Research Links
A Forum for Natural, Cultural and Social Studies

How do we protect Arctic char?

Using otoliths to study migration patterns and assess stocks

Photo: J. Johnson

DFO and Parks personnel angling for Arctic char off Henrietta Nesmith Glacier, Lake Hazen, Ellesmere Island National Park

Vicki Sahanatien, Jim Reist and John Babaluk

Arctic char (*Salvelinus alpinus*) and Dolly Varden char (*S. malma*) are two salmonid species found in national parks north of the Arctic Circle. The migratory nature of these species make them difficult to monitor and manage. However, by analyzing trace element concentrations in the otolith (part of the fish's inner ear), researchers are gathering data about migration patterns and differentiating among populations to understand char life history.

CHAR DISTRIBUTION AND MIGRATION

Arctic char have a circumpolar distribution (Johnson 1980) and are found in numerous lakes and rivers in Ellesmere Island National Park Reserve (EINPR), Auyuittuq, Tuktut Nogait and Aulavik National Parks. In Canada, northern form Dolly Varden char are restricted to the Northwest Territories and Yukon North Slope region from the Mackenzie River west to Alaska (Reist et al. 1997). In Ivvavik National Park (INP), Dolly Varden char is most common, and relict Arctic char populations are present in only two lakes.

Char are of interest throughout Arctic Canada for sport, subsistence and commercial fisheries. The sensitivity of Arctic char and Dolly Varden char to intensive fishing pressure has been documented across the Arctic and severe catch restrictions have been imposed where necessary. Char are very susceptible to exploitation because they concentrate predictably in time and space during spring and fall migrations at the mouths of rivers, in spawning habitats and in over-wintering habitats. The life histories of both species reflect their adaptation to the extreme conditions and low productivity of mid- and high Arctic environments. Char biology and limited productivity contribute to low annual recruitment and reduce a population's ability to rebound if it becomes depressed.

Water systems inhabited by char can be open or closed. Open systems allow organisms, water and nutrients to flow in from many sources and to flow out in many directions. The Dolly Varden char of INP annually migrate down the Firth River over 100 km to the Beaufort Sea; travel unknown distances along and away from the coastline and Park to exploit richer marine areas during the summer feeding season and then return. The char are exposed to fishing pressure throughout the migration. The closed systems may only receive spring melt as input and may or may not have outlets, thus having fewer food and habitat resources which cycle primarily within the system. These systems are comprised of lake resident char populations that cannot (e.g., Arctic char in INP lakes) or do not migrate (e.g., Lake Hazen Arctic char in EINPR). Because of lower productivity and smaller population sizes, char in closed systems can be more vulnerable to disturbance and fishing pressure.

To what extent can a national park protect char populations? In the case of the open char ecosystems of INP, only habitat within the park is protected. By chance, the most vital and limited habitat is found within park boundaries: namely the spawning and over-wintering areas. Conservation of char populations in Arctic national parks is and will be an increasing challenge. For this reason, char research programs have been active in recent years.

OTOLITH MICROCHEMISTRY

Otoliths are a part of a fish's inner ear composed primarily of calcium carbonate which is deposited in annual layers (annuli) as the fish grows (Mugiya 1964). Rapid deposition during high growth summer periods followed by slower deposition during low growth winter periods makes this bony structure a good indicator of age.

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FEATURE ARTICLES

DEPARTMENTS

FRANCOPHONES

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SUBMISSIONS WELCOME FOR THE SPRING ISSUE. SEND EXPRESSION OF INTEREST BY NOVEMBER 15, 1997.

EDITORIAL

Research Challenges in Canada's North

This issue of *Research Links* presents several articles about on-going monitoring and research projects in National Parks "North of Sixty." Northern Parks have been able to advance a program of research and monitoring to preserve ecological integrity, ecosystem health, and cultural landscapes in spite of many challenges experienced over the last 10 years. Northern research and monitoring are the result of innovation, cooperation, and approaching the development and delivery of programs with what one would call a "non-standard paradigm."

The results achieved by Parks Canada are remarkable given the fluid nature of the working landscape and the need to cope with operating costs involved in quality monitoring and research activities in the north which can be 30% higher than those for southern parks. To get from one end of the new Territory of Nunavut to the other, takes at least 3 hours by jet. Airfares to the field (there are no roads in the eastern Arctic) can be $3,000 per return ticket. Parts of the western Arctic are accessible by road but the time required to move from one point to another is costly. Field support and accommodation charges are high in all parts of Canada's North. In addition, there is little access to a resident or university science and research community as there is elsewhere in the country.

Northern research and monitoring programs are closely tied to land claims, and other programs and activities of the aboriginal peoples surrounding parks and sites. All national parks and historic sites have some form of joint parks management committee, resource and wildlife board, or community advisory committee which are actively involved in the planning and management of research programs. Increased stakeholder involvement has meant a corresponding increase in consultation time, and a redefinition of approaches to research design. In many cases, cooperative efforts result in better quality projects, long-lasting decisions with community support, and the active integration of traditional ecological knowledge directly into Parks Canada programs.

This interdisciplinary perspective has resulted in opportunities for cooperation with other government agencies and institutions of public government, which would not have taken place 10 years ago. Several of the articles featured in this issue are based on cooperative research projects. Agriculture Canada was involved with human use impact work in Ellesmere Island and Auyuittuq National Parks, the Department of Fisheries and Oceans (DFO) was instrumental in Arctic char research, and the Canadian Centre for Remote Sensing, NWT, has been providing weather satellite data for northern vegetation monitoring.

Parks throughout the Northwest Territories and the Yukon have been developing a suite of monitoring protocols which will provide direction and support the effective delivery of monitoring programs. Results from these programs must tie directly to Parks Canada's mandate, including actively using results in business planning, meeting CEAA (Canadian Environmental Assessment Act) obligations, ecological integrity statements and park management planning. Of necessity, research must be applied, and research results must be communicated and presented regularly outside Parks Canada to ensure program support.

In future years, the success or failure of northern research and monitoring programs will depend very heavily on the restructuring of research design to ensure value is being produced for the expenditure of limited resources, and on the ability of managers to communicate and cooperate with aboriginal stakeholders, research groups and institutions of public government and with other research groups working within Northern Canada. With this support, well designed research and monitoring projects will not be jeoparized, as the costs of delivery increase, and as the availability of trained Canadian northern researchers decreases.

Bruce Rigby
Manager, Ecosystem Secretariat
Nunavut Field Unit

EDITORIAL BOARD UPDATE

WELCOME!

We formally welcome two new members to the *Research Links* Editorial Board:

Chuck Blyth

Chuck Blyth has worked in Parks Canada since 1979. Prior to that he researched grizzly bear habitat in Banff. His previous roles in Parks include resource management planner in the Western Regional Office, senior park warden and biologist for Elk Island National Park, chief park warden for Nahanni and National Warden Service Coordinator in Ottawa. He is currently in Fort Smith as the Ecosystem Secretariat manager for the southwest Northwest Territories unit.

Robert Coutts

Robert Coutts is an historian with the Cultural Resource management unit of the Western Canada Service Centre in Winnipeg. He has worked extensively in the areas of Native and fur-trade history and serves as the regional Parks coordinator for the Federal Heritage Buildings Review Office. He is also co-editor of the provincial journal *Manitoba History* and author of the book *Voices from Hudson Bay: Cree Stories from York Factory*.

THANK YOU!

We extend our sincere thanks to John McIntosh for his long-term commitment to the *Research Links* Editorial Board. John has been offering his expertise to *ResearchLinks* for over three years. We will miss his keen eye for punctuation and his encyclopedic memory for scientific names. John continues to work in Pacific Rim National Park Reserve as Conservation Biologist for the Ecosystem Secretariat.

FEEDBACK

Tangled Web

Thank you to all our readers who provided feedback regarding their difficulty finding *Research Links* on the Internet.

It is true it can be very difficult to access *Research Links* on "the web." For some time, we have been behind with the electronic versions of our issues, and it seems that even these dated issues are often inaccessible. We are currently working with the graphics departments in Calgary and Banff to provide you with more direct access to the electronic version of *Research Links* in the future.

For the time being, we are not linked to the Banff Homepage. We will keep you updated on our electronic status and pass on a new web page address when available.

Thank you for your patience.

Dianne Willott
Production Editor, Research Links

Beyond Boundaries:

South Nahanni Woodland Caribou

Doug Gullickson

PHOTO NOT AVAILABLE

Photo: Doug Gullickson

INTRODUCTION

Greater park ecosystem research and management are fundamental to maintaining the ecological integrity of Nahanni National Park Reserve (NNP). Boundary selection during the establishment of NNP emphasized protecting the South Nahanni Watershed from hydroelectric development. The resulting park area is a linear corridor centered on the South Nahanni and Flat Rivers that affords only partial protection for several large mammal populations, most notably western woodland caribou (*Rangifer tarandus caribou*). To date, the relative isolation of the southern Mackenzie Mountains has served to protect the regional ecosystem. However, existing and impending land use activities such as mining, oil and gas exploration, outfitted big game hunting, tourism and uncontrolled road access have the potential to negatively affect the ecological integrity of NNP.

NNP conducted field investigations from March 1995 - March 1998 to provide baseline biological data on the demography and seasonal distribution of the South Nahanni Woodland Caribou Herd (SNH). Parks Canada sponsored the three-year study to:

- further the "greater park ecosystem" concept,
- address the concerns of local First Nations,
- develop partnerships with territorial wildlife agencies, and
- provide baseline information regarding habitat protection and population viability for woodland caribou within and migrating beyond the boundaries of NNP.

BACKGROUND

Compared to barren-ground caribou and mountainous woodland caribou populations in the Yukon, little effort has been invested to research, protect or manage this subspecies in the Northwest Territories. As an informed guess, Bergerud (1980) suggested a total population of 10,000 woodland caribou for the entire Mackenzie Mountains. Lortie (1982) tentatively identified the three major migratory herds for the Selwyn-Logan-Mackenzie Mountains Region—the Bonnet Plume Herd, the Redstone Herd and the South Nahanni Herd (SNH).

The SNH is estimated at 2000 to 3000 caribou but a population census has yet to be conducted (Farnell pers. comm. 1994). NNP and periphery provide the herd's only known winter range (Lortie 1982). Observations of park staff since the 1970's indicate that large numbers of woodland caribou migrate into the park area during late autumn and out of the park area during early spring, using the South Nahanni River Valley as the principal migration corridor. Virtually no information was available at the outset of the study regarding the herds population size, composition or seasonal distribution during the calving, summer and autumn rut periods.

METHODS

The study consisted of four main components: seasonal distribution and movements, population composition, winter forage quality and winter forage availability. Researchers studied the seasonal distribution and movements of 25 adult female caribou radio collared on late winter range in March 1995. Radio collared caribou were surveyed by fixed wing aircraft during winter, calving, post-calving and autumn rut periods over the three-year study period. Helicopter classification surveys were flown over

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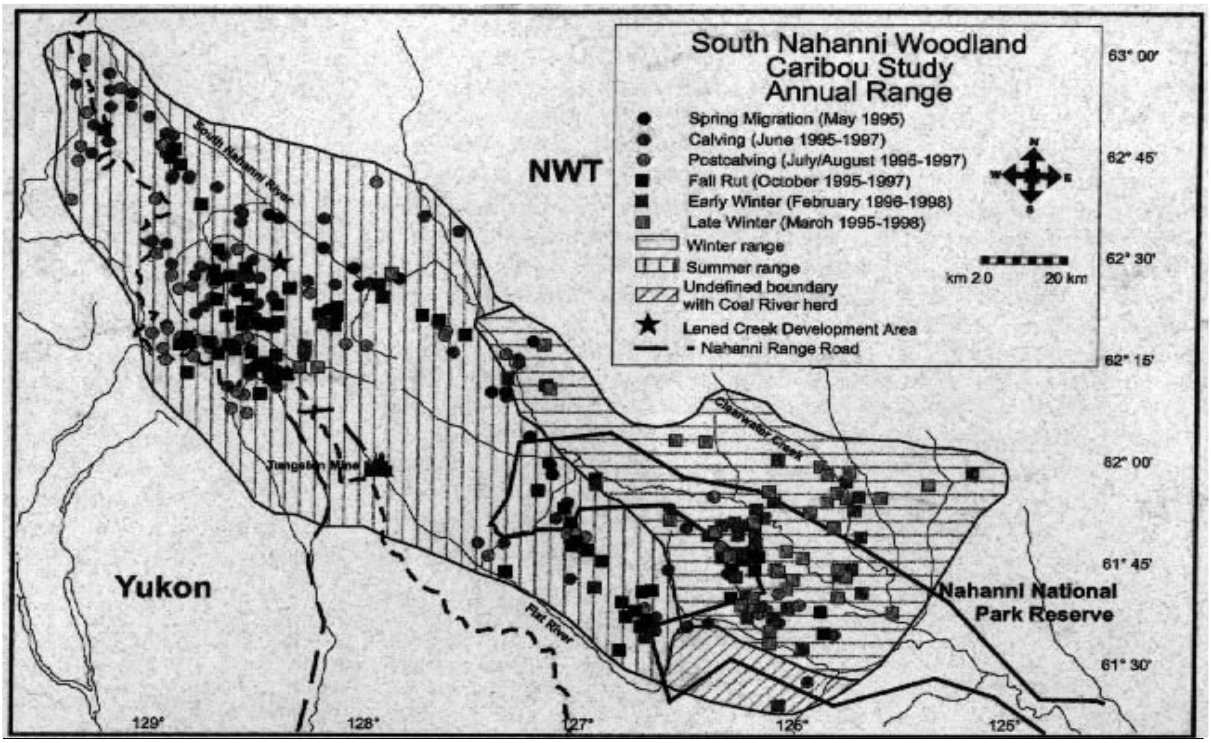


The Big Picture:

Monitoring Northern Ecosystems from Weather Satellites

Stephen McCanny

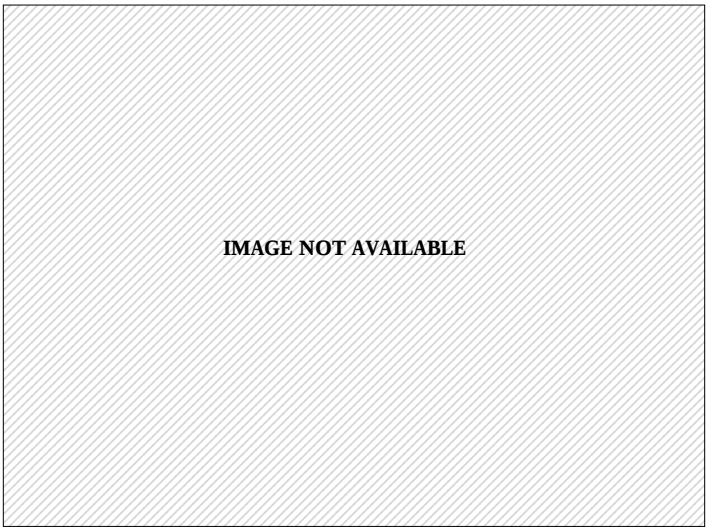
Photography is a standard tool in monitoring. But what if your subject is hundreds of kilometres across? The solution, of course, is to step further back. Satellite monitoring of parks has been discussed for many years and has provided us with some startling images from space. The question is whether this technology can become a regular part of a monitoring program, providing meaningful data about greater park ecosystems.

Cost and availability are major obstacles in using satellite images. Standard LANDSAT Thematic Mapper images (digital photos used for land mapping) cost several thousand dollars without analysis. These images are taken every two weeks for a given area, yet good quality (cloud-free) images may not be available for a specific year. Many LANDSAT images are required to cover the regional ecosystems of our large northern parks. The NOAA weather satellites overcome these obstacles by providing inexpensive (sometimes free) images of earth as often as four times daily. The images cover large portions of the North American continent, so it is easy to place Canada's northern parks in the context of their larger ecosystems. The tradeoff is that the images have a coarse resolution making it possible to examine only landscape patches larger than a square kilometer.

Weather satellite data can be analyzed in much the same way as the more detailed land mapping data for landscape classification and plant growth estimation using the Normalized Difference Vegetation Index (NDVI—an index of green vegetation). The images are available so frequently that it is possible to study the rhythm or phenology of the seasons.

In 1997, Parks Canada set up an agreement with the Centre for Remote Sensing in the Northwest Territories government to analyze weather satellite data for three parks: Wood Buffalo, Ivvavik and Ellesmere. Images with less than 10% cloud cover were analyzed for the months of May, June, July and August. Snow cover was measured for May and plant growth (NDVI) was estimated through August for all three parks. The area of forest fires in and around Wood Buffalo National Park was also estimated.

Snow cover and plant growth analyses were conducted on twenty selected sites in each park. These sites were 10 km^2 and each consisted of fairly uniform vegetation. Snow cover and NDVI followed a predictable north-south gradient (Table 1), with longer lasting snow and lower productivity in the high arctic (Ellesmere). The sum of the NDVI values for the growing season (Total NDVI) can be calibrated to the weight of annual plant growth if required. However, the raw index is generally sufficient to compare growth from year to year.



NOAA satellite image of EINP three weeks after polar dawn

The area of burned forest in and around Wood Buffalo (Table 1) represents 24 patches larger than 50 km^2 or approximately 2.5% of the landscape. Since it is difficult to distinguish current-year burns from 1 to 5 year old burns, this number represents a cumulative total.

Snow cover was absent from the coastal area in Ivvavik in the spring time. This area also lagged behind the rest of the park in NDVI during June, probably as a result of the ice pack's moderating effect on temperature. Vigorous regeneration appeared to be occurring in the recent burns in Wood Buffalo. These areas had higher NDVI values than other vegetation types. Plant growth in Ellesmere was barely detectable by the NDVI method, but indicated that signs of productivity were more consistent in the Lake Hazen area than in Tanquary Fijord.

One of the advantages of satellite interpretation is the extensive collection of images that have been archived for different satellites over the past few decades. We are in the process of analyzing baseline data for the 10 km^2 sites in the parks of the Nunavut Field Unit. These weather satellite images date from 1984 to 1995 and give us a point of comparison for our monitoring data.

The Canadian Centre for Remote Sensing (CCRS) has prepared a Canada-wide landscape classification using weather satellite data. Parks Canada will also work with CCRS and the Manitoba Centre for Remote Sensing to access biweekly cloud-free data for all of Canada. The objective is to deliver timely images of each northern park ecosystem and provide annual summaries of growth and snow cover. Modern data management means these pictures and data will become a regular part of park operations in the north.

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Table 1: Snow cover, plant growth and forest fire area for three northern parks in 1997

National Park	Snow Cover in May (%)	Total NDVI	Forest Fire Area (km^2)
Ellesmere	94	0.09	—
Ivvavik	66	0.53	—
Wood Buffalo	32	0.87	6462

LIFE HISTORY OF CHAR

These two species of char exhibit fundamental differences in life history which must be taken into account during management. Dolly Varden char are primarily adapted to riverine environments, whereas Arctic char primarily occupy lacustrine (lake) environments, using rivers as migratory pathways. Both species are iteroparous (i.e., spawn several times over their life) but they differ with respect to the timing of key life history events. Anadromous forms of northern Dolly Varden char smoltify (i.e., make the transition from early life history exclusively in freshwater to annual migrations to the sea) earlier than Arctic char (3-5 years vs. 4-7 years). Similarily, Dolly Varden char mature earlier (5-7 years vs. 4->10 years). Dolly Varden char are much shorter lived than Arctic char (12-15 years vs. 38 years in EINPR).

Char in INP exhibit four life history types (Reist 1989): 1) anadromous Dolly Varden char that migrate annually between freshwater and the sea after living the first few years of life in freshwater; 2) stream resident (residual), non-anadromous Dolly Varden char, mostly small, male char that use the same freshwater habitats as anadromous char; 3) isolated, stream resident Dolly Varden char that cannot migrate due to impassable barriers, such as waterfalls and; 4) lake resident Arctic char that do not migrate to sea. Arctic char exhibit anadromous and non-anadromous, residual life history types as well as non-anadromous, lake dwelling populations (Johnson 1980). The Arctic char of EINPR, that have been studied to date, consist of non-anadromous lake dwelling populations only despite the opportunity to migrate to sea. In lake dwelling populations, distinct growth forms typically occur and in Lake Hazen, two morphotypes, small and large, are known (Reist et al. 1995). The diversity present in char populations is largely unknown in Arctic Canada, thus this knowledge and the life history characteristics of particular char populations must be understood for their conservation, management and protection.

Also, the chemical constituents of annuli do not resorb during the fish's lifetime, thus otoliths contain a permanent record of trace elements, such as strontium (Sr), that are taken up from the surrounding water environment.

Scanning proton microprobe (SPM) analysis uses the x-ray spectrum emitted by an otolith that has been bombarded by protons to identify the amounts (in ppm) of trace elements (in this instance Sr). Portions of the SPM studies of EINPR and INP char have been completed (Babaluk and Reist 1996, Babaluk et al. 1997a, Babaluk et al. 1997b) and the studies are continuing in conjunction with the universities of Guelph and Manitoba.

ANADROMOUS OR NON-ANADROMOUS BEHAVIOUR

SPM analysis of otolith Sr can help researchers understand the life history strategies of a char population. Otolith cross section Sr scans can provide information on the chemical nature of the aquatic environments experienced by the fish over its lifetime. Marine environments have higher Sr concentrations than freshwater, so large variations in otolith Sr concentrations are associated with migrations from freshwater to marine environments. SPM line scans of otolith Sr can be used to determine anadromy, the age of first migration to the sea and the number of such migrations (Babaluk and Reist 1996, Babaluk et al. 1997a).

The typical otolith Sr profile of known non-anadromous Arctic char or Dolly Varden char is relatively "flat" with only small Sr variations over time (Figure 1A). However, the typical Sr profile of known anadromous char (Figure 1B) is "flat" until year 7, in this case, when large oscillations begin, indicating migrations to the sea. The Sr profiles of otoliths from Lake Hazen Arctic char were similar to those illustrated in Figure 1A, indicating that the char were non-anadromous (lake resident). Otolith Sr profiles similar to Figures 1A and 1B were evident in Dolly Varden char from various rivers in INP indicating that both anadromous and non-anadromous forms were present.

STOCK ASSESSMENT

Preliminary results have shown that SPM spot analysis may be useful for differentiating populations of Arctic char and Dolly Varden char (Halden et al. 1996, Babaluk and Reist 1996, Babaluk et al. 1997b). The otolith Sr concentration results from INP showed that lake resident Arctic char can be clearly distinguished from all forms of Dolly Varden char sampled (Table 1). A difference was also found between the Canoe River/Babbage River and Firth River/Joe Creek systems. Further, it appears that the Firth River and Joe Creek populations can be recognized as distinct biological populations which confirms understanding gained from previous genetics research (Reist 1989). Further studies are being conducted on char from these systems.

BIOLOGICAL DIVERSITY

Char are known to vary widely in form (size and shape) and colouration (green, blue or brown; with or without spots) (Johnson 1980). This diversity can be readily observed within lake populations from Lake Hazen in EINPR (Reist et al. 1995). To date the most common and reliable means of differentiating species of char has been the use of meristic data (e.g., gill raker and pyloric caeca counts) (Reist et al. 1997) but such approaches also show promise for understanding sub-specific diversity in chars. Database compilations of the biological, morphometric and meristic information for all char sampled to date from EINPR and INP are in progress.

Advances in genetics research, specifically mitochondrial DNA control region sequencing, will provide additional quantitative methods to plan for and evaluate conservation of intra- and inter-specific diversity within char. Genetic structure investigations continue in both EINPR and INP (Brown Gladden et al. 1995, Maiers 1998, J. Reist, DFO, Winnipeg, pers. comm. 1998).

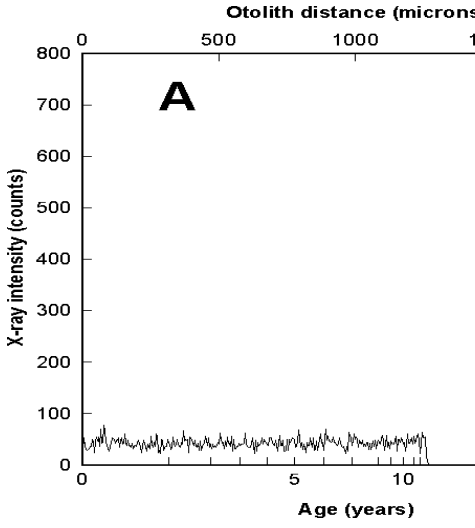

Figure 1. Typical Sr profiles from scanning proton micro

tect Arctic Char?

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Table 1. Summary of micro-PIXE analytical data from otoliths of char from Ivvavik National Park. Strontium concentrations are expressed as parts per million plus or minus one standard deviation.

Location	Life history	No. of otoliths /no. of analyses	Mean Sr conc. (ppm) ±1σ
Canoe River	anadromous	8/24	387 ± 33
	residual	8/24	431 ± 25
Babbage River	isolated resident	7/21	311 ± 11
Joe Creek	anadromous	7/21	466 ± 15
	residual	8/24	456 ± 20
Firth River	anadromous	7/21	541 ± 22
	residual	8/24	514 ± 14
Lake 103	resident	7/21	287 ± 8
Lake 104	resident	4/12	282 ± 4

UNDERSTANDING AND MANAGING CHAR IN ARCTIC NATIONAL PARKS

The next step for EINPR and INP is to consolidate all the current data and knowledge to describe the ecology and status of Arctic char and Dolly Varden char populations. By bringing together pieces of the puzzle it is possible to develop models that may be used for conservation, management and protection purposes.

In open char ecosystems, such as those of INP, the future must be anticipated. These populations may come under greater fishing pressure as visitor use of the Park increases and if other stocks outside Park boundaries become depleted. The degree of

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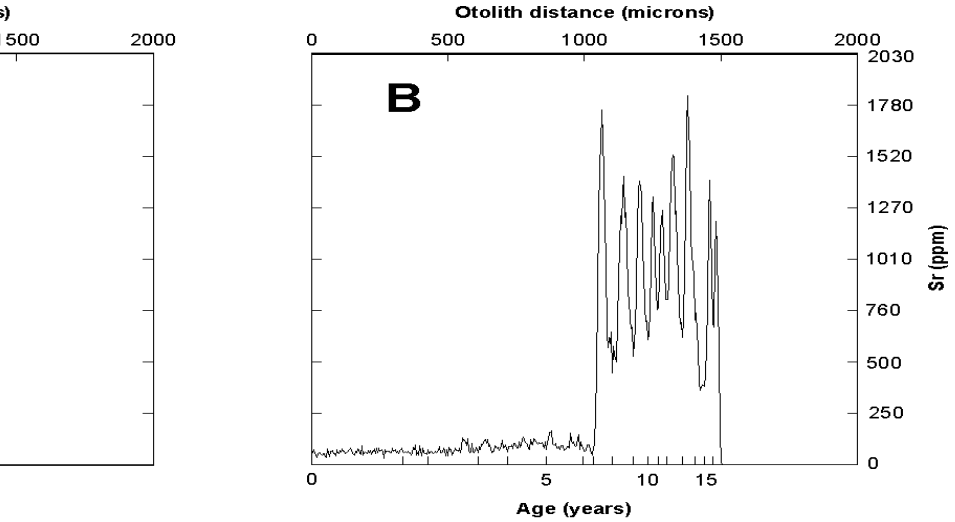


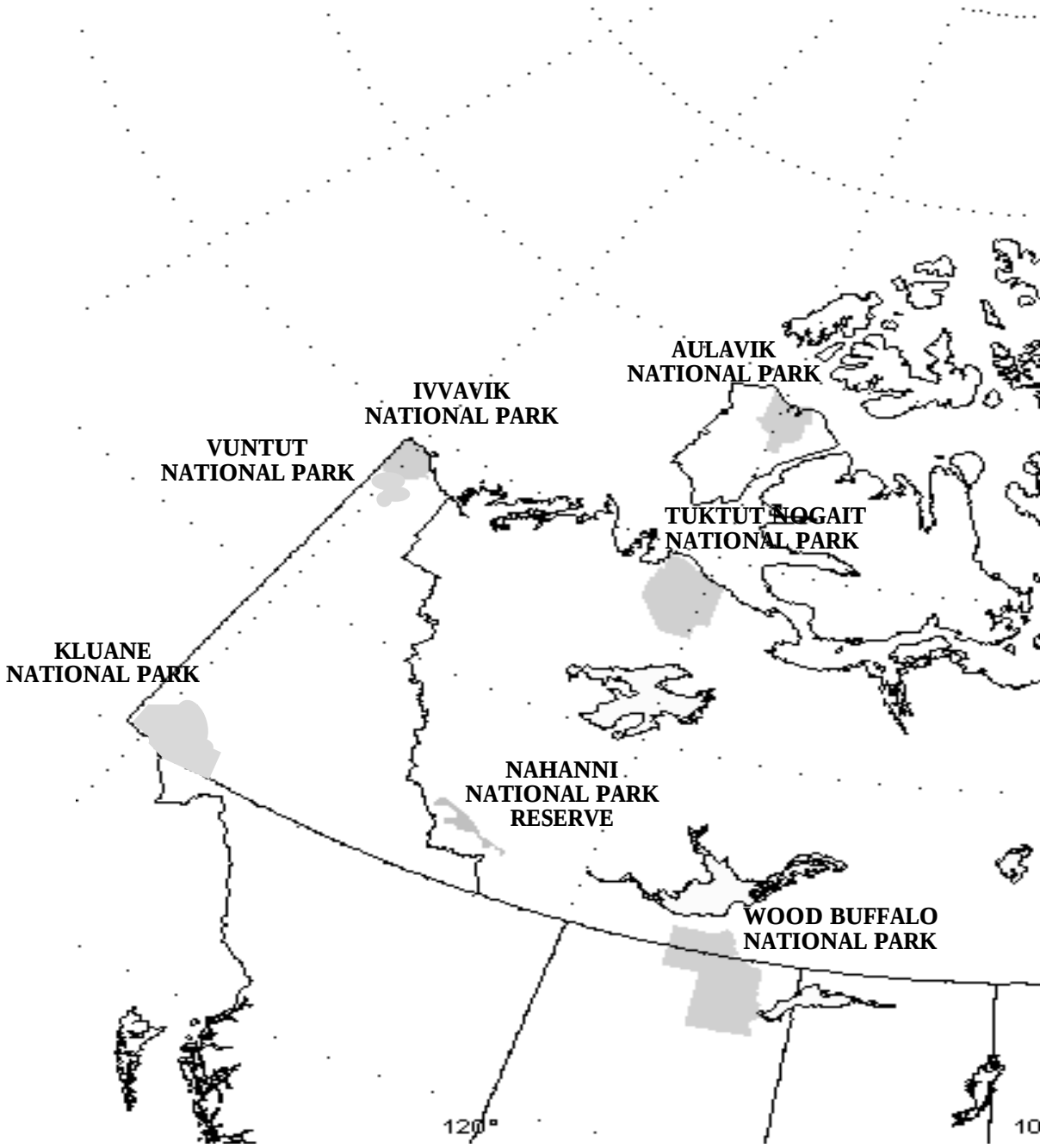
probe line scans of otoliths from a known non-anadromous char (A) and a known anadromous char (B).

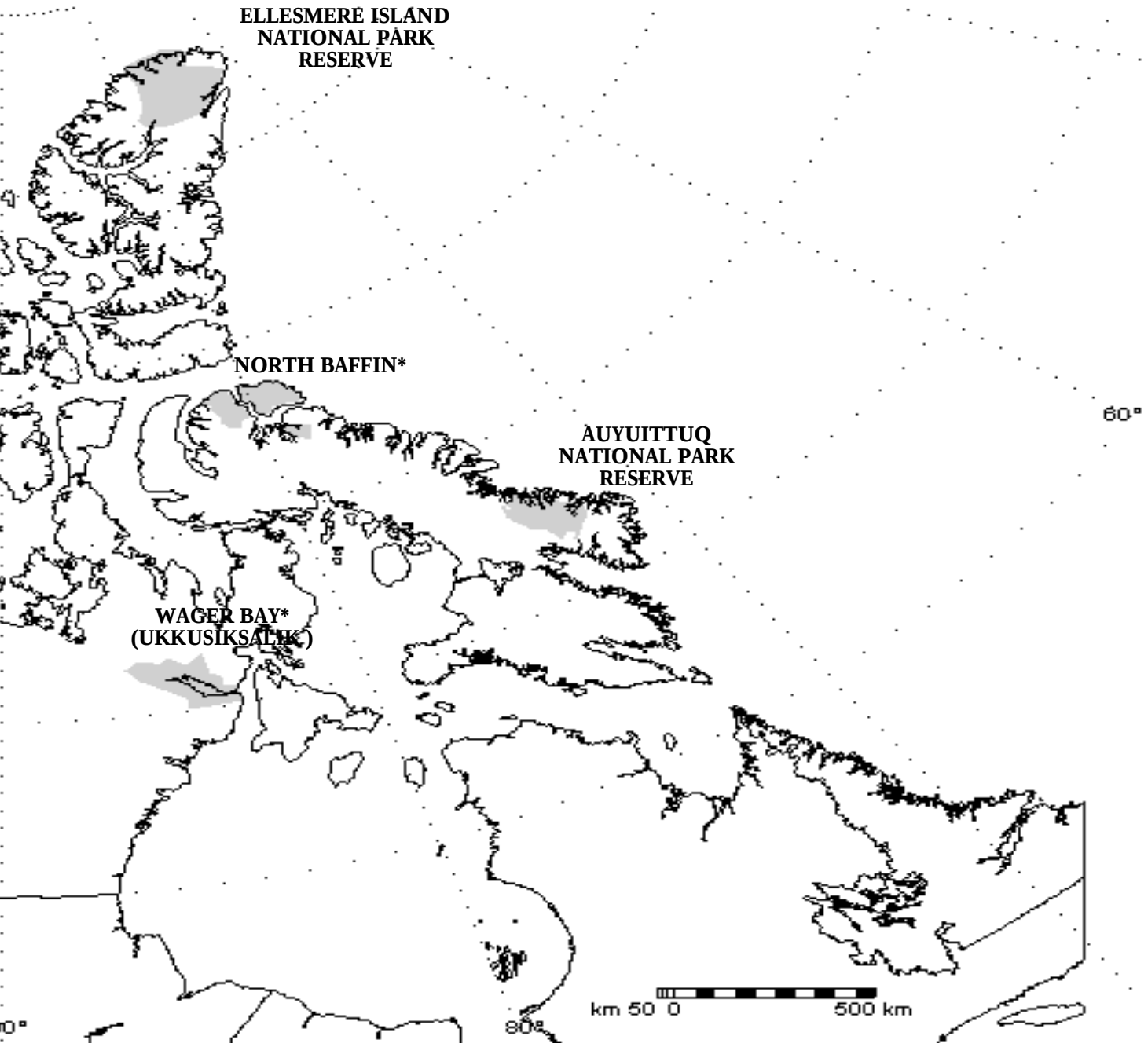
Cooperative Research

As a result of the impetus of Comprehensive Land Claims settlements in the Canadian Arctic, Parks Canada has established an ongoing research partnership with the Department of Fisheries and Oceans (Arctic Fish Section, Winnipeg) for char studies in Arctic national parks. The program in Ellesmere Island NPR follows investigations initiated by the Fisheries Research Board of Canada (precursor to DFO) dating back to the 1950's prior to park establishment (Hunter 1960, Johnson 1983). The program in Ivvavik NP follows joint investigations by DFO and the FJMC conducted prior to park establishment (e.g., Reist 1989). The goal of these research partnerships is to develop sufficient understanding of char diversity and ecology to provide the basis for appropriate management and protection decisions. As such, the studies have been wide ranging: population dynamics, hydroacoustic enumeration, assessment of genetic and morphological diversity re-evaluation of char age determination techniques, investigations into life history strategies and movements using radiotelemetry and mark-recapture methods, otolith microchemistry using scanning proton microprobe analysis, habitat assessment, diet analysis and parasitology.

Normal and dwarf Arctic char

National Parks of the North




ELLESMERE ISLAND
NATIONAL PARK
RESERVE
NORTH BAFFIN*
AUYUITTUQ
NATIONAL PARK
RESERVE
WAGER BAY*
(UKKUSIKSALIK)
60°
km 50 0 500 km
80°
National Park/National Park Reserve
* Not yet designated as a National Park

Beyond Boundaries:

South Nahanni Woodland Caribou

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autumn rutting range during October of each year to estimate sex ratio and calf recruitment. Composite fecal samples were collected on late winter range (1996–1998) and analyzed to estimate late winter diet and forage quality. Winter feeding sites were assessed for snow depth and density during March (1996–1998) to estimate winter forage availability.

RESULTS

Radio telemetry contacts and visual observations over the three year study found the SNH to inhabit a winter range of approximately 4,000 km^2 within and adjacent to NNP. A snow gradient survey of the herd's total range suggests that traditional winter range is located in a "snow shadow" region similar to woodland caribou ranges in British Columbia and Yukon (Bergerud 1978, Farnell and Russell 1984, Farnell and McDonald 1987, Farnell and McDonald 1989, Hatler 1986). Annual herd fidelity to winter range suggests that these areas have a biological significance essential to herd welfare (Farnell et al 1991) and that this behaviour is primarily an obligatory response to climatic conditions (Farnell and McDonald 1990). Estimates of forage quality and availability on late winter range indicate that these variables were not limiting caribou survivorship during the three-year period. Analysis of winter fecal samples revealed a high incidence of lichens combined with graminoids and a low incidence of moss indicative of a high quality late winter diet (Russell pers comm 1995). Snow depth and density measurements conducted at randomly selected late winter feeding areas found favorable cratering conditions for all but one of the 43 sample sites.

The SNH was more dispersed during calving, post-calving and autumn rut periods with an overall annual range of approximately 16,000 km^2 located principally within the upper South Nahanni Watershed. The longest seasonal migration was between winter and calving periods with a mean annual straight line distance of 109.3 km (S.E.=9.6). Calving behavior was typical of woodland caribou populations in mountainous environments with adult females highly dispersed in alpine habitats over much of the herd's total range. Radio-collared caribou displayed fidelity to these calving locations with 52% located within a 15 km radius of previous calving periods (n=21). This dispersal pattern is theorized to reduce the vulnerability of newborn calves to predators and make use of previously successful sites (Bergerud et al 1984).

Radio-collared caribou dispersed widely in subalpine or alpine habitat after calving, with several groups observed on alpine snowpatch areas, presumably to obtain relief from heat stress and/or insect harassment (Ion and Kershaw 1989, Farnell and McDonald 1990). The distribution of caribou during the autumn rut period was similar to calving and post-calving periods. Numerous bands of caribou were observed in high elevation terrain with large concentrations on subalpine/alpine plateaus of the Little Nahanni River, Mac Creek and Lened Creek drainages.

The sex and age composition as estimated from autumn composition surveys averaged 39 bulls:100 cows (range 32.0 – 47.0) and 21 calves:100 cows (range 17.1 – 25.6), the latter indicating low recruitment into the population. Aboriginal, resident and guided non-resident hunters harvest the SNH but the extent of harvest specific to this herd is not well documented.

The proximity of the SNH to the Nahanni Range Road, Lened Creek Development Area and Tungsten Mine Site during calving, post-calving and autumn rut is concerning. Western woodland caribou have been designated "vulnerable" by the Committee on the status of Endangered Wildlife in Canada due to their relative intolerance to change, low productivity, susceptibility to overhunting and predation, and reduction of their habitat through wildfire, logging and other actions of man (Kelsall 1983). Hunters currently have access to the SNH during the autumn rut via the Nahanni Range Road, and it is possible the herd will be negatively

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PHOTO NOT AVAILABLE

Doug Gullickson and local First Nations representatives in Nahanni National Park

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affected should world markets prompt a reopening of this mineral rich development area.

Results of this study provide an enhanced understanding of the demography and seasonal range use of the SNH. Information collected has further clarified the extent of the "greater park ecosystem" and will be used by park managers and other interested stakeholders to mitigate the potentially negative effects of human use and development within the region.

Doug Gullickson served as Senior Park Warden-Resource Management at Nahanni National Park Reserve from 1993 - 1998. He is now Frontcountry Operations Supervisor for Prince Albert National Park. Tel:(306) 663-4538 Fax:(306) 663-5585.

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Partnership Development

Nahanni National Park has realized substantial partnership advancements with the Governments of the Northwest Territories (GNWT) and Yukon (YTG). Biologists of the YTG have provided valuable technical support for this study from the outset. In 1996, the YTG provided funds and staff to jointly conduct composition surveys based on documented movements of the SNH into the Yukon Territory. The results of this study, the communication efforts of Parks Canada and the consistent support of local First Nations have resulted in the GNWT committing to take a lead role in the further research and management of the SNH.

Beginning in October 1998, the GNWT has proposed to take a lead financial and coordinating role to:

1. remove expired radio collars from the present sample;
2. capture and radio collar additional caribou to return the sample size to 25;
3. conduct a composition survey of the SNH during the autumn rut;
4. conduct a stratified population census of the SNH on late-winter range in 1999 with the assistance of experienced staff from the YTG;
5. complete a detailed harvest analysis of the SNH.

Parks Canada has demonstrated its commitment to ecosystem based management in the region and, by doing so, has enhanced the ability to protect and manage woodland caribou within the Greater Nahanni Ecosystem. Professional relationships have been enhanced and knowledge shared with representatives of local First Nations, the GNWT and YTG. When proposed research initiatives are carried through to completion, Parks Canada will have more than doubled its investment in ecosystem based research within the region.

How do we Protect Arctic Char?

- continued from page 7 -

stock mixing at sea and the effect of relative fishing pressure on each stock are unknown. SPM analysis and traditional tagging methods may provide answers. As a result of the cooperation with the Department of Fisheries and Oceans (DFO) and the Inuvialuit Fisheries Joint Management Committee (FJMC), Parks Canada can work toward sustainable fisheries management and preserve intra-specific diversity of these char populations.

In the high Arctic, closed char ecosystems, such as Lake Hazen in EINPR, any exploitation needs to be seriously questioned. EINPR is home to some of the most northern populations of Arctic char: fish that live in extremely severe environmental conditions. Lake ecosystems here are simple (i.e., Arctic char is the only species of fish present), and removing char from the system could be a significant ecological perturbation. It is essential to evaluate the impact of fishing in Lake Hazen to maintain ecological integrity.

Parks Canada decisions on char management cannot be made in isolation. Ellesmere and Ivvavik National Parks are located within settled aboriginal land claim areas—Nunavut and Inuvialuit Settlement regions, respectively. Decision making processes, involving inter-jurisdictional fish management boards, are prescribed. Parks Canada must work within this context to ensure that char species and populations are not threatened by human activities.

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Monitoring Human Use Impacts

in Auyuittuq and Ellesmere Island National Park Reserves

Vicki Sahanatien

INTRODUCTION

Arctic national parks provide some of the most exhilarating and unique hiking opportunities in the world. The landscapes, wildlife and Inuit cultures attract a steady flow of tourists annually to Northwest Territories national parks. The volume of hikers is considerably lower than experienced in the back country of southern national parks: 65–100/year in Ellesmere Island National Park Reserve and 400–500/year in Auyuittuq National Park Reserve. The challenges of managing visitor impacts and maintaining a wilderness experience are similar to all parks, but the potential for long lasting, adverse effects on vegetation, soil erosion and wildlife displacement is much greater in the mid and high arctic.

Auyuittuq and Ellesmere are vast in size, but suitable habitat for plants, wildlife and humans is limited. The landscape is dominated by ice caps, glaciers, mountain ranges, rock and bare ground. As a result, most life concentrates in these limited areas. In addition, the short growing season and severe climate limit the ability of vegetation to grow and recover from damage. Permafrost underlies all surfaces and reduces soil stability. Minimizing human impacts within productive habitats in arctic parks is vital.

Long-term monitoring of human use impacts began in 1990 at Ellesmere Island National Park Reserve, and Auyuittuq National Park Reserve started a similar study in 1996. The Ellesmere monitoring program, which was developed as the prototype, consists of detailed landform, soil and vegetation mapping, "trafficability" rating predictions, and annual measurements on permanent transects. The methods used build on the work completed by Welch and Churchill (1986) and Cole (1989). The methodology developed for Ellesmere was used in the Auyuittuq study.

METHODS

Using methods developed by Charles Tarnocai and others (Tarnocai *et al*., 1991; Tarnocai and Gould, 1996, 1998, Tarnocai and Veldhuis, 1998; Tarnocai, 1998), data were gathered from eight transects in Auyuittuq, and nine transects in Ellesmere. The transects were sited using the following criteria:

i) Areas that will be affected by foot traffic, especially where topography concentrates traffic.
ii) Areas associated with sensitive soils. Sensitive soils are those that, because of texture, ice content or slope, are highly susceptible to erosion and thermal degradation
iii) Areas of wildlife habitat (*e.g*., sedge meadows) that are particularly sensitive to disturbance because of moisture levels, soil type, etc.
iv) Areas where disturbance has occurred (to monitor potential recovery).

"Trafficability" is defined as "the ability of the soil (landscape), based on its physical characteristics, to sustain foot traffic, either as dispersed traffic or as trail traffic, and not be altered or degraded beyond acceptable limits"

— p. 32 in Tarnocai and Veldhuis, 1998

Hiking traffic was monitored using two methods: detailed, which is performed during the first year and every fifth year thereafter; and yearly, which is performed each year that detailed monitoring is not.

Detailed monitoring during the first year established the baseline soil and vegetation characteristics. This involves sampling and describing soils, landforms, parent materials, and vegetation. Soil types and landforms were mapped as homogenous units or "polygons." "Trafficability" ratings were then assigned to each polygon. The same parameters are resampled at five-year intervals. Detailed monitoring has been completed by contract soil scientists and botanists.

Yearly monitoring occurs in mid-July and is completed by Parks Canada staff. During this monitoring oblique photographs are taken and the vegetation, soil and erosion conditions are described qualitatively at the points established during the detailed monitoring of Year 1. Estimates of the number of people hiking that part of the trail are recorded, along with comments and site sketches.

BASELINE DATA FOR AUYUITTUQ

Thematic soil, landform and interpretive ("trafficability") maps (1:40,000), were created of Weasel and Owl River valleys, where the Akshayuk (Pangnirtung) Pass Trail is located, using the CanSIS ARC/INFO system. Each map also shows elevation contours and drainage.

"Trafficability" of the lower valley areas was rated three times during the thaw season: early season (June), mid-season (July), and late season (August). Soil texture, drainage, ice content (%), depth of thaw (cm), surface expression, slope (%), and slope stability were used to rate trafficability for dispersed and trail foot traffic. Five ratings were defined: very good, good, fair, poor, and very poor. Most of the hiking trail traverses areas rated fair, good and very good. Future monitoring will test the values assigned to each polygon. The next detailed monitoring will occur in 2000 (*south Akshayuk Pass Trail*) and 2001 (*north Akshayuk Pass Trail*).

Vegetation cover has decreased or completely disappeared along most sections of trail that pass through vegetated areas. Plant cover loss has led to soil erosion and compaction on several sections of the hiking trail and next to most emergency shelters. Fine, sandy soils are most susceptible to wind and water erosion and some trail sections were observed to be depressed up to 20 centimeters. In low "trafficability" areas, continued erosion and potential changes in permafrost activity are anticipated.

FIVE YEAR EVALUATION OF IMPACTS *AT ELLESMERE*

Detailed monitoring of each transect occurred in 1990 and 1994. The following parameters were compared: depth of thaw, soil moisture, soil strength, total vegetation cover, and the percent cover of each plant species.

Measurable human impacts were noted on only one transect. This transect, near Tanquary Fiord, is situated where hikers concentrate in a gully between steep slopes. Total vegetation cover decreased slightly over most of the transect area. Transects crossing regularly used (40-50 people/year) informal trails showed few negative changes. Trail length and width remained stable, soil compaction and displacement of cobble materials were observed, boot prints remained, and in one location there was an increase in plant cover.

Natural forces caused qualitative and

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Monitoring Human Use Impact

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measurable changes on some of the remaining transects. Wind caused the most visible effects, depositing and eroding materials, especially in sandy textured soils that are common throughout the study area. Soil moisture changes were observed on many of the transects. These changes were brought about by sheet and stream water flow, which deposited sediments (increasing soil moisture) or eroded material, and by permafrost action which caused cracks or increased ground profile (dried the soil). Changes in soil moisture regime in turn resulted in changes of plant species relative abundance and patterns of distribution. Wildlife tracks, scats and evidence of browsing were observed in many transects. Some trampling was observed as a result of muskox activities.

MANAGEMENT APPLICATIONS

Ellesmere

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Visitor management in Ellesmere is unstructured. People register in and out, appropriate backcountry camping and travelling etiquette and personal safety are emphasized, and an exit survey is provided. There are no formal hiking trails in the park. Fortunately the number of hikers has been low enough to permit this approach without degrading the park environments. It also seems that in some areas of the park, wind and water processes may be sufficient to erase any effects caused by hikers.

Unfortunately, visitation patterns and limited circulation suggest if larger numbers of hikers use Ellesmere, significant impacts are likely to result. For the average backpacker, hiking routes are limited by glaciers and ice caps, and aircraft landing sites are restricted. Charter flights to the park are very expensive, so most visitor groups are relatively large (at least ten people). Almost all hiking groups are in the park during the month of July.

Auyuittuq

Auyuittuq faces similar but more significant challenges to maintaining the integrity of the hiking trail environment. To date visitor management in this park has also been unstructured. Park managers anticipated that hikers would disperse themselves throughout the routes, but this has not been the case. Human use has affected the vegetation and soils of the Akshayuk Pass Trail.

Akshayuk Pass Trail is linear. Most visitors use the south portion of the trail, beginning and ending their trip from the same location. Most hiking activity occurs in July with some in late June and early August, this does not include visitation in the snow months. Group size ranges from one to twelve. Emergency shelters with pit privies are located at intervals along the trail and many visitors have focused their daily hiking destinations on these locations, causing significant damage to vegetation and soil. For many years, the trail has been formalized with cairn markers, rock borders and attempts to repair eroded sections, and bridges have been built for river crossings.

MANAGING HIKING IMPACTS

The "trafficability" study recommended interim mitigative measures: trail repairs, trail relocation, and conscious efforts to divert hiking traffic and camping activities. Park managers need to take the results a step further to assess how visitation can be managed to reduce ecological impacts and how the trail and other facilities can be maintained to minimize further degradation.

Visitor databases and improved visitor registration methods and exit surveys were developed for each park in 1998. This will provide better understanding of where, when and how many people are using different areas in each park, thus, a better estimation of traffic volume over each monitoring transect. The exit survey also gathers information on the quality of a visitor's wilderness experience relative to trail conditions and the activities of other people they may encounter. This information may provide insight into potential visitor management approaches.

Auyuittuq and Ellesmere human use monitoring may be the only long term studies gathering quantitative and qualitative data to evaluate the effects of low-impact, wilderness-tourist activities in the arctic. The data collected should apply to sites across the arctic and may be used in conjunction with remote sensing. Digital maps, photograph series and cross-section pictorial depictions of each transect provide means to quickly understand the nature and state of hiking trails.

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BOOK REVIEW

QUEST for the Origins of the FIRST AMERICANS by E. James Dixon

Review by William Fox

There is a developing awareness in natural science circles that the archaeological record holds important information concerning such topics as regional species distributions and even densities over the long term. This is not to say that data interpretation is always straightforward; however, the role of Aboriginal peoples in modifying and maintaining ecosystems over tens of thousands of years is becoming appreciated, as is the cultural concept of "home place" as opposed to "pristine wilderness." For scientists and managers wishing to better understand the environmental context of the lands Parks Canada manages, Dixon's volume is a useful historical introduction to the big picture.

The dramatic story of human entry into the Americas begins in the north, specifically in Alaska. I found Dixon's small (154 page) book a pleasure to read, as it is written for a "broad and diverse audience". His introductory story will capture the attention of anyone with a love of the outdoors, particularly the north, and the subsequent intertwining of personal narrative with technical data is engaging. For those wishing to pursue more detailed technical information, Dixon provides a substantial bibliography (181 entries) as well as a useful index.

These are exciting times for "Paleo-Indian" research, with the Internet buzzing with discussions concerning the significance of recent mtDNA analyses of Amerindian populations and the discovery of an early site in the Brazilian rain forest. Perhaps readers will be surprised that South America is the location of the best dated and most extensively excavated early site in the Americas.

While there remains considerable debate concerning occupations dating to more than 20,000 years ago, there can be no doubt that the Americas were populated prior to the arrival from the Eurasian steppes of the mammoth killing machine known as the "Clovis" or "Fluted Point Peoples" around eleven to twelve thousand years ago. These sophisticated and specialized hunting groups swept rapidly across North America south of the Laurentide ice sheet and penetrated South America at least as far south as Peru. There are reputed "pre-Clovis" sites in North America; such as Meadowcroft Rockshelter in Pennsylvania, Pendejo Cave in New Mexico and even a site in the Bow River valley of suburban Calgary. But the best documented site at present is Monte Verde in Chile, where a well-dated 13,000 year old occupation includes an amazing array of artifactual and structural remains due to unusual organic preservation. There are even preserved footprints! The Monte Verde peoples appear to have practiced a diverse subsistence strategy, based on a wide-ranging knowledge of the diverse environmental zones characterizing this region of South America. Interestingly, they do not appear to have been newcomers.

For the average person unfamiliar with this complex and controversial subject, Dixon's initial chapters provide the reader with a brief history of research into the former existence of the Bering land bridge and an overview of theories concerning North American "paleoindian" migration routes. He then turns to paleoecological evidence to determine the nature of the late Pleistocene environment of Beringia in which human groups subsisted. His next chapter addresses and dismisses the controversial Old Crow data which had been used by Canadian researchers to argue for a twenty to thirty thousand year old human occupation in the northern Yukon. All the above are interwoven into Dixon's narrative of a research trip to the Smithsonian Institution in 1986. Subsequent chapters deal with the definition of the "American Paleoarctic Tradition," blood residue analysis as applied to stone tools, the discovery and definition of the early Nenana Complex in Alaska, and a synthesis of recent evidence for early human occupations throughout the Americas.

In his concluding chapter entitled *Speculations*, Dixon reviews the evidence for pre-Clovis occupations in the context of recent archaeological information relating to the marine colonization of Austronesia in the southwestern Pacific 35,000 to 40,000 years ago. While most would summarily reject his suggested potential for trans-Pacific travel to South America, the level of maritime proficiency evidenced in the western Pacific at an early date (there is even recent evidence suggesting sea crossings half a million years ago in this region) adds further support to the Pacific coastal entry hypothesis for the earliest peopling of the Americas. I would not be surprised to see an initial date in the thirty to fifty thousand year range confirmed in the years to come.

Personally, I find it exciting that Parks Canada research is contributing to this rapidly unfolding story of human exploration. Since Dixon's volume was published, we have discovered the first Paleo-Indian fluted point site on the Yukon north slope in Ivvavik National Park. The form of the dart heads suggests that this occupation is related to a relatively late "backwash" event, with populations arriving from the south, as suggested by Dixon. They may have been hunting the bison dated to ten thousand years ago at the nearby site of Engigstciak.

Another fluted point site was investigated last year to the south, in Vuntut National Park, and a Chindadn point (characteristic of the earlier Nenana Complex) was reported this year just south of Vuntut. While the c.11,000 year old Nenana Complex is the earliest identified to date in Alaska, there is always the possibility of still earlier evidence of human activities within the unglaciated lands known as Beringia, whose easternmost extremity includes portions of both aforementioned parks. This means that some of the earliest evidence concerning the colonization of the Americas may await discovery in Ivvavik or Vuntut National Park - a truly exciting prospect. Consistent with these dynamic times for Paleo-Indian research, Parks Canada's Darryl Fedje will be reporting the first archaeological evidence relating to the early exploration of the Americas to be recovered from a late Pleistocene drowned site on the continental shelf, just east of Gwaii Haanas National Park!

Dixon's volume presents an eloquent and wide-ranging synthesis of the direct and indirect evidence for the initial peopling of the Americas. This he accomplishes in a highly readable style characterized by plain language text and useful illustrations. The history of the Americas is a lengthy and hugely complex story. It is an archaeological "work in progress," which is becoming interwoven with the oral history of many Aboriginal groups, as the dialogue improves between America's First Peoples and Western Science. This little book is a brief and accessible step toward understanding the scientific contribution.

William Fox is Superintendent of the Western Arctic Field Unit and was formerly Chief of Archaeology for the Prairie and Northern Region of Parks Canada. For more information, please call (867) 777-3248.

E. James Dixon is a widely published Alaskan archaeologist, who is curator of archaeology at the University of Alaska Museum and professor of anthropology at the University of Alaska Fairbanks. Quest for the Origins of the First Americans is published by the University of New Mexico Press (1993).

Research Links

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MEETINGS OF INTEREST

August 30-Sept. 3, 1998

Community-based Integrated Coastal Management—Sharing our Experience—Building our Knowledge. Coastal Zone Canada '98. (CZC'98) Victoria, BC. CZC'98 will build on the results of the first two CZC conferences (1994 and 1996), and create a working forum where a broad cross-section of stakeholders in the coastal zone will define issues, share experiences and identify the range of alternatives for addressing Integrated Coastal management at the community level. Interactive workshops, round tables and some not-so-traditional communication sessions. Sessions will be supported by technical papers, posters and outreach and training opportunities. Representatives of community groups, resource harvesters, First Nations, international agencies, government organizations, natural and social scientists, landowners, business people, and other interested people are welcome. Contact: Coastal Zone Canada '98 c/o Institute of Ocean Sciences, 9860 West Saanich Road, Sidney, BC. V8L 4B2. Fax: (604)363-6479; e-mail: czc98@ios.bc.ca; web site: http://www.ios.bc.ca/czc98.html

November 19-22, 1998

Working Together on Innovative Approaches to Sustaining Protected Areas, Vancouver, BC. Hosted by the BC Chapter of the Canadian Parks and Wilderness Society (CPAWS). This conference will focus on practical approaches and new ideas for maintaining ecological integrity, educating parks users, paying for parks and working on stewardship initiatives to maintain parks. This is an excellent opportunity to learn from other participants and speakers from across Canada and internationally about developing innovative tools, models and partnerships that will help ensure the future of our parks. Contact: CPAWS—BC, #611 - 207 W. Hastings St. Vancouver, BC, V6B 1H7. Tel: (604)685-7445, e-mail: communication@cpawsbc.org

March 22-26, 1999

Conférence biennale de la George Wright Society (GWS). Great Smokies Holiday Inn Sun Spree Resort, Asheville, Caroline du Nord. Des séances se tiendront simultanément suivant trois filières : une filière gestion, pour mettre en lumière des études de cas et des applications pratiques; une filière analyse / synthèse, pour discuter de résultats de recherches et de politiques; une filière à vision régionale axée sur les enjeux touchant les Appalaches. Les sommaires de mémoires seront acceptés jusqu'au 15 octobre 1998. Un formulaire de présentation de sommaire est disponible sur le site Web de la conférence, au http://www.portup.com/~gws/gws99.html

May 17-22, 1999

Wilderness Science in a Time of Change. Missoula Montana. This conference will present research results and synthesize knowledge and its management implications. This conference should result in a state-of-the-art understanding of wilderness related research. It will also improve our understanding of how research can contribute to the protection of wilderness in the 21st century. Considerable attention will be devoted to the ever-changing role of wilderness in society and the need to better integrate diverse social and biophysical sciences. Plenary sessions will explore: the values of the transactions between science and wilderness, the need to precisely define "wilderness" so scientific process can be effectively applied to wilderness management, the implications of increasing technological development and external pressures. For information contact: Natural Resources Management Division, Centre for Continuing Education, The University of Montana, Missoula, MT 59812. Tel: (406)243-4623 or (888)254-2544; e-mail: ckelly@selway.umt.edu
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