. Arctic states, until recently, have conducted research in isolation from each other. Many arctic and northern problems go beyond the bounds of individual states and need the consolidation of the efforts of several regions, particularly on issues related to environmental protection (animal migration, pollution, global climate change), which has resulted in an increase in the number of international organizations involved in arctic and northern issues. It is believed that, in the former Soviet Union, impetus for the development of international research collaboration was given by perestroika, when joint research between Russian scientists and specialists from other countries was made possible.

The analysis of data collected by the Scott Polar Research Institute Library, Cambridge University shows that about 30 international Arctic organizations were established between 1880 and 1980, whereas in the last 20 years the number of organizations has grown to 80. All of these organizations are involved in science and research to some extent. Activities of these organizations may be thought of as circumscribed, and each organization has its proper „niche", though there are a number of organizations accomplishing at first glance similar tasks. The building of the hierarchic structure in the international academic community, the rationalization of the organizational system and the delineation of tasks will gradually take place. The tendency towards that can already be seen. The group of organizations in charge of various fields of activity are outlined below.

The International Arctic Science Committee conducts fundamental global research (climate warming, the state of the ecosystem in macroregions such as the Barents and Bering basins, interrelations between marine and ground ecosystems, etc.) calling for consolidation of forces and resources at national and academic levels. The prerogative of the CAFF and WWF Arctic Program covers issues of the preservation of flora and fauna and the establishment of protected areas. The launch of the Circumpolar Universities Association and the University of the Arctic allows the full and effective use of the available potential of higher education institutions, the building of a unified system of arctic education, and the significant improvement of academic training. The organization operating most actively in the development of interregional cooperation is the Northern Forum, whose basic activity concerns the implementation of prioritized and endorsed projects in a number of fields. Examples include the following projects: Reindeer Management, Wildlife Management, the Northern Forum Academy, and Boreal Forest Management.

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There are also academic scientists involved in the implementation of these projects.

Undoubtedly, these organizations will not be able to cover the entire range of activities; there is no need for that. Both national and international organizations, as well as small teams and even individual scholars and specialists, are able to conduct basic and applied research. Science is diverse, and there are many still unoccupied 'niches' calling for cooperative efforts at various levels.

Contemporary Arctic science concerns three major fields which include a multitude of problems:

1. Global climate change
2. Environment (flora and fauna preservation problems, pollution, establishing protected areas)
3. Sustainable development.

These fields are, clearly, not isolated from one other. They have certain things in common and are closely interrelated. The sustainable development of not only the Arctic but also world civilization as a whole depends on environmental conditions and the possible consequences of climate change. The increase in mean annual atmospheric temperature by a few degrees will result in catastrophic changes in high latitude regions. Ice melting in the Arctic Ocean, the northern mountain ranges and the permafrost will cause flooding of huge areas, which in turn will cause a compete change of landscape and the disappearance of a variety of plant and animal species. Many settlements will be under water, population migration will take place, the need for radical restructuring of northern economies will occur, etc.

Research within the above-mentioned fields is conducted at a number of different levels: intergovernmental, interregional, national, regional, depending on the scope of problems considered. The research formats differ also. For instance, the study of global climate change, ozone depletion, pollution, and the status and preservation of flora and fauna is carried out in on-site stations and by expeditions.

Monitoring stations of different types (meteoservice and solar-earth monitoring stations, polar stations, etc.) operate throughout the Arctic. A network of regional stations has been created and a united Arctic monitoring system, which will be part of the global system, should become available in the near future. International biological stations have been built with WWF's assistance. In the Russian Arctic, in 1995, two stations were built: in Taimyr and the Lena Delta. Under the auspices of CAFF, the Arctic Key Monitoring Areas Program has been developed. Many national and international institutions are involved in this monitoring. The possibilities of the expedition form of research have not been exhausted either. This is of particular relevance in the Russian North, where long distances and remote areas, poorly developed infrastructure, and shortage of financial and material resources limit the development of work stations. At the same time, narrowly specialized expeditions are also unjustified. The least expensive and most effective way of doing research of this kind is to arrange composite teams of specialists from different disciplines. We have become convinced of this from personal experience, having been the coordinators of the Sakha Arctic Expeditions since 1993. Original academic ideas and solutions are originated precisely in expeditions, where specialists in various fields work together. Prompt exchange of information and opinions and mutual instruction in methods and traditions, even among researchers from remote academic disciplines, take place when working together. In that way, researchers capable of posing and solving interdisciplinary tasks successfully are developed.

As the experience of the Sakha Arctic Expedition has demonstrated, when confronted with significant financial expenditures for conducting research in the Arctic area, the most effective arrangement is a complex expedition with a common coordinating center, based on the joint financial resources and academic potential of the concerned institutions and well-known Russian and foreign specialists. That approach, which was used when investigating the Novosibirsk Islands, the Medvezh'i Islands, the Lena Delta, and the anthropogenic landscapes in the Yano-Indigirski River area, enhanced research effective-

ness and saved considerable financial resources. The expeditions operate mainly in the following areas: ecological evaluation, monitoring, rare and endangered animal species ecology, ways for the rational and complex use of biological and mineral resources, and native ethnic problems.

The establishment of new regions or administrative districts, okrugs, in the Russian Federation has been brought about by changes in the structure of the Russian Government and the political vertical line. The system of relations between the federal center and federal subjects is changing. The radical reformation of the northern economy lies ahead. The system of subsidies, privileges and transfers for northern cargo transportation is also being reconsidered. To that end, a new look must be taken at socio-economic conditions in different regions, and at priorities for economic development and social policy. In Sakha, a revision of earlier programs for the socio-economic development of uluses has begun. In view of the fact that uluses situated along the same river system are closely interrelated, we have proposed the use of a basin principle when developing programs for socio-economic development in these settlements. That approach is amenable to the Sakha Government. Within the context of the Arctic expedition, the Center has launched a program for the socio-economic development of the Nizhnekolymskiy, Srednekolymskiy and Verkhnekolymskiy uluses situated along the Kolyma River. The problems of transportation, energy, construction and social security are foremost, and call for solution not only in these uluses but also throughout the Sakha Arctic.

Sakha understands how links to other regions and countries, the exchange of information and knowledge, are important. Sakha is a member of the Northern Forum and a moving force behind the establishment of the Northern Forum Academy. It should be stressed that the Sakha Republic actively works towards international academic cooperation. Introduction of new communications has allowed the establishment of contacts with many foreign institutions. It is paradoxical that interregional links are considerably weaker, and there are no joint works with even the closest neighbors, such as specialists from the Magadan Oblast, the Krasoyarski Krai, and the Chukotski Autonomous Okrug. Reasons most likely include mutual financial problems, and lack of reliable communications. The development of interregional academic cooperation would certainly be beneficial The Northern Forum Academy's organizational form is conducive to these goals, but due to its reorganization, which has dragged out, it does not yet operate at full capacity.

In some areas of regional science there has been rapid development, for example in aboriginal studies, in the use of traditional environmental knowledge when establishing protected areas, and on some issues concerning economic development in northern regions. Recently, in Russia, greater attention has been given to the support and development of local academic institutions, which have gotten more involved in large programs. That is testified to by the complex expedition conducted by the Russian Academy of Sciences, whose aim was to evaluate the effect of the Northern Sea Route on social and economic development in the Russian North.

In order to make most effective use of academic cooperation, a balanced development is needed of all its levels: from regional to national and international. Interregional associations may be within one country or between regions of different countries. Additionally, the contemporaneous development of international organizations in specific narrow fields will enhance the effectiveness and quality of research conducted.

Science and Policy in the Circumpolar North*

Oran Young

In the North, as in other parts of the world, the challenge of fostering a productive relationship between the policy community and the research community is great. Not only do members of the two communities lack natural and neutral settings in which to interact in an informal and off-the-record atmosphere, but they also belong to relatively self-contained and non-overlapping cultures. Under the circumstances, it is hardly surprising that the two cultures continually threaten to devolve into two solitudes. In the Circumpolar North, this dynamic is exemplified by the experiences of the Arctic Council (AC), the principal region-wide intergovernmental organization concerned with northern affairs, and the International Arctic Science Committee (IASC), the main non-governmental organization concerned with the advancement of Arctic science. Nothing in the constitutive norms, rules, and procedures of the two bodies precludes extensive and mutually beneficial interaction between participants in these forums. In fact, IASC enjoys observer status with the AC and regularly sends representatives to both the AC's Senior Arctic Officials meetings and the biennial AC ministerial meetings. The relationship between the two bodies is proper and generally cordial. In reality, however, their interactions are extremely limited and, for the most part, lacking in substantive content. Why is this the case? What can and should we do to improve the dialogue between science and policy in the Circumpolar North? In this presentation, I sketch answers to these questions framed in terms of contemporary Arctic issues. But the main points are generic and apply to relations between science and policy more generally.

Two Cultures – Two Solitudes?

The worlds of policy and science are founded on divergent goals, unrelated processes, and distinct criteria of evaluation. Policymakers seek to solve public problems; scientists endeavor to solve scientific puzzles. Whereas policymakers want to understand the probable impacts of climate change on human welfare in the Arctic, for instance, scientists strive to solve puzzles such as what happens to flows of carbon dioxide generated by terrestrial activities that do not end up in the atmosphere and whether the North Atlantic Oscillation (NAO) is actually a component of a larger Arctic Oscillation (AO). Policymakers strive to build consensus around programmatic responses to public problems; scientists seek to subject provocative hypotheses to rigorous testing. While policymakers are endeavoring to forge agreement on international regulations banning or strictly limiting uses of persistent organic pollutants (POPs), for example, scientists are busy testing hypotheses about rapid climate change derived from the paleo-record preserved in the glaciers and ice sheets of the circumpolar world. Similar remarks are in order

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regarding criteria of evaluation. Policymakers generally judge success in terms of evidence of public support for their initiatives, whereas scientists are primarily concerned with the results of peer reviews. Where policymakers worry about public reaction to an initiative like the opening of the coastal plain of the Arctic National Wildlife Refuge to hydrocarbon development, for instance, scientists routinely subject hypotheses pertaining to matters like the impact of climate change on thermohaline circulation to intense scrutiny and view the launching of powerful critiques of such ideas as a mark of respect.

Each of these cultures provides guidance for a well-defined, goal-directed activity; each is coherent and easy enough to understand on its own terms. But the two cultures give rise to fundamentally different social practices. In some cases, the result is a certain latent or even overt antagonism between the two endeavors. Scientists see little virtue in consensus building as an end in itself and often wonder about the value of measuring success in terms of public support in contrast to more substantive goals like the protection of biological diversity or the achievement of sustainable yields from living resources. Policymakers regard scientists as a fractious lot who never seem to agree on matters of substance and who exhibit a marked propensity to turn the analysis of any policy-relevant issue into a justification for increased research funds. More often then not, however, the two cultures simply give rise to two solitudes. Policymakers and scientists find it difficult to put themselves in one another's shoes and to understand each other's aspirations and worries. The course of least resistance is for the two communities to go their separate ways, wishing each other well but making little effort to comprehend each other's priorities or achievements. Of course, there are striking exceptions to these generalizations. With regard to contemporary Arctic issues, names like Bert Bolin of Sweden, Robert Corell of the United States, and Vladimir Kotlyakov of the Russian Federation come to mind immediately. But these individuals are exceptional. For the most part, we are left with a condition in which the two cultures of science and policy threaten to produce two solitudes.

Should we strive to overcome this gap? If so, what strategies are likely to prove successful and how do they apply to issues of importance in the Arctic today? I regard the answer to the first of these questions as emphatically affirmative. How else are we going to come to terms with an array of pressing concerns ranging from the impacts of climate change in the Arctic through the consequences of POPs for human health in the Circumpolar North to the achievement of self-determination and economic autonomy for the indigenous peoples of the North? Accordingly, I focus on the second question in the following remarks. In the process, I argue that there is much to be gained in efforts to overcome this problem from (1) negotiating common agendas spelling out questions of interest to both communities and (2) developing realistic expectations regarding what science can and cannot contribute to the treatment of policy issues.

Common Agendas

For the most part, scientists and policymakers address their own issues and march to their own drummers. The incentives of scientists are dominated by the desire or even the need to publish peer-reviewed articles in the flagship journals of recognized disciplines. In advanced fields, such articles are accessible only to a handful of specialists; little or no effort is made to explain the findings, much less the logic of the argument, in terms that are understandable to a broader audience. The incentives of policymakers, by contrast, are dominated by the need to craft agreements or compromises that can gain the support of majorities in legislative settings or find their way into consensus drafts of international agreements.

Nonetheless, there are ways around this seeming dilemma. Perhaps the most promising avenue involves a conscious effort on the part of both communities to frame issues in such a way that they are of interest simultaneously to policymakers and scientists. For the most part, this means adopting a problem-based approach rather than a discipline-based research program. There is little prospect that policy-

makers will take an interest in studies of the mass-balance of glaciers or the vegetation of tundra ecosystems as ends in themselves. But studies addressing questions like the long-term ecological impacts of industrial development in northern settings, the consequences of changes in sea ice for the population dynamics of marine mammals, or the determinants of cultural survival in the face of rapid social change can produce results of obvious interest to policymakers.

A promising development in this realm is the rise of serious efforts to conduct systematic scientific assessments. The most familiar example is the work of the Intergovernmental Panel on Climate Change (IPCC) leading to periodic assessments of the impacts of anthropogenic emissions of greenhouse gases on the Earth's climate system. But a newly emerging and particularly interesting Arctic example centers on the Arctic Climate Impact Assessment (ACIA). ACIA grew out of discussions among scientists associated with IASC and scientifically trained public officials associated with the AC's Arctic Monitoring and Assessment Programme (AMAP) and Working Group on the Conservation of Arctic Flora and Fauna (CAFF). This project, which encompasses ozone depletion as well as climate change and variability, received formal authorization at the October 2000 Ministerial Meeting of the Arctic Council, and is now scheduled to produce a series of scientific and policy-relevant reports over a period of four years.

This is clearly good news. But even with regard to an attractive initiative like ACIA, there are serious pitfalls awaiting the unwary. From the policy side, much of the interest in ACIA arises from a concern with the potential short and long run social impacts of climate change and variability. This suggests a focused effort to think through issues relating to the vulnerability and adaptive capacity of Arctic communities and Arctic economic systems in the face of climate change and variability and to devise anticipatory measures to protect these human systems from the impacts of future climate change. But the science community is more accustomed to asking questions about the impacts of climate change and variability on the behavior of sea ice, glaciers, and permafrost or on the population dynamics of plant and animal communities in rapidly changing biogeophysical environments. There is no inherent conflict between the two sets of concerns. But neither is there any sure-fire way to link the two. Unless care is taken to demonstrate how biogeophysical changes attributable to climate change and variability translate into matters relating to human welfare or the resilience of human communities, there is a danger that ACIA will prove to be a failure, at least as a mechanism for improving communication between science and policy in the Circumpolar North.

More generally, there is a need to guard against drift in projects of this kind in which the work of scientists engaged in assessment processes slowly diverges from the concerns of policymakers. Perhaps the best response to this potential pitfall is to create scientific steering committees for projects like ACIA that include representatives of both communities who are able and willing to make a concerted effort to communicate effectively. This is a tall order. I am not convinced, for example, that ACIA has found an effective way to meet this challenge. But I am not a pessimist about such matters either.

Realistic Expectations

Equally important is the need to develop realistic expectations about the sorts of products that projects like the IPCC assessments or ACIA can deliver. The capabilities of science are impressive. By making use of technology-based observing systems (e.g. remote sensing), advanced computing systems, and other forms of information technology (IT), science has multiplied its analytic power several times over. Yet the ability of science to provide clear and unambiguous answers to questions of the sort that confront policymakers on a daily basis remains limited. Nowhere is this more apparent than in efforts to come to terms with global environmental changes, like ozone depletion and climate change. Some Arctic-related examples will make this point clear. Studies of paleo-climates based on cores extracted from the Greenland icecap indicate that the climate of the Northern Hemisphere has undergone a number

of rapid shifts in the course of the last 200,000 years. But they do not make it possible to predict the occurrence of such events during the foreseeable future, much less to explain the dynamics of largescale climate changes. Research on sea ice has made it possible to track changes over time in the extent and thickness of ice in the Arctic. But the occurrence of extensive open water in the vicinity of the North Pole in the summer of 2000 nevertheless came as a surprise to everyone. Scientific studies of social change in the Circumpolar North have generated significant insights regarding the capacity of subsistence-based communities to adapt to major changes in their biogeophysical environments. But they do not add up to a predictive theory of social vulnerability and resilience that can be used as a basis for making projections regarding community viability in the Arctic.

Under the circumstances, it is critical to be clear on what science can and cannot do in helping to come to terms with issues on the current policy agenda. As thoughtful climate modelers have pointed out again and again, science is better at improving our understanding of the workings of complex systems than at making predictions about what will actually happen in specific settings. We now know a lot more about the Earth's climate system than we did twenty years ago, for instance, but we are still unable to say with certainty that we have entered a period of anthropogenically-induced climate change. We can explore the sensitivity of the climate system to anthropogenic changes (e.g. specified increases in concentrations of carbon dioxide in the atmosphere) through the use of simulations (e.g. general circulation models), but this does not make it possible to predict actual – especially region-specific – changes in the Earth's climate system during the next two to three decades. Similar remarks are in order regarding human systems. Thus, we have some knowledge regarding the mechanisms through which rapid social and cultural change leads to social pathologies (e.g. drug addiction, suicide). But we are unable to predict who is likely to fall victim to these problems or to prescribe cures for them. We know a good deal about the problems associated with state-centric resource regimes. But this is not sufficient to provide the basis for formulating design principles that can be applied to the construction of alternative management systems for specific resources with confidence.

The results are easily summarized. Scientists can make probabilistic projections with varying degrees of confidence but are seldom in a position to make bold predictions about the behavior of specific biogeophysical or socioeconomic systems at specific times and in specific places. Modeling complex systems can shed light on the sensitivity of these systems to anthropogenic changes, but there is no simple way to translate the resultant knowledge into policy-relevant predictions about real-world systems. In most cases, there is little prospect that we can come up with simple generalizations in the form of necessary or sufficient conditions governing the occurrence of outcomes of particular interest. Among other things, this means that we should not expect to be able to formulate sets of clearcut design principles that policymakers can use with confidence as manuals in their efforts to construct resource regimes dealing with such activities as the consumptive use of living resources or the control of human activities likely to disrupt the Earth's climate system. Most systems of interest to policymakers are controlled by clusters of interactive driving forces whose operation cannot be understood in terms of simple generalizations or the construction of simple models.

What does this mean for the relationship between science and policy? Above all, it suggests that turning to scientists as experts and asking them to make specific predictions regarding the consequences of particular policy options (including the option of doing nothing) will lead to disappointing and frustrating results. Advocates of specific policy options will invariably produce their scientists as expert witnesses, a process that is more likely to undermine the credibility of science than to encourage well-informed and effective policymaking. It is also likely to make serious scientists wary of agreeing to assume the role of expert in policy settings, so that the quality of the information that is used in policy debates is likely to decline over time. And the more important and contentious an issue becomes in the arena of policy, the lower the quality of the knowledge claims on which the debate turns is likely to become.

What is to be done? In my judgment, the key to success in this realm lies in combining realistic expectations about the contributions of science with a process that encourages scientists and policymakers to interact with one another in informal, off-the-record settings in contrast to turning scientists into expert witnesses in formal public policy debates. The goal should be to generate scientifically informed discussions of policy issues rather than to use scientists and scientific findings as weapons in battles over the relative merits of specific policy options. Science seldom supports confident predictions regarding the consequences of complex policy options; it certainly is not able to resolve value conflicts of the sort embedded in debates over many policy options (e.g. whether to grant subsistence users of living resources priority over commercial or recreational users or whether to prohibit the harvesting of various marine mammals altogether). Yet scientifically informed policy debates are far more likely to yield results that are progressive in the sense that they contribute to the achievement of the common good than debates in which ideological views that appeal to various groups of partisans become substitutes for knowledge.

In Conclusion

How can we bridge the cultures of science and policymaking in a manner that will encourage efforts to promote the common good? In the case of the Arctic, I believe, one of the best prospects lies in the activities of groups like AMAP and CAFF. The work of these groups, which are subsidiary bodies of the Arctic Council but which have generally non-partisan mandates, is conducted largely by officials from government agencies who have advanced training in the sciences and who are able to interact in a knowledgeable manner with members of the research community, even though they are not in a position to pursue active research programs of their own. Although most of them are career officials rather than high level policymakers, the roles that these scientifically trained individuals play as gatekeepers and go-betweens is critical. In effect, they are in a position to translate scientific findings into forms that are usable in policy settings and to frame the needs of the policy community in a manner that is comprehensible to members of the research community.

As the case of ACIA makes clear, however, the success of these endeavors in specific cases is far from assured. Officially, ACIA is an Arctic Council project that is organized as a joint venture among AMAP, CAFF, and IASC. So far, so good. But how will this partnership work in practice? Not only is there a pronounced tendency for AMAP and CAFF operating as integral parts of the AC to marginalize the contributions of IASC, but also IASC itself has little capacity to address creatively the human dimensions of climate change and ozone depletion. Although ACIA has been promoted throughout as a project designed to add to our understanding of the social impacts of ozone depletion and of climate change and variability in the Arctic, the actual design of the assessment betrays little sophistication in its treatment of human behavior and social institutions. This example highlights the problems I have been discussing in this presentation.

Nonetheless, I do not want to end on a pessimistic note. The AC itself has provided an excellent opportunity in this case for collaboration among AMAP, CAFF, and IASC. There are mechanisms available as well for bringing social science expertise into this assessment effort. The International Arctic Social Science Association (IASSA), for example, is recognized as a standing advisory body to IASC and could well be called upon as a source of relevant expertise in the social sciences. In the absence of a concerted effort, ACIA will fall prey to the usual problems of communication between science and policy and, for that matter, between the natural sciences and the social sciences. Done right, however, ACIA has the potential to become a striking example of constructive collaboration between the research and policy communities as well as a source of policy-relevant information regarding the social impacts of climate change and variability as such.

Social Science and Sustainable Development in the Arctic*

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The idea of sustainable development is a human centred concept, focusing on the long term viability and welfare of human societies and their adaptation to environment and resources. The social sciences have as their task to study and promote knowledge of such processes. The aim of the workshop was to focus on the role, relevance and input of social science for sustainable development, arctic science and policy in the Arctic regions. Furthermore, it was to ask and discuss critical questions relating to the relatively low profile of the social sciences in the sustainable development debate, this being so in spite of the fact that sustainable development is intrinsically concerned with human behaviour and institutions, in terms of both causes and final impact.

The Inari workshop was the second in a series of informal meetings designed to provide opportunities for members of the research and policy communities to meet and exchange ideas and discuss issues, especially those related to the Arctic Council. The first meeting took place in Akureyri, Iceland from the 8th to the 10th of April, 1999 and addressed the overarching theme of Sustainable Development in the Arctic. The rationale behind the Inari workshop was a concern that the social sciences need to sharpen their arguments and reconsider their potential input into northern policy and science. Although the focus was on social science, it also looked at how natural science can interact more with social dimensions and with increased policy relevance. There is every reason to think that the natural sciences welcome a conversation on these issues and are willing to participate constructively, not only to identify the reasons for lack of success but also to provide input for a new and stronger strategy. This should help social scientists in developing approaches which make interdisciplinarity an integral part of any project that seeks understanding of contemporary and future viability of the arctic regions. It must be clear, however, not only why this is important, but also how to implement it, and how to seize opportunities for reaching out to the science community, policy makers and other stakeholders in order to introduce this perspective.

To address these issues, the sponsors took the initiative of organizing a workshop designed to critically examine the above-mentioned issues. The task of the workshop was to 1) clarify the role of the social sciences as a human dimension expert discipline, 2) identify the causes of the relatively weak position of human dimension consideration in the formulation of arctic science agendas, 3) spell out key problems in the communication between social and natural sciences working in the Arctic, 4) discuss the interplay of theory and practise, research and politics, and 5) suggest more effective and clearer modes of participation for the social sciences in arctic science and assessment projects relating to sustainable develop-

* Invited Position Paper

ment in particular, and to human-nature interactions in general. These general issues were tackled with reference to a number of concrete Northern case studies presented at the workshop, dealing with sustainable uses of living resources, e.g. fish and reindeer/caribou, and the new Arctic Climate Impact Assessment (ACIA).

Impressions from the Workshop

The task of this document is to distil some of the main themes that appeared during the presentations and discussions which most directly relate to the purpose of the workshop and the specific questions it addressed. The impressions are to be seen as an overview with selective highlights.

The discussion was broad in scope covering issues relating to human-environmental interactions in the Arctic. The concept of sustainable development encourages interdisciplinary thought and approach, seeing social and biophysical processes as interlinked rather than separated. It thus calls for co-operation between natural and social sciences in order to gain a meaningful understanding of the problems and prospects facing northern residents, affecting welfare and viability in the long and short run. Similarly, methodological tools for operationalising sustainable development, such as Environmental Impact Assessments (EIA), have already been developed in the form of Guidelines as part of the Arctic Environmental Protection Strategy (Finnish Ministry for the Environment 1997). The Arctic EIA is a useful and practical model for clarifying understanding of human environmental relations, stressing multidisciplinarity and the need to combine methods and approaches from the social and natural sciences to ensure the sustainability of social systems and natural resources. Such assessments focus on a balance between the four legs of the chair of sustainability – social, cultural, economic and environmental.

The initial reason for holding the workshop was a growing sense of frustration among social and natural scientists and other stakeholders that the social sciences and the human dimension are not fully integrated into Arctic science plans and projects, but rather added as a token element or an afterthought. Also, that the human dimensions of environmental and sustainability issues are neglected. This calls for a constructive dialogue among scientists, policy makers and other stakeholders.

Among the several international Arctic projects and programmes considered at the workshop was the new Arctic Climate Impact Assessment, Implementation Plan, version 3.5. The discussion resulted in a letter drafted and sent to the ACIA Assessment Steering Committee. The letter stated that the ACIA was a timely and important initiative, particularly in view of the potentially large impact climate change is likely to have on the environment, resources and inhabitants of the Arctic. It was, however, emphasized that it is very important that social scientists are actively involved in the development of the ACIA initiative. To date, it does seem that there has been limited involvement of social scientists in the development of the Implementation Plan. The workshop participants were firmly of the opinion that the critical perspectives and methodologies of the social sciences would benefit the work of the Assessment Steering Committee. To sharpen the focus of the chapters which will deal with the impacts on humans and their activities, the workshop recommended the following actions:

- The ASC should include one social scientist with expertise in climate change research.
- The ASC should seek recommendations from the International Arctic Social Sciences Association (IASSA) regarding social science contributions to ACIA.
- The lead authors of the chapters dealing with social science issues should be leading social scientists, or else there must be significant representation of social scientists in the writing teams.
- References to key and cutting-edge social science research on climate change should be included in the Implementation Plan.

The Arctic Climate Impact Assessment project reminds us that human beings have entered the 'Anthropocene', a period where the major changes in

the global biosphere result from human actions. The Arctic is already strongly affected by rapid natural and biophysical changes, and we need to know what adaptive mechanisms societies and cultures in the north have at hand, how they can react, and what determines their reactions. To understand the effects, and the adaptations and welfare of Arctic societies, we need to use the most advanced tools modern social science offers for evaluating these societies and how they interact with exogenous threats and opportunities. The concept of interaction is crucial, as human societies are not just impacted upon, as dead matter; they react creatively within social and cultural structures that guide actions and adaptations of individual actors. Social science can help us better understand how human societies think about and cope with changes.

The promotion of social science is not an end in itself but rather an acknowledgement of the importance of the human dimension and the fact that the reason we worry about the present and the future is that human welfare is at stake. This lies at the heart of most of the interest of policy makers in the light research might bring to bear on large scale environmental changes and how they will affect the lives of the people they work for and represent.

The social science perspective is also crucial in that it reminds us that the causal effects of global biophysical changes are to a large extent social or anthropogenic in nature, affecting natural systems, which in turn affect and interact with human systems. This is important to keep in mind, as large-scale environmental changes are often presented as if they just existed, there to be studied in isolation. The lesson we can learn is that if these environmental changes are caused by social and economic structures and institutions, then the solutions to the problems should also be sought in these structures and institutions, rather then in the environmental factors themselves. It means that we are not dealing with unalterable laws of nature but rather with the results of human actions, changeable through alternative attitudes and lifestyles, worldviews and behaviour.

The problem with many research programmes is that they adopt and imply a simplistic behavioural response to environmental stimuli, not recognising that human societies respond in a different manner to stress than do plants and other animals. To make matters even more difficult, such a simple deterministic view of human society is sometimes combined with a lack of awareness of cultural diversity, not taking into account, for example, that the Arctic is home to a great number and variety of non-indigenous cultures and communities. It is a common problem with otherwise ambitious projects that social science is included as an afterthought or as a token participant, in programmes that are already framed in terms of strict natural science questions. The reverse may also be true sometimes.

Policy makers, decision-makers, and managers all have to reconcile the demands and interests of many constituencies. They also have to embrace the concepts of sustainability and therefore consider the needs of future generations. Decisions must be made based on the best available information and that is where research comes into play. The role of research, free from advocacy, is to provide the knowledge base for illuminating the issues on which judgements must be made. Thus, in the context of sustainable development, we have two distinct components.

First, there is the knowledge base, which provides the best available evidence on a series of questions which require different methods of work:

- What is there? (survey)
- What is changing? (monitoring)
- What are the causes of change? (research)
- How is it likely to change in the future? (prediction)
- What are the options for change and the effects of different combinations? (risk assessment and synthesis)

This, in the words of Oran Young on sustainable development, is "an analytic framework intended to provide structure and coherence to thinking about human/environment relations".

Second, the decisions are made on the basis of the

evidence and the judgement of the politicians and managers. This completes the "framework for organising action and thought pertaining to human/environment relation, to be contrasted with alternative frameworks like environmental protection or sustained economic growth" (Young, 1998). However, the success of the decisions has to be determined – so back to monitoring.

Emerging Research Paradigms

But the issues to be addressed are changing and with them the challenges for researchers. Issues of climate change and its effects, exploitation of natural resources (food, fibre, fuel), impacts of the global economy, employment opportunities, human health, etc., all demand improved information. New technologies certainly will help, but for these to be effective will require changes in research culture. Researchers have to expand their visions and adapt technologies to tackle challenges with three distinct scales:

- Longer time scales, with experiments and observations to distinguish short-term from delayed and adaptive responses, with extrapolation from the present to the future (descriptive to predictive).
- Larger spatial scales, with shifts from local intensive studies to more extensive, regional scale studies, and from analysis of immediate causes to that of more distant causes and consequences.
- Greater complexity, with the focus on multiple rather than single factors, with more understanding of interactions and feedbacks, with synthesis to complement analysis, with greater interdisciplinarity, and with a recognition of non-linearities in the systems.

These changes in focus demand a fundamentally more holistic, systems approach. It is not simply a question of 'We need to do more research' or 'We need more money'. It requires a change not only in research culture and approach, by individuals and institutions, but also in the ways they are supported if we are to generate more usable knowledge.

Usable Knowledge

Research has to generate what can be termed usable knowledge, knowledge and information that illuminate the issues, the ways in which the systems function, knowledge which responds to change, and provides a logical basis for decisions. Thus there are a number of different knowledge claims or key types social science can make, with clear relevance from a policy point of view:

- Documentation of trends and fluctuations, of e.g. markets over time and their variation across the circumpolar region, and putting them on the agenda.
- Verification of cycles, for an understanding of the cyclical behaviour of the many human and environmental systems.
- Empirical generalisations of relationships within the system, both deterministic and probabilistic, such as those that link and show associations between cultural integrity and the survival of language.
- Construction of empirically measured indicators that provide sensitive and interpretable measures of change and can be used to track phenomena relating to human development and the state of the natural capital.
- Construction of formal models, to use deductively for simulations and scenarios which provide explanations of the dynamics of the system and indicate probabilities of future change. Examples include the prisoner's dilemma or tragedy of the commons, directing our attention by the use of analogy/model.
- Simulation models, to help us understand complex systems.
- Different discourses and paradigms such as the implicit values of the Arctic Environmental Protection Strategy and the Sustainable Development projects of the Arctic Council.
- Policy analysis, identifying problems, what we should do, assessment of pros and cons, for helping policy makers understand the full range of consequences and choices.

These types of usable knowledge are generated through research using the different approaches of

survey, monitoring, experiment and observation, prediction and synthesis. To be usable by decision-makers, clear reciprocal communication is essential, using a diversity of methods.

Barriers and Hurdles to Research

So, what are the barriers or hurdles that research has to overcome to address the emerging issues of the Northern Dimension? Whilst there are great strengths in the northern research system, there are some weaknesses which significantly inhibit its ability to address emerging issues:

Personal characteristics. Individual heritage, culture, training and experience bring important attributes to the issues but are often limited to or focussed on current local conditions. Natural defensive and competitive behaviour tends to inhibit wider vision. This position is reinforced by traditional academic discipline courses and by the reward system, which encourages disciplinary depth rather than breadth. At the research level, the emphasis on cutting-edge science, rigorous experimental design, and publication in premier academic journals, discriminates against cross-disciplinary, long-term, broad-scale and predictive studies. The response of individual scientists is to dig deeper within their personal research disciplines. 'Interdisciplinarity is academic suicide' is not an attractive statement to quote but it does still have an element of truth in the real world.

Institutional history and territory. The strength of departments, universities and institutes is usually based on a history of excellence in research in particular disciplines and the reputation of senior members. Therefore there is a natural momentum, enhanced by success in grant awards, to defend the institution and the research lines ('more of the same'). Again, the reward system favours continuity rather than diversification. 'Senior scientists too often equals senile science' was another statement heard at the workshop, coming from a senior researcher.

National boundaries. National boundaries rarely follow environmental patterns and are crossed by economic and social forces. However, national boundaries do retain distinctive political, economic, social, cultural and environmental variations, which influence the controls and responses to global change. Thus, research on emerging transnational issues must reflect both the influences which cross the boundaries and the variations which are contained within the boundaries. However, the funding of research remains primarily national and uncoordinated across national boundaries (with the major exception of the European Commission). Further, within the national boundaries, responsibility for different matters of government are generally delegated to certain traditional departments and ministries. The emerging issues tend to cross these boundaries or to combine their interests. Natural institutional defensive and competitive responses and differing priorities tend to inhibit co-operation – again, the well known 'turf wars'.

Interdisciplinary research. 'Interdisciplinarity is academic suicide' reflects a view held by many. The academic reward system is based on in-depth research, and within disciplines new technical approaches are encouraged. These tend to inhibit communication between disciplines as the jargon develops into new languages. The result is a significant time lag between development of new technologies and their applications in other areas of research.

Limited communication and interaction between the classical natural sciences such as physics, chemistry and biology has tended to maintain their disciplinary boundaries. Similarly, the artificial boundaries between natural, socio-cultural and economic sciences has been maintained by language and methodological differences as well as by the disciplinary territories and associated review and reward systems. In particular, any actions aimed at crossing disciplinary boundaries tend to be added at the end of a funding announcement or research proposal. Interdisciplinary efforts are not an 'add-on' in relation to the issues which have to be addressed; they are central.

Ways forward?

To address the emerging issues, with their larger spatial scales, their longer time scales, and their increasing levels of complexity, research has to balance the dichotomy between (i) the continued search for knowledge of component mechanisms and processes and (ii) the more holistic understanding of how the components of the system combine and interact. Understanding the integrity of the circumpolar system is the main challenge.

How can we overcome the barriers and hurdles that inhibit such integrated research?
Some suggestions are:

- **Education** that provides experience of the circumpolar region. Increased mobility of students and researchers provides experience of human-environment variations and interactions. This has the added value of the establishment of long-term personal contacts across international boundaries.
- **New (or restructured) institutions.** To overcome the weight of institutional and disciplinary history, new structures which have flexibility and motivation, combined with systems expertise, are needed. These may be 'institutions without walls' in the sense of groups of people (consortia) that combine expertise and work across disciplinary and national boundaries.
- **Incentives and rewards.** Higher priority has to be given by funding organisations to interdisciplinary and multidisciplinary research. Correspondingly, the academic system has to adapt its performance criteria to acknowledge the value of such research.
- **Participation.** Knowledge is not the preserve of researchers. Many different stakeholders, including indigenous and local people, have experience and expertise in matters of human-environment interactions. Their involvement in research, not simply as providers or users of information, is an important development.
- **Social science as interface.** The social sciences have an important role to play as an „interface" between the western knowledge tradition and the region's indigenous peoples. Work in fields such as anthropology and the social sciences is intimately connected with northern peoples' own agendas – for cultural preservation and political development. Such disciplines are among the ones in which indigenous people are most likely to pursue advanced study.
- **International funding.** Dependence on national funding for research that crosses national boundaries has proved inadequate to meet the challenges of emerging issues. There is little synchrony between funding systems in timing or in priorities. National funding consortia are increasingly effective and extension of this principle is essential.

Finally, Youth holds the key to progress and they are the stakeholders of the future. They have the flexibility and enthusiasm to overcome the limitations that we have imposed on them by our historical structures and perceptions. They also have the capacity to set aside the paradigms, models and institutional structures that now hinder cross-disciplinary communication and a comprehensive approach to issues and problems facing arctic residents.

Acknowledgements

The Inari meeting was supported by contributions, in cash, in kind, and in other ways, from a variety of co-sponsoring organizations, including the Arctic Centre/University of Lapland, the Stefansson Arctic Institute in Iceland, the Institute of Arctic Studies at Dartmouth College in the United States, the Finnish Ministries of Foreign Affairs and the Environment, the Northern Research Forum of the University of the Arctic, the projects on Human Role in Reindeer/ Caribou Systems and on Sustainable Uses of Living Marine Resources in the Arctic of the International Arctic Science Committee, the DEATNU Project, the Lapland County Union, and the Thule Institute at the University of Oulu.