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Shrub Line Advance in Alpine Tundra of the Kluane Region: Mechanisms of Expansion and Ecosystem Impacts

by Isla Myers-Smith

INTRODUCTION

WITH A WARMING CLIMATE, northern ecosystems will face significant ecological changes such as permafrost thaw, increased forest fire frequency, and shifting ecosystem boundaries, including the spread of tall shrubs into tundra. In northern mountain ranges such as those in the southwestern Yukon, the shrub line will likely advance up mountain slopes with climate warming (Danby and Hik, 2007). This loss of alpine tundra will decrease the success of obligate tundra species such as hoary marmot (*Marmota caligata*), collared pika (*Ochotona collaris*), and ptarmigan (*Lagopus* sp.) (Martin, 2001). Vegetation changes in northern ecosystems are also likely to affect foraging mammals and birds (Hinzman et al., 2005). For example, increases in the biomass of woody shrub species such as willow may reduce habitat for caribou (Sturm et al., 2005a) while benefiting moose (Kelsall, 1972). In addition to modifying wildlife habitat, increased shrub height and density will make traversing tundra more difficult, a problem for hikers and hunters.

In the last 50 years, repeat aerial photography has documented rapid shrub expansion in Arctic Alaska (Sturm et al., 2001a, Tape et al., 2006) and the northern Yukon and Northwest Territories (T. Lantz, University of British Columbia, pers. comm. 2007). Paleoecological evidence suggests that tall shrubs last invaded tundra ecosystems in Alaska and northwestern Canada during the warm post-glacial period, between 7000 and 12 000 years ago (Ritchie, 1984). Growing-season temperatures are again warming in Alaska and western Canada (ACIA, 2004; Chapin et al., 2005), and satellite imagery shows a concurrent greening of the Arctic tundra (Jia et al., 2003; Stow et al., 2004). The correlation between warming and greening has been used to link climate change with shrub expansion (Sturm et al., 2001a; Epstein et al., 2003); however, the mechanisms driving shrub increase are likely more complex. A combination of changes in nutrient mineralization, snow depth, microclimate (Sturm et al., 2001b; Grogan and Jonasson, 2006), disturbance (Forbes et al., 2001; Racine et al., 2004; T. Lantz, University of British Columbia, pers. comm. 2007), and species interactions are all contributing to the landscape patterns of shrub expansion.

Increased shrubs in Arctic and alpine tundra alter the partitioning of solar energy during the growing season, the trapping of snow in the winter, and soil thermal dynamics year round (Sturm et al., 2001b). These changes create feedbacks that alter both the structure and the function of ecosystems (Sturm et al., 2005a). Increases in the density and distribution of tundra shrubs change organic matter inputs to soil, accelerate carbon cycling (Mack et al., 2004), and modify nitrogen dynamics and plant species interactions (Bret-Harte et al., 2002). As the canopy height and expanse of shrubs increase on the landscape, albedo (reflection of light) will decline, and this will create a positive feedback to climate warming (Chapin et al., 2005). Increased shrubbiness is a major structural change to Arctic systems, with implications for alteration of microclimates, biogeochemical cycles, and ecological habitats.

FIELD SITES

My field research is based at the Arctic Institute of North America's Kluane Lake Research Station and remote field camps in the Ruby Range Mountains, Burwash Uplands, and Kaskawulsh Glacier Valley (Fig. 1). Since this region of the southwestern Yukon is located at the convergence of the coastal and Arctic air masses, climate change could lead to increased variability in winter temperatures and precipitation (Northern Climate ExChange, 2006). The study area varies in elevation, aspect, and proximity to glaciers, making it an ideal location to test shrub expansion hypotheses (Fig. 2).

STUDY OBJECTIVES

My objectives for this study are threefold: 1) to quantify patterns of shrub expansion across the landscape in relation to warming and disturbance; 2) to investigate the impact of

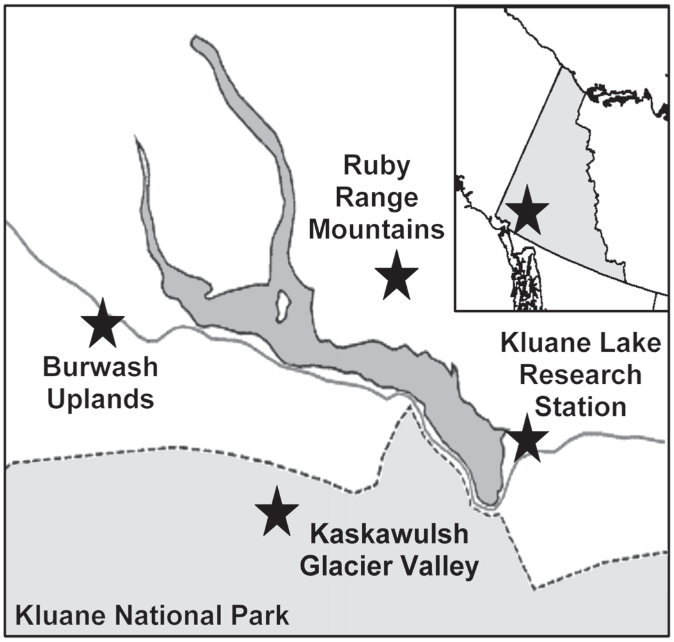

FIG. 1. Map of study region, showing the Kluane Lake Research Station and the three research sites in and adjacent to Kluane National Park.

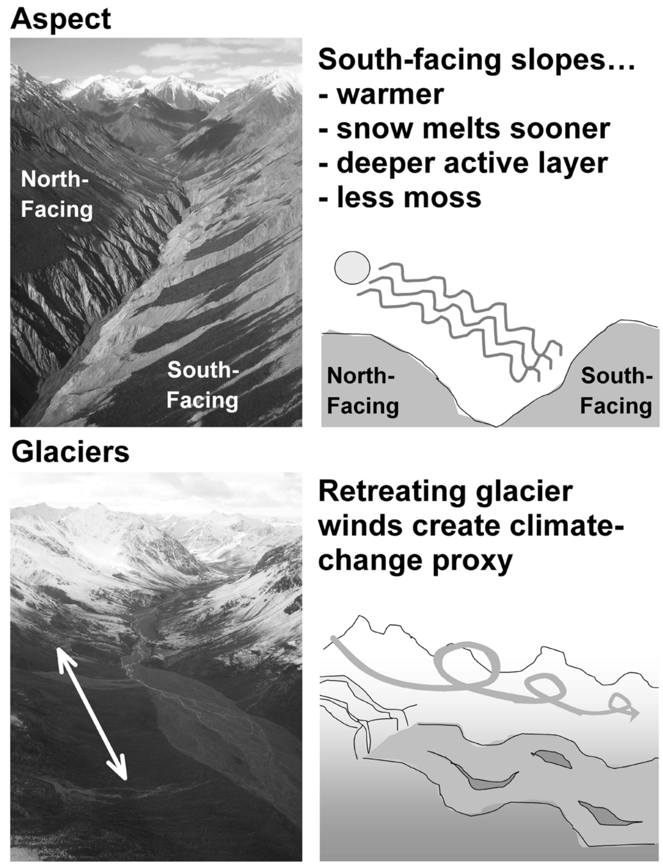

FIG. 2. Proxies for climate variation found in the Kluane region include north- and south-facing aspects and proximity to glaciers.

increased shrubs on ecosystem properties including species composition and carbon cycling and 3) to evaluate experimentally the relative importance of ground temperature and nutrient increases as drivers of shrub expansion.

PATTERNS OF SHRUBS ON THE LANDSCAPE

To quantify shrub expansion, I will compare the age of shrubs at and below the shrub line (the maximum extent at which shrubs occur) through an analysis of growth rings from sections of willow stems. I predict that shrubs growing at higher elevations will be younger and have thinner annual growth rings, though this pattern may differ with aspect and with proximity to the St. Elias icefields. By constructing the historic rates of shrub expansion, I hope to better understand the current and future rates of spread.

Clonal growth of willow is likely to be the dominant form of invasion at the shrub line. Sexual recruitment through seed dispersal might also allow some shrubs to establish above the historic shrub line. Shrub abundance in the Kluane region appears to be correlated with the presence of disturbances, such as drainage channels, soil slumps, landslides, and animal burrows (Fig. 3). I predict that the prevalence of each shrub species and hybrids will differ with elevation and aspect. I also expect to find a higher diversity of shrub species in areas undergoing greater levels of disturbance. Preliminary samples for shrub-ring and genetic analysis of willow shrubs were collected during the growing season of 2007, and further field sampling will take place during the growing season of 2008.

IMPACTS OF SHRUB INCREASE

The potential impacts of shrub expansion are warmer winter soils, enhanced nutrient cycling, and altered plant communities (Sturm et al., 2001b, 2005a; Bret-Harte et al., 2002; Mack et al., 2004). Previously, greenhouse and nutrient-addition experiments and modeling exercises have been used to project impacts of expanding shrub tundra (Walker et al., 2006). In this study, I am investigating species composition, plant phenology, nutrient fluxes and pools, soil temperatures, and other ecosystem-level variables that will be altered by increasing shrubs. Preliminary results indicate that species diversity and the dominance of herb tundra plant species are reduced under a dense shrub canopy.

To quantify the influence of shrub expansion on nutrient cycling and ecosystem function, I am investigating nutrient cycling. I have installed anion and cation exchange resin probes (Plant Root Simulator™ probes from Western Ag Innovation Inc. Saskatoon, Saskatchewan, Canada) to measure ammonium and nitrate bioavailability, and litter bags to quantify the rate of decomposition under shrubs and in adjacent shrub-free tundra. Tying together flux rates, decomposition, and nutrient pools will help to elucidate the impact of shrubs on carbon storage. I hypothesized that rates of CO_2 efflux would be higher under the

FIG. 3. Animal burrows are associated with both the presence and diversity of willow shrubs in the alpine tundra. (Photo: Isla Myers-Smith)

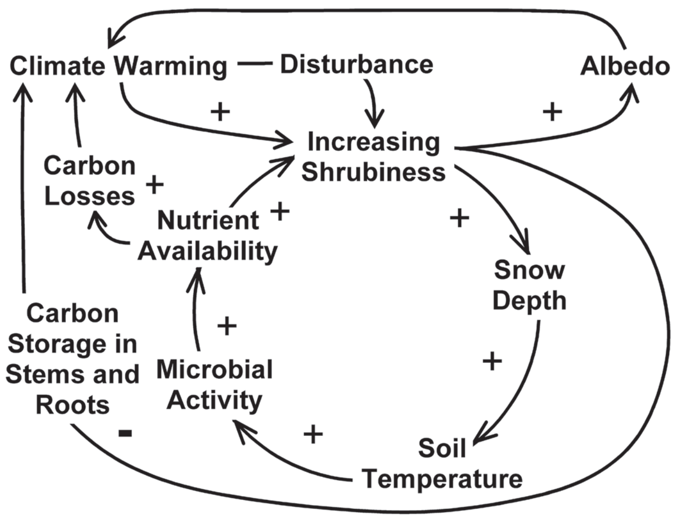

FIG. 4. Positive feedbacks among shrubs, climate change, snow, and nutrients (after Chapin et al., 2005).

shrub canopy during the growing season due to enhanced decomposition and higher autotrophic respiration. To test this hypothesis, I conducted CO_2 flux measurements using a Li6400 infrared gas analyzer (LI-COR Environmental Lincoln, Nebraska USA) from May to September 2007, in plots under the shrub canopy and in adjacent shrub-free tundra. Preliminary data do not show a significant relationship between shrub cover and CO_2 efflux however.

MECHANISMS OF SHRUB INCREASE

Tundra shrubs can significantly modify the distribution and physical characteristics of snow, and influence the exchanges of energy and moisture between terrestrial ecosystems and the atmosphere (Liston et al., 2002). In the winter, snow trapping can insulate soils (by trapping heat)

FIG. 5. Isla Myers-Smith installing snow stakes in September 2007. (Photo: Helen Wheeler)

and has been proposed as a positive feedback mechanism for promoting the expansion of shrubs in the Arctic (Sturm et al., 2001b; Grogan and Jonasson, 2006). During spring, dark-coloured shrubs that extend above the snow alter the albedo and accelerate local snowmelt (Sturm et al., 2005b; Pomeroy et al., 2006). Surveys after snowfall in September 2007 showed much lower reflectance of shrub plots compared to shrub-free tundra plots.

Winter soil warming has also been attributed to enhanced nutrient cycling and reduced soil carbon stores (Mack et al., 2004). During summer, conversely, shading by shrubs decreases soil temperatures under shrub canopies (Pomeroy et al., 2006). Though complex, the interactions between shrubs, snow, and soil warming may act as a positive feedback to shrub expansion (Fig. 4, Chapin et al., 2005). To measure the influence of snow-capture by shrubs on soil warming, I have manipulated shrub cover to compare soil temperatures beneath plots with (a) intact shrubs, (b) shrubs removed, (c) artificial vegetation canopies, and (d) adjacent, shrub-free tundra. In September 2007, six artificial shrub and tundra plots were constructed by cutting down shrubs and affixing them to stakes in the soil in adjacent shrub-free tundra (Fig. 5). Six manipulation plots and paired control monitoring plots are instrumented with snow stakes that have iButton Thermochron temperature loggers (Dallas Semiconductor

Corporation, Dallas, Texas, USA) at 2, 5, 25, 50, 100, and 150 cm along their length, and with Hobo micro station 12-bit temperature sensors (HOBO, Onset Computer Corp., Massachusetts, USA), installed at 2 and 5 cm below the soil surface. The experiment will test whether shrubs trap more snow than the adjacent tundra, whether this snow melts out earlier in the spring season, and how much this snow insulates the soil.

SIGNIFICANCE OF RESEARCH

This study will contribute to our understanding of vegetation changes in northern alpine ecosystems. It will provide data on shrub expansion in the southwestern Yukon, which will contribute to a synthetic examination of shrub expansion in Alaska and northwestern Canada and provide better estimates of the strength of climate forcing mechanisms such as changes in albedo and carbon storage. Improved projections of the trajectory of alpine vegetation change will assist the Yukon territorial government, Yukon First Nations, and Parks Canada to manage their natural resources and ecological capital.

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The Effect of Anadromous Arctic Charr (Salvelinus alpinus) on Food Web Structure and Contaminant Concentrations in Coastal Arctic Lakes

by Heidi K. Swanson

EVERY SPRING, anadromous (sea-run) arctic charr (*Salvelinus alpinus*) hatch in freshwater lakes in the circumpolar North. In the West Kitikmeot region of Nunavut, the charr spend 3–8 years growing in these lakes before beginning annual migrations to the sea (Johnson, 1989). They feed in the sea for approximately 2–4 weeks before returning to freshwater to spawn or overwinter, or both (Johnson, 1989; Klemetsen et al., 2003). Arctic charr are both culturally and economically significant to Northerners and represented more than 40% of traditional-use species harvested in Nunavut between 1996 and 2001 (Nunavut Wildlife Management Board, 2004). They are also vulnerable to a variety of anthropogenic stressors, including climate change and industrial development. Climate-induced changes to migration routes are impacting sea-run arctic charr populations. Migrations are less successful in warm, dry years when flows in migratory streams are not high enough (Svenning and Gullestad, 2002), and increases in temperature can also have negative effects on stock size and recruitment (Power et al., 2000). Some northern communities have already noted climate-induced changes to migration habitat used by sea-run arctic charr and are attempting to restore and manage this habitat. For example, the community of Kugluktuk is currently documenting and teaching youth the history of a traditional fishing area near Bernard Harbour, and the community would like to examine the feasibility of restoring migration habitat for sea-run arctic charr in this area.

Despite the importance and high profile of sea-run arctic charr, various aspects of their ecology remain poorly understood. For instance, little is currently known about how sea-run arctic charr affect the structure and function of freshwater food webs. It appears that their presence may affect top-down or bottom-up changes in food web structure because they can function as both predator and prey in freshwater lakes. Fry and juveniles feed on freshwater invertebrates until the first sea migration, which usually occurs at three to eight years of age, but are also available as prey to resident piscivorous fish such as lake trout (*Salvelinus namaycush*). Once they reach sexual maturity, sea-run arctic charr do not usually feed in freshwater; however, they may require several sea migrations to reach sexual maturity, and until this happens, immature fish may feed in freshwater after their return from the sea in the fall (Rikardsen et al., 2003). This information indicates it is likely that lakes in the Canadian Arctic with sea-run arctic charr populations have different food web structures than those without this species. These differences, in turn, may affect contaminant concentrations.

Heidi Swanson with sea-run arctic charr (spawning male).

The accumulation of toxic contaminants in Arctic biota has been a concern for some time (e.g., Jensen et al., 1997). Many contaminants biomagnify up food webs to reach significant concentrations in top predator species. These high contaminant concentrations pose toxicity risks not only to wildlife, but also to local human populations. Northern residents can be exposed to relatively high concentrations of contaminants through consumption of traditional foods, such as fish and marine mammals (Oostdam et al., 2003). Although concentrations of some older, well-known contaminants such as PCBs seem to be decreasing in the Arctic (Jensen et al., 1997), many people are concerned about increasing concentrations of new contaminants such as polybrominated diphenyl ethers (PBDEs), used in flame retardants, and perfluorinated compounds (PFCs), used in stain repellents (e.g., de Wit et al., 2006; Environment Canada and Health Canada, 2006). The nearly ubiquitous presence of these new compounds throughout the Arctic can be attributed to a combination of local sources (e.g., PBDEs in air from trash incineration) and remote sources (brought by atmospheric or oceanic transport, or both) (Dinglasan et al., 2004; de Wit et al., 2006). Most of these new contaminants biomagnify (Giesy and Kannan, 2001; Van de Vijver et al., 2003).

Previous studies have shown that contaminant concentrations tend to be higher in fish from lakes with long food chains than in fish from lakes with short food chains (e.g., Kidd et al., 1998). To date, it is not known if the presence of juvenile arctic charr lengthens or shortens the food chain to other predatory fish (e.g., lake trout), or whether sea-run arctic charr occupy a higher or lower trophic position than other predatory fish species in freshwater

Marilynn Kullman, a field assistant, fishing at the mouth of the Nauyuk River.

Heidi Swanson uses a "tundra buggy" to move gear between lakes.

lakes. However, it is likely that there are food web–induced differences in biomagnifying contaminant concentrations between lakes that do and do not support sea-run arctic charr populations.

My research questions are: 1) do sea-run arctic charr affect food web structure in coastal Arctic lakes; and, 2) do contaminant concentrations in traditional food fish species (e.g., lake trout and lake whitefish, *Coregonus clupeaformis*) differ between lakes that do and do not contain sea-run arctic charr, and can this difference be attributed to differences in food web structure?

BRIEF DESCRIPTION OF METHODS

Field Sampling and Laboratory Analyses

In summer 2006 and 2007, field research was performed on six lakes (three with sea-run arctic charr and three without) located near Hope Bay, Nunavut. Hope Bay is the site of an underground gold development and is approximately 110 km southwest of Cambridge Bay and 65 km east of Umingmaktok. Invertebrates (*Mysis relicta, Gammarus lacustris*, *Saduria entomon*), ninespine stickleback (*Pungitius pungitius*), cisco (*Coregonus* spp.), lake whitefish, and lake trout were collected from all six lakes, and arctic charr, from three lakes. Laboratory analyses for samples collected in 2006 are partially complete whereas samples collected in 2007 are currently being processed for analysis. All samples are being analyzed for stable carbon (C), nitrogen (N), and sulfur (S) isotopes to determine carbon source, trophic position, and anadromy, respectively. Concentrations of metals (including mercury) and organic contaminants (including PCB congeners and organochlorine pesticides, polybrominated flame retardants, and perfluorinated stain repellents) are also being determined in all samples. For fish that make annual migrations to the sea, microchemistry is being conducted on otoliths to determine age at first migration and frequency of migration.

Data Analyses

Differences in nitrogen sources between lakes can obscure differences in food web structure (e.g, Cabana and Rasmussen, 1996). To correct for this, invertebrates are being used to "normalize" the nitrogen isotope ratios found at the bottom of the food webs. Isotope ratios and contaminant concentrations from fish and invertebrates are also being adjusted for organism size prior to hypothesis testing. In addition to a number of exploratory analyses, I am testing the following null hypotheses: 1) there are no differences in species-specific trophic position between lake types (lakes with sea-run charr versus those without charr); and 2) there are no differences in species-specific contaminant concentrations between lake types. I am also examining migration patterns determined by otolith microchemistry and comparing them to previous records.

PRELIMINARY RESULTS AND DISCUSSION

Approximately half of the samples collected for this study have been analyzed; these represent one lake with sea-run arctic charr and three lakes without this species. During analyses of stable isotopes and otolith microchemistry, I found that there are sea-run lake trout in some of the study lakes, which complicates the analysis but is an interesting finding in itself. Although there has been anecdotal and limited scientific (see Martin and Olver, 1980) documentation of lake trout in coastal Arctic waters, it is generally thought of as a freshwater species. However, lake trout do have the ability to survive in saltwater (Hiroi and McCormick, 2007), and my preliminary results show that sea-run lake trout can be distinguished from their resident (no sea migration) counterparts by stable nitrogen, carbon, and

Morphs of lake trout captured in one of the study lakes.

sulfur isotopes, as well as by strontium concentrations in the otoliths (H. Swanson and K. Kidd, unpubl. data). These are the first isotopic or otolith microchemistry data that show this phenomenon. In addition, I observed a number of colour morphs of lake trout; further investigation is required to determine whether these morphs have different feeding strategies or habitat preferences, or both.

It appears that the presence of sea-run arctic charr in a lake may affect food web structure by providing an alternative prey source (juvenile arctic charr) for resident lake trout. Lake trout had a significantly lower trophic position (as determined by stable nitrogen isotopes) in the lake with sea-run arctic charr than in the lakes without sea-run arctic charr. These results are preliminary, but the data suggest that juvenile arctic charr serve as a high-quality, low–trophic position prey for resident lake trout. If lake trout from lakes with sea-run arctic charr have lower trophic positions, they may also have lower concentrations of biomagnifying contaminants. To date, I have data for only one contaminant, mercury, and these data are from a subset of lakes. It appears, however, that sea-run lake trout and arctic charr have lower concentrations of mercury than resident lake trout and arctic charr. When comparing only resident fish, I found that lake trout have lower mercury concentrations in lakes with sea-run arctic charr than in lakes without sea-run arctic charr. It will be interesting to see whether this pattern holds true once all of the samples have been analyzed, and if the pattern varies with the contaminant analyzed.

RELEVANCE

Results from my research are intended to be applicable to academia, industry, Northerners, and government. Given the current concern surrounding effects of climate change and industrial development on sea-run arctic charr, I anticipate that many community and industry groups will focus habitat restoration or compensation efforts on the migratory habitats of this species. Many of these efforts are made in collaboration with government regulators, such as Department of Fisheries and Oceans. For restoration or enhancement plans to be successful, however, we must first understand the ecological consequences of increasing or restoring these fisheries. For instance, will increasing the numbers of sea-run arctic charr lengthen or shorten food chains to lake trout? Will this change have an impact on contaminant concentrations in traditional food fishes? If so, it is possible that this research will help fishers select freshwater fishing sites that are relatively less contaminated. Also, by increasing our knowledge of the natural variability of migration patterns in this species, my research will be useful in evaluating the success of habitat restorations and enhancements for sea-run arctic charr.

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Heidi K. Swanson, a doctoral student in the Department of Biology at the University of New Brunswick in Saint John, is the recipient of the Lorraine Allison Scholarship for 2007.

AINA NEWS

IPY Publications Database Growing

As of early November, the International Polar Year Publications Database (IPYPD) at <www.nisc.com/ipy> described 321 publications. The database will attempt to identify and describe all publications that result from, or that are about, IPY 2007–08 and the three previous IPYs. The database, part of the IPY Data and Information Service, is expected to grow to approximately 20 000 publications in the next ten years.

The records in the IPYPD contain citations, abstracts, subject and geographic indexing terms, and, in most cases, links to the online full text of the publications. The success of the IPYPD depends on the willingness of IPY researchers, educators and communicators to report their publications, as requested by the IPY Data Policy.

The IPYPD was created by AINA's Arctic Science and Technology Information System (ASTIS), the Cold Regions Bibliography Project at the American Geological Institute, the Scott Polar Research Institute Library at the University of Cambridge, the Discovery and Access of Historic Literature of the IPYs (DAHLI) project at the National Snow and Ice Data Center at the University of Colorado, and National Information Services Corporation.

The Canadian IPY Publications Database at <www.aina.ucalgary.ca/ipy> described 210 publications as of early November. This bilingual database makes the IPYPD's Canadian content available separately. Seed funding for the Canadian component of the IPYPD has been provided by EnCana Corporation.

Diary and Photo Album on Loan to Photo Archive Project

A diary depicting the harrowing 1921 journey of a Vancouver woman on the maiden voyage of a Hudson's Bay Company (HBC) schooner has been loaned to AINA. Frances Gladys O'Kelly made the trip from Vancouver to Tree River, NWT, with her husband, Patrick Thomas O'Kelly, an HBC employee. In her diary, she captured highlights of the five-month-long journey, including the ramming of the schooner by an American tug, a fire onboard, and becoming lost in heavy fog and ice. At one point, the ship was trapped in ice, and the captain believed they would have to spend the winter marooned up north. Fortunately, a few days later the ice broke. O'Kelly wrote, "Everyone smiling and hopeful of getting out of the country now before freeze up." The *Kindersley* did manage to sail out of the Arctic, and O'Kelly and her husband returned to Vancouver, where she continued to live into her eighties.

This generous loan was made to AINA by Vickie Newington, a Calgary resident whose father was raised by Frances and Patrick O'Kelly (his aunt and uncle). The diary and album have been digitized and are available in AINA's online photo archives.

Arctic Issues under Microscope at Gussow

This October, the Arctic Institute of North America collaborated with the Canadian Society of Petroleum Geologists to organize the 2007 Gussow Conference on Arctic Energy Exploration at the Banff Centre. Participants in the two-day conference heard more than 25 experts speak on a variety of issues ranging from northern pipeline development to terrestrial and underwater reserves, Arctic sovereignty, and the potential impacts of climate change on exploration and development. The wide range of topics reflected the changing state of the Arctic and the challenges facing the North. Presenters at the 2007 Gussow Conference agreed that while the Arctic has significant oil and gas resources, the lack of a pipeline and the complex, multi-layered regulatory regime are significant obstacles to oil and gas exploration and development there.

AINA Research Associate Receives RSGS Award

AINA Research Associate Norman E. Hallendy has been awarded the 2007 Mungo Park Medal by the Royal Scottish Geographical Society (RSGS). Dedicated to the memory of Scottish explorer Mungo Park, who died 200 years ago while exploring the River Niger in West Africa, the medal recognizes outstanding contributions to geographical knowledge through exploration or research in potentially hazardous environments. For over 40 years, Mr. Hallendy has conducted ethnographic research in the Eastern Arctic, particularly on southwest Baffin Island, where he spent many seasons traveling with the elders and learning the meaning of the stone *inuksuit*. In 2001, Douglas & McIntyre published Hallendy's definitive book on the subject, *Inuksuit: Silent Messengers of the Arctic*. Mr. Hallendy received the 2007 Mungo Park Medal, according to the RSGS, "in recognition of his distinguished contribution to the study of the people and landscape of the Canadian Arctic."

AINA Continues Active Outreach Program

This fall AINA continued with its busy outreach program and co-hosted several public events. On October 30, Brigadier-General C.T. Whitecross, OMM, CD Commander, Joint Task Force North, Canadian Forces, spoke on Canadian Arctic security issues. The public talk at the Rozsa Centre was jointly sponsored by AINA, the Centre for Military and Strategic Studies, and the Department of Political Science.

On November 5, McGill paleontologist Dr. Hans Larsson spoke on his adventures and discoveries made while fossil hunting in the Arctic and Africa. This talk at the Calgary Zoo was co-hosted by AINA and the Zoo's new Polar Interpretive Centre of Canada.

AINA partnered with the Alberta Global Forum to host a talk on Arctic sovereignty by political scientist Rob Huebert. This late November event was held at the Rozsa Centre.

Also in November, Executive Director Benoît Beauchamp spoke on Arctic issues at the Canadian Society of Petroleum Geologists' Honorary Address. The annual address was held at the Jubilee Auditorium and was heavily attended by public school students as well as members of the general public. Also speaking was Jeff MacInnis, son of deep-sea diver Joe MacInnis. The younger MacInnis spoke on his adventures sailing the Northwest Passage in an 18-foot boat in just 100 days.

AINA Staff Help with Shoreline Cleanup

Silk wedding flowers, one lens from a pair of glasses, and a makeshift coffin containing the remains of a pet hamster were among the 674 pieces of garbage collected along the Bow River by staff of the Arctic Institute of North America (AINA). For the second year in a row, AINA staff volunteered to clean a portion of the riverbank as part of the TD Great Canadian Shoreline Cleanup in September. The group worked the shoreline along Baker Park and collected two bags of trash, which included items such as toys, cans, plastic bags, coffee cups, and the ubiquitous cigarette butts.

The annual event was started 14 years ago by four Vancouver Aquarium employees who decided to clean a small beach. Since that date, participation in the event has grown steadily. This year, more than 50 000 Canadians registered to clean over 1200 shorelines throughout Canada.

Northern Granular Resources Bibliographic Database

The Northern Granular Resources Bibliographic Database at <www.aina.ucalgary.ca/ngr> now describes more than 1730 publications about granular resources (gravel, sand, and crushed rock for use in construction) in the Yukon, the Northwest Territories, and Nunavut. The database also describes publications about surficial geology, geotechnical investigations, permafrost, and ground ice as they relate to granular resources. AINA's Arctic Science and Technology Information System (ASTIS) maintains the database for the Land and Water Management Directorate of Indian and Northern Affairs Canada (INAC).

In order to make publications more accessible to users in the North, over the past five years the Land and Water Management Directorate has devoted considerable effort to the digitization of granular resources reports that were prepared by or for INAC. More than 700 database records now contain links to online PDF files.

New Member Services Coordinator

The Arctic Institute was pleased to welcome Jenny Hoops to the staff in October. After earning degrees in biology and psychology from Queen's University, Jenny worked as a water resources technologist and enforcement officer for Alberta Environment before establishing her own professional speaking and publishing business. Eager to spend more time with her young family, Jenny has taken on the part-time position as coordinator of member services for AINA. In addition to handling new AINA memberships and renewals, Jenny provides administrative support for the Northern Scientific Training Program and the AINA scholarships. Her long-term goals are to expand the AINA membership base and to raise awareness of the scholarship programs available to graduate students conducting research in the North.

AINA Library Collection Relocated

Increased visibility and greater accessibility are two benefits of the relocation of the library collection of the Arctic Institute of North America (AINA) from the MacKimmie Library Tower to the Gallagher Library. The collection had been housed in an out-of-the-way corner in the basement of MacKimmie Tower, a space that did not encourage browsing by people walking to and from other library collections. The Gallagher Library, on the other hand, is located in a busy corridor in the Earth Sciences building.

Especially pleased with the move are some scientists in Earth Sciences. "I've heard from a number of researchers with northern interests who are quite excited that the collection is closer to them," says Northern Studies librarian Claudette Cloutier. And, points out Ross Goodwin, manager of the Arctic Science and Technology Information System (ASTIS), the move will benefit the institute as a whole. "AINA staff who use the collection will have to walk farther, but this move will raise our profile on campus." AINA staff, who are located on the eighth floor of the MacKimmie Tower, regularly access the collection to create new records for the ASTIS database.

CONFERENCES

Arctic Frontiers
20–25 January 2008, Tromso, Norway
Contact: Reinhold Fieler
E-mail: Reinhold@akvaplan.niva.no
Website: http://www.arctic-frontiers.com

Remote Regions/Northern Development Sessions
Western Regional Science Association 47th Annual Meeting
17–20 February 2008, Waikoloa, Hawaii
Contact: Lee Huskey
University of Alaska Anchorage
E-mail: aflh@uaa.alaska.edu
http://www.u.arizona.edu/~plane/wrsa.html

Arctic Discourses 2008
21–23 February 2008, Tromso, Norway
Contact: Silje Gaupseth
E-mail: silje.gaupseth@hum.uit.no
Website: http://uit.no/humfak/arkdisk/4?Language=en

2008 Ocean Sciences Meeting
2–7 March 2008, Orlando, Florida
Website: http://aslo.org/meetings/orlando2008/

Warming of the Intermediate Water Layer in the Eurasian Arctic: Causes and Consequences
2008 Ocean Sciences Meeting
2–7 March 2008, Orlando, Florida
Website: http://aslo.org/meetings/orlando2008/

Ecosystem in Sea Ice Influenced Areas
2008 Ocean Sciences Meeting
2–7 March 2008, Orlando, Florida
Website: http://aslo.org/meetings/orlando2008/

Arctic Marine Communities and Biodiversity
2008 Ocean Sciences Meeting
2–7 March 2008, Orlando, Florida
Website: http://aslo.org/meetings/orlando2008/

Climate Impacts on Sub-polar Seas: Mechanisms of Change and Evidence of Response
2008 Ocean Sciences Meeting
2–7 March 2008, Orlando, Florida
Website: http://aslo.org/meetings/orlando2008/

Arctic Sea Ice Variability Interacted with Atmospheric and Ocean Circulation Patterns
2008 Ocean Sciences Meeting
2–7 March 2008, Orlando, Florida
Website: http://aslo.org/meetings/orlando2008/

Arctic Science Summit Week 2008
26 March–2 April 2008, Syktyvkar, Russia
Website: http://www.assw2008.org

Russia and the Circumpolar World: Transforming Nations, Contested Frontiers
Association of American Geographers 2008 Annual Meeting
15–19 April 2008, Boston, Massachusetts
Website: http://www.aag.org/annualmeetings/2008/index.htm

Carbon and Water Cycles in the Changing Arctic: Past, Present, and Future
Association of American Geographers 2008 Annual Meeting
15–19 April 2008, Boston, Massachusetts
Website: http://www.aag.org/annualmeetings/2008/index.htm

Climate Change and Indigenous Peoples
Association of American Geographers 2008 Annual Meeting
15–19 April 2008, Boston, Massachusetts
Contact: Doug Herman
E-mail: hermand@si.edu
Website: http://www.aag.org/annualmeetings/2008/index.htm

New Generation Polar Research Symposium
4–11 May 2008, Colorado Springs, Colorado, USA
Contact: Sheldon Drobot
E-mail: drobot@colorado.edu
or
Sue Weiler
E-mail: weilercs@whitman.edu
Website: http://ccar.colorado.edu/ngpr/

North by Degree: An International Conference on Arctic Exploration
22–24 May 2008, Philadelphia, Pennsylvania, USA
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or
Robert Peck,
Academy of Natural Sciences
Phone: (215) 299-1138
E-mail: peck@ansp.org
Website: http://www.ansp.org/research/Arctic/

Ninth International Conference on Permafrost
29 June–3 July 2008, Fairbanks, Alaska
Contact: Elizabeth Lilly
E-mail: elilly@nicop.org
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Interactions Between Climate Change and the Fate of Contaminants in Polar Environments, SETAC World Congress
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