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Research Links

A Forum for Natural, Cultural and Social Studies

Climate Change and Polar Bears:

Long-term Ecological Trends Observed at Wapusk National Park

Nick Lunn and Ian Stirling

There is a growing consensus that the world is getting warmer and that, over the next century, this additional warming will have serious consequences for the global environment. As the planet warms, changes in average temperatures are expected to be greatest in the Arctic. By 2100, winters in the Canadian Arctic are projected to average 5-8°C warmer than they are now (Government of Canada 1999), which may result in a decrease in Arctic Ocean ice cover. While some northern fauna may benefit from such a change by exploiting new habitats, others, such as ringed seals and polar bears, may be in jeopardy because they are dependent on sea ice for reproduction and feeding. Analyses of changes in both body condition and production of cubs by polar bears in western Hudson Bay over the past two decades, in relation to the timing of sea ice break-up, indicate that climate change may already be having an impact on this population.

BACKGROUND

Polar bears *Ursus maritimus* are distributed throughout the Arctic in relatively discrete populations (Paetkau et al. 1999). They feed predominately on young ringed seals *Phoca hispida* (Stirling and Archibald 1977, Hammill and Smith 1991), although they are capable of catching seals of any age. Recent analyses using predation and energy matrices confirm that ringed seal populations can support high levels of polar bear predation only if a large proportion of the total seals killed are young-of-the-year (Stirling and Øritsland 1995).

From shortly after their birth in early spring until break-up of the annual sea ice in early summer, ringed seal pups are abundant, easier to catch than older seals because they are less experienced, and provide a high caloric return per unit of energy expended by a hunting polar bear. Polar bears reach their lightest weights of the year in late March, just before the birth of ringed seal pups. Therefore, polar bears are dependent on high hunting success in spring and early summer to maximize the body reserves necessary for survival, reproduction, and nursing of cubs through the rest of the year. Consequently, factors that influence the production of seal pups or the availability of good ice habitat for hunting can potentially have a profound effect on the population ecology of polar bears (Stirling and Derocher 1993).

Polar bears in western Hudson Bay are near the southern limit of their distribution and are particularly vulnerable to changes in ice formation as a consequence of environmental fluctuations. The concentration of sea ice in most of Hudson Bay is influenced significantly by air temperature; a warming of only 1° C is projected to result in break-up occurring 6-8 days earlier in southwestern Hudson Bay (Etkin 1991). Analyses of regional climate data have shown that between 1950 and 1990, the mean air temperatures in April, May, and June in western Hudson Bay have warmed at a rate of 0.3-0.5° C per decade (Skinner et al. 1998). Data also show that the break-up of sea ice on western Hudson Bay has occurred earlier since at least 1979, and is probably a consequence of the warmer spring temperatures (Stirling et al. 1999). The Canadian Wildlife Service's long-term studies of polar bears in western Hudson Bay has resulted in an unequalled ecological database, including population and n reproductive parameters, with which we can evaluate the possible impacts of climate

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DEPARTMENTS

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UPCOMING DEADLINES

March 30, 2001 - SUM./AUT..2001
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EDITORIAL

Science and Management in Wapusk National Park.

Since the late 1980s, seven new national parks have been established in northern Canada, and there are at least three more on the way. At two recent meetings I've heard people wish that they could learn more about these new parks. This edition of Research Links should help by presenting a broad look at current research in one of Canada's least known northern parks, Wapusk. Two articles from other parks complement themes in these by reinforcing the utility of biological collections (Storr, p.3) and the suitability of high trophic level species as indicators of ecological integrity (Cannings, p. 4).

Wapusk (WAH-pusk) National Park was established in 1996 and represents the Hudson-James Lowlands natural region in Parks Canada's system plan. In the Wapusk area, intensive research began with the Canadian and American military in the 1940's, and a wave of major projects started in the late 1960s and early 1970s. Four of these projects are still running, including the Canadian Wildlife Service's Polar Bear Project and the Hudson Bay Project on lesser snow geese, profiled in this issue. The history of science in this area is rich, and there are many projects, organizations and individuals not recognized here who have contributed a great deal to it.

Long-term studies have produced results which, in some cases, reflect global impacts on the park's ecosystem. For example, the link between climate change and reduced body condition in polar bears in Western Hudson Bay could only have been established with several decades of detailed data—which no other polar bear study has (Lunn & Stirling, p. 1). The Hudson Bay Project team were the first to identify the impacts of increasing snow goose populations (resulting from human influences) on coastal ecosystems throughout the Arctic (Gadallah, p. 9). This history has given Wapusk a priceless legacy of baseline data on many components of the ecosystem. Such established databases provide useful context for park management decisions, and can make significant contributions to maintaining the ecological integrity of national parks. As long-term data sets grow, they can provide more and deeper insights into ecological integrity issues, so their value increases every year they continue.

However, academic science is not the only source of information for park management. Wapusk has a management board which has consistently stressed the importance of traditional knowledge. To usefully apply different knowledge systems in management requires just such a participatory decision-making structure, and the park is well ahead of many in making real use of traditional knowledge, in the broadest sense of the term. Some of the newest research in the Wapusk area, including a study of landscape ecology and work on bear viewing tourism, incorporate strong local knowledge components.

Wapusk is where I first set foot in the north, as a graduate student working with the Canadian Wildlife Service in the early 1990s. I had the unique opportunity to see my study area become a national park, and to take part in its establishment. I have worn two hats there: as researcher and Chief Warden, but I never really stopped being a student. It was humbling to be on the land with people who were out there when I was still learning to walk. Listening to Cree elders' experiences taught me much about understanding and respect. To me, Wapusk is a place of discovery and wonder. In my mind's eye I will always be able to see the explosion of life on thawing tundra in springtime, the ease of a white bear swimming along the floe edge, and the bright ice of Hudson Bay stretching out to meet the winter sky.

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In Support of Natural History Specimens:
"Detailing" a Natural History Collection

Lorrie Storr

Natural and cultural history collections in our national parks are of value for many different reasons. They arise from and contribute to research, provide useful material for talks and presentations, and grow with park-related items found by staff and visitors. Specimens are most useful when they are well-preserved, exhibited and stored. A properly stored, accessible collection preserves the state and context of items so they can reveal as much information as possible to researchers, interpreters and the public.

In May 2000, Wood Buffalo National Park invited WCSC conservators Liz Croome and Lorrie Storr to improve the storage of the natural and cultural history collections and conserve the pieces as needed. The intent was to protect the specimens and increase their accessibility for the staff for the purposes of research and presenting information to the public. The new storage techniques are simple, so park staff can apply them to other parts of the collection at a later date.

> *When we were at Wood Buffalo some of the staff saw what we were doing and said, "Oh, do we have that?" or "I could use that for…" Someone in another park was able to analyze the alcohol from a fish's spirit jar for mercury. That kind of analysis was not important or even considered when the fish was collected, but because the specimen and its preserving solution had been carefully preserved it has added value. To have this kind of added value from more of our specimens, we need collections to be accessible and presented effectively. People should be able to say, "That specimen relates to my research," and obtain pertinent information.*
>
> *— Lorrie Storr*

Collections in Wood Buffalo National Park consist of floral and faunal material, geological specimens and cultural artifacts. The collections have evolved over time and in different directions, through the efforts of many people, so what is collected and how it is stored varies. The care of the collections fluctuates according to the time and resources available. Most of the collections are stored in standard, painted, steel cabinets designed for the storage of museum specimens and herbarium collections.

Herbarium collections are generally stored by stacking the plant specimens on shelves. Problems arise as the numbers of plants increases. Over time, the card stock on which the plants are mounted, warps to conform to the curve created by the layers of plants below, causing the plants to crack, or the glue joints to fail. To solve the problem, corrugated plastic (Coroplast) can be inserted where the specimen boards are starting to bend. A piece of polyethylene foam glued to one or both sides helps to level the pile (Figure 1). This technique uses a minimal amount of space in the cabinet, puts minimal additional weight on the specimens, preserves how the specimens are sorted, and increases the visibility of some specimens.

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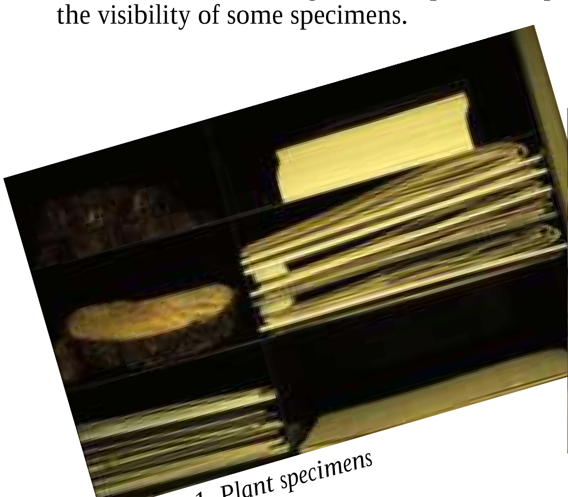

Figure 1. Plant specimens

Figure 2. Skull storage

UPDATES

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Photo George Doerkson, Royal BC Museum

The Dragonflies of the Colu

Field Surveys, Collections Development

Aeshna canadensis (Canada Darner) is an inhabitant of sedgy fens and beaver ponds in the Columbia/Kootenay region. Dragonflies are visual predators and the large compund eyes fill much of the head. Prey is captured in the spiny legs during flight.

Robert Cannings

In 1998/99 the Royal British Columbia Museum (RBCM) and British Columbia Conservation Data Centre (CDC) (part of the Ministry of Environment, Lands and Parks) joined forces to study the dragonflies *(Insecta: Odonata)* of the Columbia Basin in south-eastern BC. This study was part of the Museum's Living Landscapes project, designed to take its resources to the diverse regions of the province, stimulating local residents and organizations to conceive their own research projects and participate in the Museum's research, collections and public programming activities.

Our main objective was to determine the status, precise locations and habitat requirements of the dragonflies of selected areas of the Columbia Basin. The RBCM has dragonfly specimens and a species list for the region that represented our knowledge up to 1997, mostly based on Cannings and Stuart (1977), Walker (1953, 1958) and Walker and Corbet (1975). However, no comprehensive survey for dragonflies had ever been made; some of the recorded populations were known only from collections made in the early 1900s. We were keen to collect new data that would help in wetland management and conservation planning. But we also wanted to create simple educational materials that would promote understanding of dragonflies and their relationship to diverse and healthy wetland habitats. In addition to a report on the internet (http://livinglandscapes.bc.ca/www_dragon/toc.html), complete with photographs and distribution maps of every species, we are producing slide shows and videos for distribution to parks, naturalist groups and schools. Another long-term goal is to involve a few residents of local communities in the detailed study of dragonflies and the long-term monitoring of selected species and localities. Several naturalists have expressed interest in these activities. Dean Nicholson of Cranbrook discovered several species new to the East Kootenays during this study, and presented several dragonfly slide shows in provincial parks.

In mountains, the most extensive wetlands are usually in the broadest and flattest valleys, where water pools. Such corridors, relatively easily travelled, develop concentrations of transportation and stopover facilities. In the southern Canadian Rockies, Kicking Horse and Bow valleys are the largest and best examples of such wetland habitats. Parks Canada was a partner in this project from the beginning. John Woods (Faunal Specialist, Revelstoke and Glacier National Parks) was excited to have baseline data on these aquatic insects from sensitive habitats along major transportation corridors. The broad scope of the project precluded any comprehensive work within parks. Nevertheless, we targeted a fen in the Beaver River Valley between the CPR mainline and Highway 1, fens and marshes along Highway 1 at Leanchoil in Glacier and wetlands at the confluence of the Ottertail and Kicking Horse rivers in Yoho.

Dragonflies and their damselfly relatives seldom receive attention from government biologists and resource managers. However, they are of ecological importance for many reasons. They are upper-level predators in aquatic and semi-aquatic habitats, often the dominant group of the large invertebrates, especially in fish-free systems. For the most part, adults inhabit the edges of

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Photo: George Doerkson, Royal BC Museum

Argia vivida (Vivid Dancer) lives around streamlets associated with warm springs; most of the Canadian population lives in the mountains of the Columbia/Kootenays. It's habitat is vulnerable to development and the damselfly is on the BC threatened and endangered list

Dragonfly larvae are among the most abundant of the large invertebrate predators in aquatic ecosytems. In turn, they are food for many invertebrate and vertebrate animals. The majority of the life of most dragonfly species is spent in the larval stage. This is Aeshna interrupta (Variable Darner).

Photo: Robert Cannings, Royal BC Museum.

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& Public Education

"25% Fen" Photo: Leah Ramsay

water bodies, living in the riparian interface between land and water *(Figure 1)*. The aquatic larvae (*Figure 2)* of many species are habitat-specific. Some are sensitive to temperature fluctuations and siltation caused by habitat change, and their presence can be used to characterize healthy wetlands of all sorts. Furthermore, unlike most invertebrates, dragonflies are identifiable in the field by experts, and surveys can proceed with speed and efficiency. These surveys are ideal for long-term monitoring programs. Finally, because the adults are large, colourful, diurnal creatures with interesting behaviours, dragonflies are excellent subjects for nature interpretation programs and public education about aquatic ecosystems in general.

We visited the widest possible array of habitats — mountain fens and bogs, trickling springs, warm lake beaches, grassland alkali ponds and rich cattail marshes - to identify and document dragonflies, emphasizing habitats likely to support rare species. We usually netted adults for close examination and kept voucher specimens, critical for identification reference and for confirming species occurrence. Larvae, or the cast skins of larvae (exuviae), can also be used as indicators of a species' use of a particular site. Specimens were prepared, labelled, identified and accessioned into the RBCM collections. Synoptic collections will be deposited with both Parks Canada and BC Parks. Details of dragonfly numbers, behaviour and ecology, as well as precise UTM grid co-ordinates of collection sites were recorded in an RBCM database. Distribution maps of each species were produced using ArcView GIS. The distribution of larvae and breeding adults will be analysed to determine critical habitats.

By the end of the 1999 season, we had visited 291 sites (RBCM collections made before the survey came from 75 localities) and the original regional species list increased from 57 to 66. These species represent 76% of the 87 species recorded from BC, and 33 % of the 201 species recorded in Canada. The 4 National Parks host 40 species. One site, the peatland squeezed between Highway 1 and the CPR in Glacier National Park's Beaver River Valley, was fondly dubbed "The 25 Per Cent Fen" because it contained no less than 22 species, one quarter of the provincial fauna.

The 9 species added to the Columbia/Kootenay list were River Jewelwing *(Calopteryx aequabilis)*, Sweetflag Spreadwing *(Lestes forcipatus)*, Subarctic Bluet *(Coenagrion interrogatum)*, Olive Clubtail *(Stylurus olivaceus)*, Lake Emerald *(Somatochlora cingulata)*, Forcipate Emerald *(S. forcipata)*, Ocellated Emerald *(S. minor)*, Brush-tipped Emerald *(S. walshii)* and Crimson-ringed Whiteface *(Leucorrhinia glacialis)*.

The inventory also improved our understanding of the status of other species rarely recorded in the Columbia Basin. Twelve are considered rare and of management concern in BC based on collections in museums; 3 of these occur in the 4 mountain national parks and 2 more are known from Banff. However, with increased study, species such as the Black-tipped Darner *(Aeshna tuberculifera)* and Lake Emerald *(Somatochlora cingulata)* proved to be more widespread than initial records suggested. The Vivid Dancer *(Argia vivida)* is a Kootenay specialty because its Canadian range is centred in the region and it is restricted there to the outlets of hot springs in the area's mountain ridges. Although we found a few new populations of this damselfly, it is still considered vulnerable because it has been eliminated from some springs and most of the others are threatened by development. Several species, including the Alkali Bluet *(Enallagma clausum)*, Hagen's Bluet *(E. hageni)*, Azure Darner *(Aeshna septentrionalis)* and Hudsonian Emerald *(Somatochlora hudsonica)*, were not found in the region, but probably occur there.

The River Jewelwing *(Calopteryx aequabilis)*, Sweetflag Spreadwing *(Lestes forcipatus)* and Forcipate Emerald *(Somatochlora forcipatus)* are species new to BC. The Jewelwing represents the family Calopterygidae. This spectacular damselfly, with its metallic green body and brown-banded wings, had been recorded as close to BC as Stevens County, Washington and for several decades we suspected that it lived in the streams of the Boundary district. However, we did not find it there until July 1999, when it appeared along Christina Creek, the outlet of Christina Lake.

In 1998, in a wetland near Donald in the Rocky Mountain Trench, we located the Sweetflag Spreadwing, previously not confirmed elsewhere in Canada west of Manitoba. This uncommon species had been overlooked because it was not expected and because it closely resembles the widespread and abundant Common Spreadwing (*Lestes disjunctus)* Subsequently, it was found in many more localities, and some museum

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Somatochlora forcipata (Forcipate Emerald) had not been found in the Rocky Mountains since the 1920s. It was rediscovered in 1998 at three locations in Yoho and Kootenay National Parks, flying over trickling spring seeps in subalpine forest.

Photo: Blair Nikula.

Climate Change and Polar Bears:

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change on upper-trophic level animals in the Arctic.

METHODS

Each autumn since 1981, 150-200 polar bears were located by helicopter and immobilized. We measured body length and estimated body mass from axillary girth (Kolenosky et al. 1989). An index of body condition for both adult male and female polar bears was calculated from the ratio of body mass over body length squared (Stirling and Lunn 1997), after adjusting body mass to a constant date to account for mass loss during the summer (Derocher and Stirling 1992).

RESULTS

During the past 20 years in western Hudson Bay, there have been significant declines in the condition of adult bears, both males (Pearson product-moment correlation, $r = -0.73$, n = 17, $p < 0.001$) and females ($r = -0.80$, n = 17, $p < 0.001$), and in average cub production per female (Spearman rank correlation, $r_s = -0.54$, n = 17, $p < 0.05$) (Figure 1). These declines appear to be directly related to warmer spring temperatures causing an earlier break-up of sea ice. The mean date of break-up, defined as the date by which 50% of the total ice cover had disintegrated, was significantly earlier (t-test, $t = 2.46$, $df = 17$, $p < 0.05$) in the 1990s (27 June ± 5 days, n = 9) than in the 1980s (10 July ± 3 days, n = 10).

The timing of break-up was positively correlated with body condition of adult male ($r = 0.55$, n = 17, $p < 0.05$) and female polar bears ($r = 0.49$, n = 17, $p < 0.05$) and with cub production ($r = 0.61$, n = 17, $p < 0.01$) (Figure 2). When the ice breaks up directly influences how long polar bears have access to ringed seals during the critical spring period and, consequently, affects the amount of fat that bears are able to store prior to being forced ashore for 3-4 months. The longer that bears can remain hunting seals on the sea ice, the better condition they will be in. Spring hunting is especially critical to pregnant females because, once ashore, they will not feed again for approximately 8 months, during which time they give birth and nurse cubs prior to returning to the sea ice.

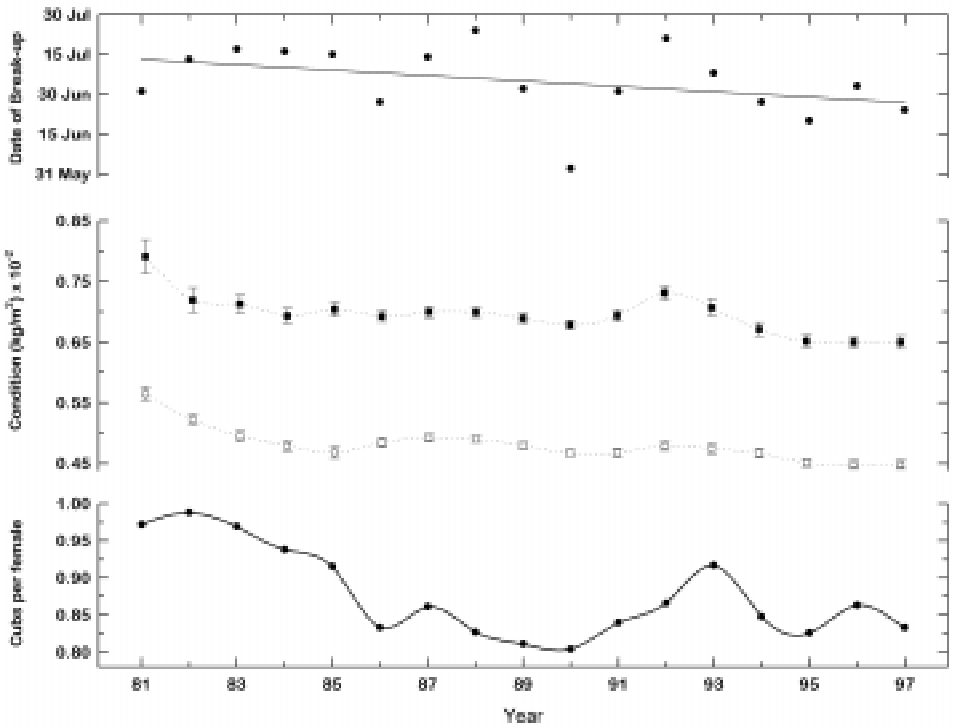

Figure 1. Date of break-up of sea ice, trends in body condition (• = adult males; ○ = adult females accompanied by cubs), and cub production of polar bears in western Hudson Bay. Condition indices and cubs per female are expressed as three-year running means. Error bars on condition indices are ± 1 standard error.

MANAGEMENT IMPLICATIONS

The polar bears of western Hudson Bay are an important economic and cultural resource to the peoples of Nunavut and Manitoba. The bears draw significant tourism activity to Churchill, Manitoba each fall and sustain a limited harvest, which is based on an estimate of 1,200 bears (Lunn et al. 1997). Despite the declines in body condition and cub production, the population appears to have remained stable during the past 12 years. While current cub production is still sufficient to maintain the size of the population, it is clear that if these downward trends continue, eventually the number of births will be insufficient to offset the number of deaths and the population will decline.

Because polar bears are at the top of the marine food chain, they have a key role as indicators of the overall health of the marine ecosystem. As long as a polar bear population is healthy, then one can probably safely assume that the rest of the components of the ecosystem are doing well. However, unexpected changes in their numbers, health or reproductive success can provide an alarm to indicate problems elsewhere within the ecosystem. Them effects of long-term climatic change are not restricted to polar bears in western Hudson Bay, but will be of obvious significance to bears throughout the Arctic. However, this population is the only one for which sufficient data currently exist to examine trends and determine effects. It is probable that similar effects will eventually be observed in other areas of the Arctic should the warming trend continue and/or spread.

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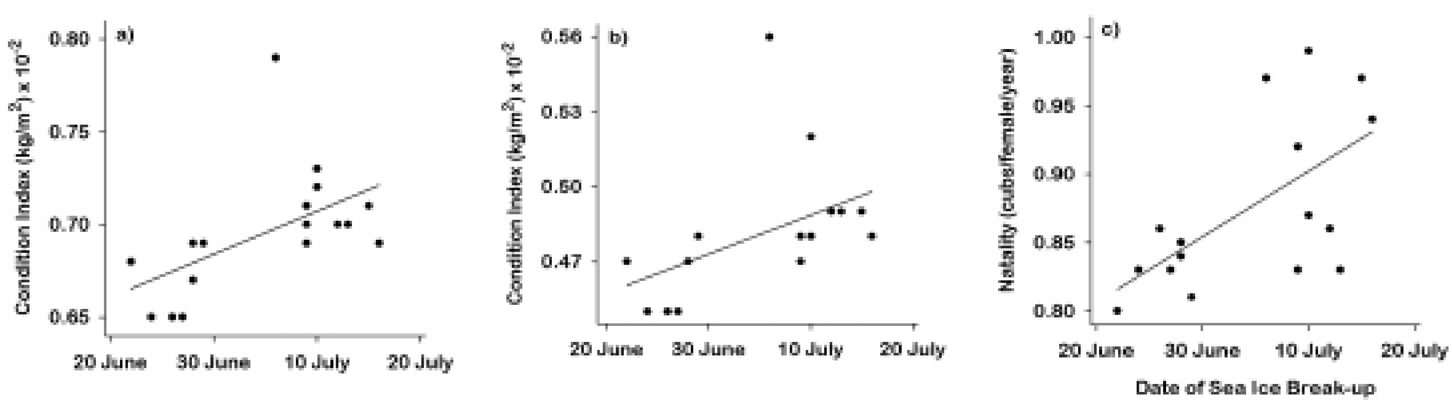

Figure 2. Trends in (a) index of body condition of adult males, (b) index of body condition of adult females, and (c) natality in relation to date of break-up of sea ice in Hudson Bay, 1980-1998. Condition indices, natality, and date of break-up expressed as 3-year running means.

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A View From Outerspace

Vegetation Mapping in Wapusk National Park

Ryan Brook, Norm Kenkel and Tom Naughten

Managers and scientists in Wapusk National Park require information about the structure, composition and distribution of vegetation across the entire park to make sound management decisions. The vegetation is constantly changing through natural processes, including fire, wildlife grazing, and succession. Wapusk has also been slowly rising out of Hudson Bay for the past 7000 years, so areas further away from the Bay are generally older and have had more time to develop vegetation. Hudson Bay continues to have a significant influence on the local climate that limits plant growth, while the land continues to rise.

Due to the complexity and natural variability of the vegetation, along with the remoteness of the region, we know little about the structure of the plant communities in Wapusk. Vegetation mapping will enable us to acquire this information and track changes over time for effective management of wildlife and human issues in the park. Management of species such as polar bears, snow geese and caribou is particularly important in this region and requires specific information about the structure of the landscape.

A vegetation map can be used to examine the ways that humans and animals use different habitats, and it provides information about the potential sensitivity of specific areas to specific impacts. An existing vegetation map for this area (Ritchie 1962) delineates some of the broad-scale variation in floristic composition and structure across the entire park, but it is out of date and lacks the detail needed to answer many questions. The need for current vegetation data was particularly high during the recent development of the ecological integrity statement for Wapusk.

WHAT IS A VEGETATION MAP?

A vegetation map can be thought of as a model of the natural world that simplifies the complexity that exists across an entire region or landscape. As a model, a map should summarize ecologically important information, while suppressing "noise." We define noise as all of the other information that obscures the salient trends and features of the data, such as minor variations in wetness or plant structure within a site. A map that includes all of the variation in an entire region would contain so much information that general trends in the distribution of vegetation would be obscured. One of the greatest challenges in producing an accurate and functional vegetation map is separating the important information from the noise.

We based our production of the map on data collection and presentation needs. The map was designed to be compatible with the data manager's software and hardware so it would fit into the existing geographic framework. We attempted to answer the management planner's questions about vegetation across the entire park (e.g. What is the extent of coastal beach ridge habitat?). The warden service staff was interested in many potential applications that required a known level of accuracy and therefore recommended that a full accuracy assessment be undertaken. This step has not always been part of National Park vegetation mapping projects, but it is critical in order to judge the value of the final product. Others told us they needed vegetation data for a wide range of applications, from understanding polar bear habitat requirements to identifying areas most sensitive to tourism disturbance. Ultimately there may be a need for several maps, each describing the vegetation in different ways or from different perspectives.

MAKING A VEGETATION MAP

An effective way to map the vegetation of an area the size of Wapusk (11, 475 km^2) is to

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The first Landsat satellite was launched in 1972. It was the first satellite devoted to continuously collecting systematic multi-spectral digital images of the Earth's surface. The MultiSpectral Scanner (MSS) sensor on board captured data with a ground resolution of 80 m (instantaneous field of view) in 4 spectral bands. In 1982, an improved Thematic Mapper (TM) sensor was launched on Landsat-4, and data was gathered at finer spatial resolution (30 m) in 7 spectral bands. The Landsat archive of optical imagery allows us to examine changes on the Earth's surface on a scale never before possible. It not only extends back in time across three decades, but it also covers most of the Earth's surface.

Satellite imagery is simply a record of electromagnetic radiation received at a sensor. This is usually not of interest in itself, but using imagery collected from optical wavelengths, reasonable estimates of target reflectance can usually be made. The pattern of reflectance of earth surfaces in particular wavelength bands can often be correlated to environmental variables, providing both qualitative information (such as the identification of a target) or quantitative information (such as an estimate of vegetation amounts or water turbidity). Vegetation absorbs light in the visible range, for photosynthesis, but the cell structure of plants scatters light in the longer near- and mid-infrared wavelengths. This distinctive pattern of low

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Monitoring Habitat Change Using Satellite Imagery

The impact of the Lesser Snow Goose on its Habitat in Wapusk National Park

Fawziah Gadallah

The need for management of natural resources on large temporal and spatial scales is increasingly clear as we come to recognize the interconnectedness of systems. In the case of Lesser Snow Geese, changes in land-use practices in the southern United States, where the birds winter, are having effects thousands of kilometers away, in the birds' breeding areas. Management of population size is controversial for this esthetic and highly visible game species, and information on habitat changes in the birds' remote northern colonies is needed not only to make sound management decisions, but for public education. Satellite imagery offers a spatially-extensive database that has been collected consistently over nearly 30 years, and is one of the few data sources available to document these changes.

Lesser Snow Goose (*Anser caerulescens caerulescens* L.) populations in eastern North America have been increasing dramatically in recent decades, on the order of 7% per year (Abraham and Jefferies 1997, Jefferies 1997). The increased numbers of geese are damaging the vegetation of their summer habitats, which are located in the few arctic and sub-arctic areas that can supply the high quality forage the birds depend on to raise their goslings. In the Eastern Canadian Arctic, the birds primarily use coastal salt marshes, and they have caused severe damage to this rare habitat, in some cases reducing large areas of marsh vegetation to bare ground. As salt marsh areas are degraded, the birds move inland, causing damage to the surrounding fresh-water marshes and willow communities. Using satellite imagery, Jano, Jefferies and Rockwell (1998) have shown that between 1973 and 1993, vegetation loss occurred in 2454 ha of summer habitat at the La Pérouse Bay colony, which is located largely within Wapusk National Park.

The quantity of salt marsh vegetation available as forage for the geese has decreased largely as a result of the birds' destructive spring feeding habits. When the geese arrive in the spring, above-ground plant growth has not yet begun, and the birds grub for below-ground plant parts. This disrupts the sward, and, in all but small grubbed patches, surface erosion and increased salinity prevents or severely slows the re-establishment of vegetation (Srivastava and Jefferies 1996). As a result, much of the area previously used by the geese at La Pérouse Bay is now bare or colonized by a few unpalatable salt-tolerant species. Heavy grazing pressure on the remaining area of salt marsh has damaged the plants and reduced their productivity, which further reduces the available food supply (Jefferies 1997). Historically, grazing by snow geese at La Pérouse Bay kept the salt marsh vegetation in an actively growing state through much of the summer (a condition termed a "grazing lawn" due to its similarity to a lawn regularly mown and fertilized), which increased the total seasonal production of forage (Hik and Jefferies 1990, Hik *et al.* 1991). This state can be maintained only if the vegetation is grazed moderately, but as grazing has become more intense, the grazing lawns no longer occur.

The reduced summer food availability reduces gosling survival (Cooch *et al.* 1993, Francis *et al.* 1992), but since adult snow geese are long-lived, the population continues to grow. Negative effects on other bird species, insect diversity, and plants have been documented by the Hudson Bay Project. If we are to manage the birds to maintain indefinitely both healthy snow goose populations and the rare salt marsh ecosystem, we need to measure both the severity and extent of the goose damage to the marshes. The timing and pattern of damage can then be related to bird numbers and weather patterns, and it is this information which will allow us to set realistic management targets.

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Remote Sensing

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visible and high infra-red reflectance distinguishes vegetation from soils (which tend to have moderate reflectance, slowly increasing with wavelength over the Landsat optical bands) and water (low reflectance, decreasing with wavelength). Accurate classification of targets depends on the nature of the desired classes and the data available. As a simple example, if we consider species occurring in Wapusk, evergreen and deciduous species will be readily distinguishable, especially if summer and winter images are combined. Willow and birch shrubs would be more difficult to distinguish. In addition, the nature of the landscape also affects the results: a fine-grained mosaic of surface types results in many "mixed pixels," which are difficult to classify.

In addition to being able to identify a pixel as containing vegetation on the basis of its spectral pattern, we can often estimate the amount of vegetation. As vegetation amounts increase, reflectance tends to decrease in the visible range and increase in the infrared. However, many other factors influence reflectance, and a great deal of research has attempted to extract accurate estimates of vegetation cover, standing crop, or leaf area index. Most efforts are based on some ratio of red to near infra-red reflectance, as this corrects to some degree for variations in illumination conditions. Variation in plant type and soil background can have large effects, and as a result, good results from one situation can rarely be extrapolated to other conditions.

The Dragonflies of the Columbia Basin

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Photo: George Doerksen, Royal BC Museum.

Enallagma boreale (Boreal Bluet) is perhaps the most common and abundant damselfly in northern and mountain wetlands. Unique in insects, dragonfliesmate in a wheel-like position; sperm is transferred from specialized secondary genitalia at the base of the male's abdomen.

specimens of the Common Spreadwing have been re-identified as the Sweetflag Spreadwing. Inventories do not simply gather new records; they force curators to re-evaluate old collections!

The Forcipate Emerald eluded us for years. In the 1920s Edmund Walker of the Royal Ontario Museum had collected this elusive dragonfly about 3 km from the BC/Alberta boundary in Banff (Walker and Corbet 1975). After much searching, we finally came across the Forcipate Emerald in Kicking Horse Pass and mapped the species at 3 peatland sites in Yoho and Kootenay national parks. This emerald is clearly a sparsely distributed member of the Rocky Mountain dragonfly community, and an inhabitant of an apparently rare habitat.

As a result of this project and additional inventory in central BC in 2000, the list of species at risk in BC as a whole has been revised. The ranks of 6 listed species in the province, 3 of which are recorded in the Columbia Basin, have been downgraded. Two of the latter species, the Black-tipped Darner and the Lake Emerald, are still considered vulnerable (Blue List) but the Sweetflag Spreadwing has been struck completely from the list only 3 years after it was discovered in the province.

Of the 9 species on the provincial Red List (extirpated, endangered or threatened), 2 are known from the mountain parks. These are the Vivid Dancer and the Forcipate Emerald. In the parks, the Vivid Dancer is known only from Banff; the larvae live in hot springs, and the damselfly has probably been extirpated from some springs, including those at Radium in Kootenay, because of pool development. The species still lives in the outlet stream of the springs in Albert Canyon, a developed spring immediately east of Mt. Revelstoke and occurs in several other springs farther south. Any warm or hot spring in the mountain national parks probably supports this rare species, and protection of these habitats should be a management priority.

Spring-fed habitats of other sorts are also of management concern. The springs along the Emerald Lake Road in Yoho comprise1 of 3 known localities (all 3 in national parks) for the Forcipate Emerald in western Canada.

The 25 Per Cent Fen, the most diverse park habitat examined, is at least partly spring-fed. This is an old, mature fen that has much variety in its component microhabitats. A rather rich marsh occupies one end of the site, and supports species such as the Pacific Forktail *(Ischnura cervula)* that are more at home in warm southern valleys. Northern species are prominent, including those such as the Subarctic Darner that require moss-filled water. The blue-listed Black-tipped Darner occurs here and, with more study, other listed species such as the Azure Darner might also be discovered. Any expansion of Highway 1 along the margin of this site could radically affect the drainage patterns that have produced these habitats. Spring-fed sites are notoriously sensitive to change.

Rare and poorly known northern dragonflies are associated with peatlands in the high mountains of national parks in southeastern BC and southwestern Alberta, especially in the Bow, Kicking Horse , Ottertail and Beaver river valleys. Because major transportation corridors follow these large valleys through the mountains, much of this habitat is vulnerable to significant physical and chemical perturbation. The accessibility of these areas makes them appealing for nature interpretation and scientific study. Thus, their study and preservation should be a high priority in the management of parks. Preliminary information from this study may be relevant to park management decisions for modifying transportation corridors.

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WAPUSK NATIONAL PARK

Small Mammal Cooperative Inventory Project

Photo: Andrew Dickinson

Jack Dubois

In 1997, Wapusk National Park and the Manitoba Museum of Man & Nature began a small mammal inventory of several habitats. The rationale for the investigation was simple: to manage the park, Wapusk staff needs to know what is out there. Field work started in 1998 and and continued through the following 2 field seasons with the primary objective of producing a credible list of mammals of Wapusk. A secondary objective was to provide the Museum with voucher specimens of several species from known locations to demonstrate habitat affiliations within the park.

Although a wide variety of biological investigations continue at Churchill, only a few species –snow geese (e.g., Cooke, Rockwell and Lank 1995), Canada geese (e.g., Pakaluk 1969, Poston et al 1990), and polar bears (e.g., Stirling, Lunn and Iacozza 1999) – have been studied extensively in the area that is now Wapusk National Park. Only a couple of studies investigated the park's other mammalian fauna (Bahr 1989, Moser and Rusch 1988). A survey of the literature (Banfield 1973, Hall 1981), discussions with a local trapper and examination of trapline returns, revealed that there are at least 40 mammal species inhabiting the park and adjacent waters, and 8 additional hypothetical species (Table 1, page 12).

During this study, small mammals were collected near the mouth of the Broad River (July 22-26, 1998), along the length of the Owl River within the park (June 10-20, 1999), and near the mouth of the Owl River (July 21-27, 1999 and June 27- July 1 2000). Local habitats were sampled for small mammals using Museum Special® traps, under Wapusk research permits. Sites included small, patchy beach meadows; sedge-meadows; and lichen-heath tundra along water bodies in inter-beach ridge swales, i.e., pond margins; shrubby pond, river and creek margins. Some samples were from treed areas within 250 m of the shoreline Along the Owl River. Richardson's collared lemming (*Dicrostonyx richardsonii*) was particularly sought after, so its preferred habitat of dry lichen-heath tundra was disproportionately sampled (Scott and Hansell 1989). Exact locations of all trap lines were recorded in UTM coordinates by hand-held GPS units. Ultimately this data will be entered into the Wapusk GIS to link each species with the classified satellite vegetation map of the park (see article by Brook *et al*. page 8).

We observed larger species opportunistically, along with their tracks and signs. Seasonal park officer Jack Batstone was interviewed regarding local medium and large mammal species because of his extensive experience in the area as a trapper, hunter and resident. Fur records for 1996 - 2000 for the registered traplines within the Park were obtained from Manitoba Department of Conservation (D. Berezanski, *Wildlife Branch, personal communication*). Some conversations were held with First Nations people about their traditional knowledge of mammal species in the area, but more work is needed in this area to get the complete picture.

Vascular plants in flower were recorded each year and a subset collected for verification by museum botanist, Karen Johnson. Additional plant specimens were collected by Elizabeth Punter, Special Projects Botanist, Conservation Data Centre, Manitoba Conservation Department (Manitoba Conservation Data Centre Report 1999). All suitable mammal specimens collected were prepared in the field as study skins and skulls and then catalogued into the collection of the Manitoba Museum of Man & Nature.

RESULTS

In total there were 2567 trap nights and 200 specimens comprising 16 species were captured. Ten additional species were observed. Weather, drought and time of year influenced trap success. The overall capture rate for this field work (7.8%) can be compared to work done in the vicinity of Churchill (capture rates of 12.7% and 2.1%) and at the mouth of the Seal River (8.1% and 8.7%) by museum field parties using similar methods some time ago (Wrigley 1974).

Some small mammal species are cyclical in population over multi-year periods (Scott 1993) and crashed in 2000. All species at these latitudes have only 1 litter per year, so the later the date in summer collection the larger the population from which to sample. All of the females captured during this study were pregnant, in oestrus or had given birth recently. Few young of the year were taken. The Richardson's collared lemmings (*Dicrostonyx richardsoni*) taken at the Owl River are 50 km south and 14 km east of the closest recorded occurrence (Bahr 1989), and thus represent a range extension for this species. Elders of the York Landing First Nation say that the collared lemmings, referred to as "polar bear lemmings" because their fur turns white in the winter, were found further south at one time (Flora Beardy, *York Landing First Nation, personal communication*).

Of the plants collected or recorded at the mouths of the Broad and Owl rivers on our expeditions, 13 species are rare for the province. Of these, 8 species are range extensions for the region. The location of 1 species, Lewis' wild flax (*Linum lewisii*) is the second recorded site for Manitoba. Further work should turn up more range extensions and new occurrence records. The peak flowering period for vascular plants in the region is generally early to mid-July, which would be the best time for collecting.

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Small Mammal Co-operative Inventory Project

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Table 1.

Mammal species collected:

- arctic shrew (*Sorex arcticus*).	[6]
- masked shrew (*Sorex cinereus*)	[1]
- meadow vole (*Microtus pennsylvanicus*)	[67]
- Richardson's collared lemming (*Dicrostonyx richardsoni*)	[13]
- southern red-backed vole (*Clethrionomys gapperi*)	[78]
- meadow jumping mouse *(Zapus hudsonius*)	[2]
- least chipmunk (*Tamias minimus*)	[2]
- heather vole (*Phenacomys intermedius*)	[22]
- northern bog lemming (*Synaptomys borealis*)	[9]
- least weasel (*Mustela nivalis*)	[1]
- arctic fox (*Alopex lagopus*)	[1]

Mammals seen but not collected:

- polar bear (*Ursus maritimus*) - several individuals seen along coast and on flights to and from Churchill to field camps, all years
- caribou (*Rangifer tarandus*) - hundreds seen on flights to Churchill from field camps (current estimated population 3013, minimum)[1], all years
- wolverine (*Gulo gulo*) - one seen west of Broad River cabin ~1 km, 1998
- red squirrel (*Tamiasciurus hudsonicus*) - sign common, a few seen
- beaver (*Castor canadensis*) - several seen but no lodges, along Owl River 1999
- northern river otter (*Lutra canadensis*) - five seen on Owl River trip 1999
- black bear *(Ursus americanus)* - sign near junction of Silcox River & Owl, 1999l
- moose *(Alces alces)* - one seen inland, along Owl River, a few on flights from camps in Park to Churchill
- arctic fox (*Alopex lagopus*)- two seen inland, along Owl River, several den complexes
- wolf *(Canis lupus)* - tracks seen, fresh caribou kill overnight, mouth of Owl River, 2000
- harbour seal (*Phoca vitulina*) - one individual, seen 50 km inland in the Owl River, 1999

Mammals seen or trapped in Wapusk over many years by Jack Batstone:

- arctic hare (*Lepus arcticus)* - Present in the park. Salmon Creek is the furthest south he has seen them. "Lots of droppings around Nestor 1 (goose research camp). Lots around Churchill now."
- least chipmunk (*Tamias minimus)* - Jack has seen them near Churchill River, south of the town of Churchill.
- woodchuck (*Marmota monax)* - Hypothetical. Closest seen was at Port Nelson.
- red squirrel (*Tamiasciurus hudsonicus)* - Present, in the treed areas of the park.
- muskrat (*Ondatra zibethicus)* - Present Inland from the coast but not in large numbers.
- beaver (*Castor canadensis)* - Present, but not common. Some beaver lodges currently present at Norton Lake.
- porcupine (*Erethizon dorsatum)* - Present. "Some here, up the creeks."
- arctic fox (*Alopex lagopus*) - Present. "Have seen lots - at least as far south as Cape Tatnum."
- coyote *(Canis latrans*) - Not present. His father trapped one up the Seal River once but he has never seen one in this area.
- gray wolf (*Canis lupus)* - Present. Common in the park.
- red fox (*Vulpes vulpes*) - Present. "All over Wapusk."
- black bear (*Ursus americanus)* - Present in the park, but not too many. Higher numbers are found along the Churchill River.
- grizzly bear (*Ursus arctos*) - Present in the park as recently as June1998. Single individual seen off and on for the last few years in the park.
- wolverine (*Gulo gulo)* - Commonly present. "Trapped one at Salmon Creek last year."
- northern river otter (*Lutra canadensis*) - Present, along the rivers.
- American marten *(Martes americana)* - Present, along the rivers.
- fisher (*Martes pennanti)* - Present, along the rivers.
- striped skunk (*Mephitis mephitis*) - Not present. One was seen at Cape Tatnum goose camp a few years ago.
- ermine (M*ustela erminea)* - Present, all over the park.
- mink (*Mustela vison*) - Present, along the rivers.
- lynx (*Lynx lynx*) - Present, when hare numbers are high.
- moose (*Alces alces*) - Present Not as numerous as further south along the Hayes and Churchill rivers.
- white-tailed deer (*Odocoileus virginianus*) - Not present There is a local story of three animals overwintering on Poplar Island in the Hayes River near York Factory.
- caribou (*Rangifer tarandus*) - "Present, in good numbers, over one thousand animals."

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Small Mammal Co-operative Inventory Project

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ACKNOWLEDGEMENTS

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Photos: Andrew Dickinson

Field data is essential for characterizing and mapping vegetation.

A View from Outerspace

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use satellite imagery, as it provides frequent coverage of the entire area at a reasonable cost. Ongoing satellite coverage enables us to purchase new images in the future to update the map as changes occur. One of the most commonly used satellite images is LANDSAT TM. This type of image measures light reflected from the ground in the visible, near infrared, infrared and thermal wavelengths, and is ideal for identifying different vegetation types. Pixels (the millions of tiny squares that make up a digital image) in the LANDSAT TM imagery are 30 x 30m in size, which provides more than adequate detail for an image covering 185 x 185 km.

Satellite images provide an excellent overview of the entire park, but relating the image to the vegetation types on the ground requires field sampling of the vegetation. So where should the sampling be done? How many sites need to be sampled? What information needs to be collected and in what format? These are difficult questions, particularly in a remote area such as Wapusk that has one of the highest concentrations of polar bears in the world during the summer months!

Field data were collected between June and September from 1998-2000. Sampling locations represented large areas containing a single vegetation type. Many sites were needed to ensure that the high compositional variability across the landscape was carefully measured. In total, over 600 sites were sampled by estimating percent cover of all plant species within 10 x10m plots and measuring the variation in vegetation height across the plot. Environmental data were also collected including soil type, wetness, distance to the Hudson Bay coast, latitude, surficial geology and nutrient status. These data were analyzed statistically to sort the vegetation into different communities and examine vegetation-environmental relationships.

A common problem in using satellite imagery is that a complex mix of several different vegetation types in a small area will produce a confusing mix of reflected signals in the digital image. Such errors are particularly problematic if the different vegetation classes have overlapping spectral signatures. In order to identify a group of classes that are distinct in the satellite imagery, we developed a multivariate statistical approach that compares the spectral signatures of the identified vegetation communities. This procedure identifies unique classes and allows the analyst to simultaneously consider multiple satellite bands for all classes in order to identify overlap in spectral reflectance values prior to classification. In total, 16 vegetation classes were recognized in the final map. Map accuracy was assessed using an independent sample of 1100 additional sites to compare the vegetation on the ground to that predicted by the map. Overall, the map was 97% accurate, though this varied among classes, ranging from 88% to 100% accuracy.

A vegetation map can be an invaluable information tool if it is created carefully and tailored to the specific needs of the end-users. The production of such a map involves considerable effort in both field data collection and computational analysis and is produced at a substantial cost. The generation of this vegetation map involved approximately 390 person-days of fieldwork and 480 person-days of computer analysis and report writing. Total cost was approximately $140,000 (including helicopter time to access sites - the single most expensive component of the project). However, this is a sound investment in the development of an information base for Wapusk, a remote and relatively poorly understood park.

The digital map can be used in a variety of applications to present the information in new ways and at different spatial scales. For example, it can be imported into a Geographic Information System (GIS) to produce maps showing specific characteristics such as an area within a 10 km radius of a field camp, a canoe route, or helicopter survey route. For general use, the entire vegetation map is available at a scale of 1:250,000, complete with a list of the dominant plant species, descriptions of the different vegetation

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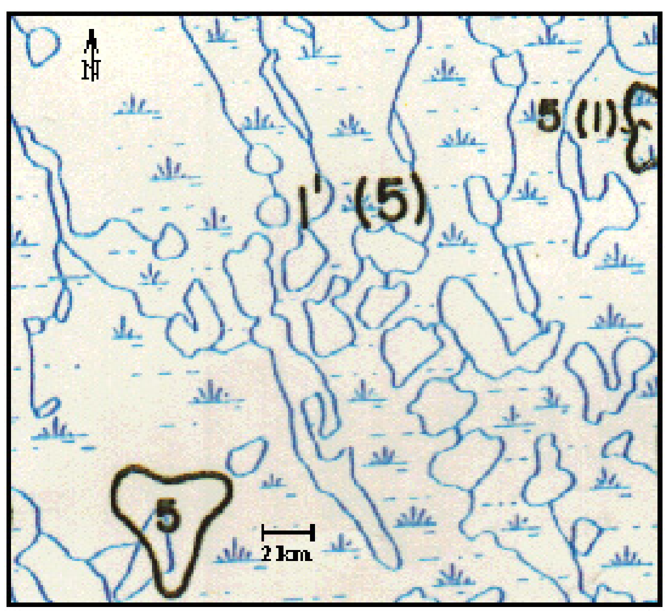

(Ritchie 1962)

Figure 3. Comparison between the vegeetation mao by Ritchie (1962) from aerial photos, and the vegetation mao from this project of the same area around Fletcher Lake, Wapusk National Park (originals in colour — see the online version of this issue at the site listed on page 24, available in April 2001)

A View from Outerspace

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Wapusk is poorly drained due to the frozen soil and flat landscape. The vegetation is dominated by lichens in much of the area, including open tundra and sparsely treed woodlands.

classes, and ground and aerial photographs of each class.

Once the map was complete, we introduced it to scientists, managers and the general public. Satellite imagery and plant ecology are technical subjects that use considerable jargon, and it was a challenge to communicate the information to our diverse audience. We used two poster-sized exhibits (one for the scientific community and another for the general public), and slide presentations for audiences including schoolchildren, tourists, university students, and Churchill residents.

The vegetation map was completed in October, 2000, and it is already being used for a wide range of applications. These include studying den site selection by arctic and red foxes, describing the vegetation for the ecological integrity statement for Wapusk, and selecting sampling sites in an upcoming fire history project. A satellite imagery project is using the map in combination with AVHRR images to monitor plant productivity. It may also provide insights into the habitats that are used by polar bears for resting, feeding and denning. Local hunters and trappers are also inquiring about using the map to identify suitable areas in and around the Park. The vegetation map is quickly becoming an essential tool in the management, research and use of Wapusk. Perhaps its most important functions will be as a baseline against which future change can be compared, and as a format for integrating Wapusk into regional ecosystem management initiatives.

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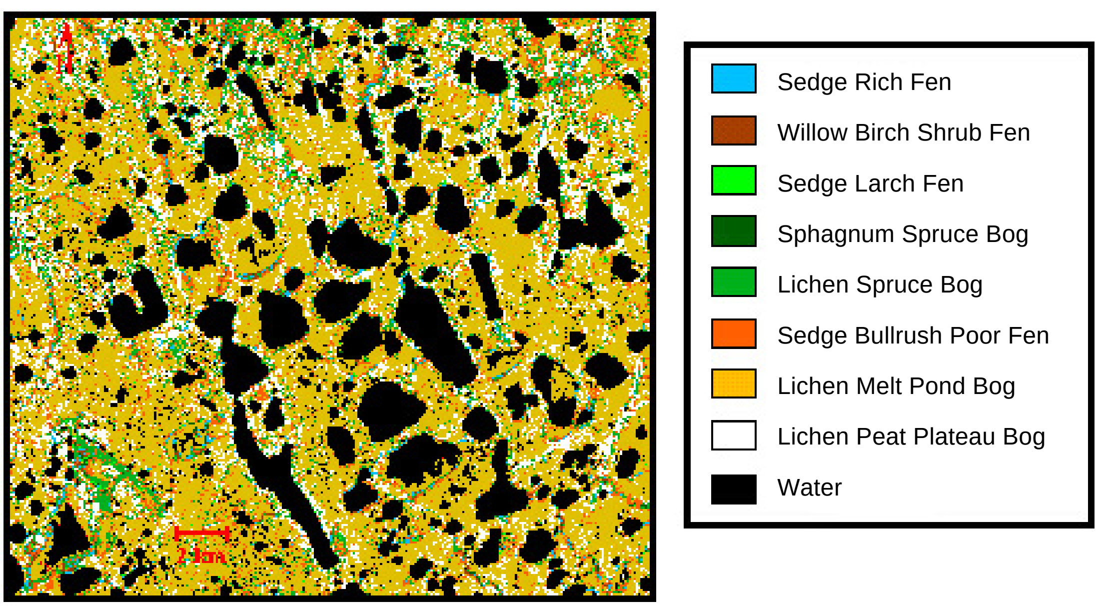

Monitoring Habitat Change Using Satellite Imagery

- continued from page 9 -

1998 aerial photo of long-term exclosures at La Perouse Bay. The exclosures were set up in 1985, when the salt marsh vegetation was intact. Geese have removed the surrounding vegetation except in mossy areas along the banks of small streams.

CHANGE ASSESSMENT

The geese prefer to use coastal salt marshes, but increasingly, they use other habitat types as the salt marsh is degraded. These alternate habitats are not only of differing value to the geese, but damage by the geese can also be expected to affect the different habitats in different ways. It is therefore important to consider changes within each habitat type. As a consequence, the first step in quantifying the change at La Pérouse Bay is to map these habitats and other vegetation types in the region, on as fine a scale as possible. Because the current vegetation is degraded, mapping also involves reconstruction of the historical vegetation.

Pixels with similar vegetation will have similar reflectance patterns, so satellite imagery can be classified using a statistical procedure which groups pixels based on their spectral similarity. Identifying these groups may be problematic, for several reasons. Natural vegetation, even within a particular vegetation type, varies in species composition, biomass, and patchiness, and so spectral pattern will vary within a vegetation type. Furthermore, pixels very often contain more than one land cover type; for example, a pixel might contain both salt marsh and water. Correctly classifying such a mixed pixel depends on precise class definitions: when should such a pixel fall into water, salt marsh, or a mixed class? Finally, different types of vegetation may not be completely spectrally distinct – indeed, they rarely are. Despite these limitations, classification can produce a detailed map of land covers, and it may be as accurate as traditional ground survey techniques.

I have produced a historical vegetation map of La Pérouse Bay, using a classification of a 1984 Landsat image as a basis. Excluding the deep water areas, sixty-three clusters of spectrally similar pixels were identified by the classification routine. These clusters were then individually identified using a variety of ancillary information sources, including four sets of historic and current aerial photographs, and a knowledge of vegetation development patterns in the area. Corrections were made to a preliminary map during a helicopter overflight (literally on-the-fly!). The final map is a result of detailed, extensive cross-comparison between photos, notes, and the Landsat image itself.

To measure the amount of vegetation in each of the habitat types the geese use, we need to determine the relationship between vegetation amount and reflectance pattern for each habitat type. Field data were collected in 1998 and 1999 using hand-held radiometers that measure reflectance in Landsat-similar bands. Using vegetation data (including cover, above-ground biomass, and green leaf area) collected at the same place and time as radiometer measurements, data exploration techniques are being used to find the best relationship between the vegetation and reflectance measurements for each habitat type. Because the ground measurements are collected at a small spatial scale (0.25 m^2), the relationships must then be scaled up to Landsat scales (900 m^2); reflectance data from ground transects will provide the necessary measures of spatial autocorrelation. We can then estimate the vegetation amounts in each habitat type for each year that imagery is available (1973, 1984, 1993, and 1996). A map of vegetation changes over time will allow us to examine the timing and pattern of those changes, and examine the relationships between goose numbers, weather and vegetation damage. The technique can be extended to map goose damage in other areas of the Hudson Bay coast and perhaps we will even be able to predict the effects of population control efforts.

ACKNOWLEDGEMENTS:

Imagery was supplied by the Hudson Bay Project and Wapusk National Park. Funding from Delta Waterfowl Foundation, NSERC, Hudson Bay Project, University of Toronto and the Dept. of Indian and Northern Affairs Canada is gratefully acknowledged. The author would like to thank Ryan Brook, Ferko Csillag, Andrew Davidson, Andrew Jano, Bob Jefferies, and the staff of Wapusk National Park for advice and assistance.

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Updated Canada National Parks Act

On October 20, 2000, Bill C-27 resulted in an several changes to the Canada National Parks Act.

The full document title is

Second Session, Thirty-sixth Parliament
48-49 Elizabeth II, 1999-2000:

Statutes of Canada 2000, Chapter 32

An Act representing the national parks of Canada

Details regarding these changes are now available on-line in PDF format at the Parks Canada main web site:

http://parkscanada/pch.gc.ca

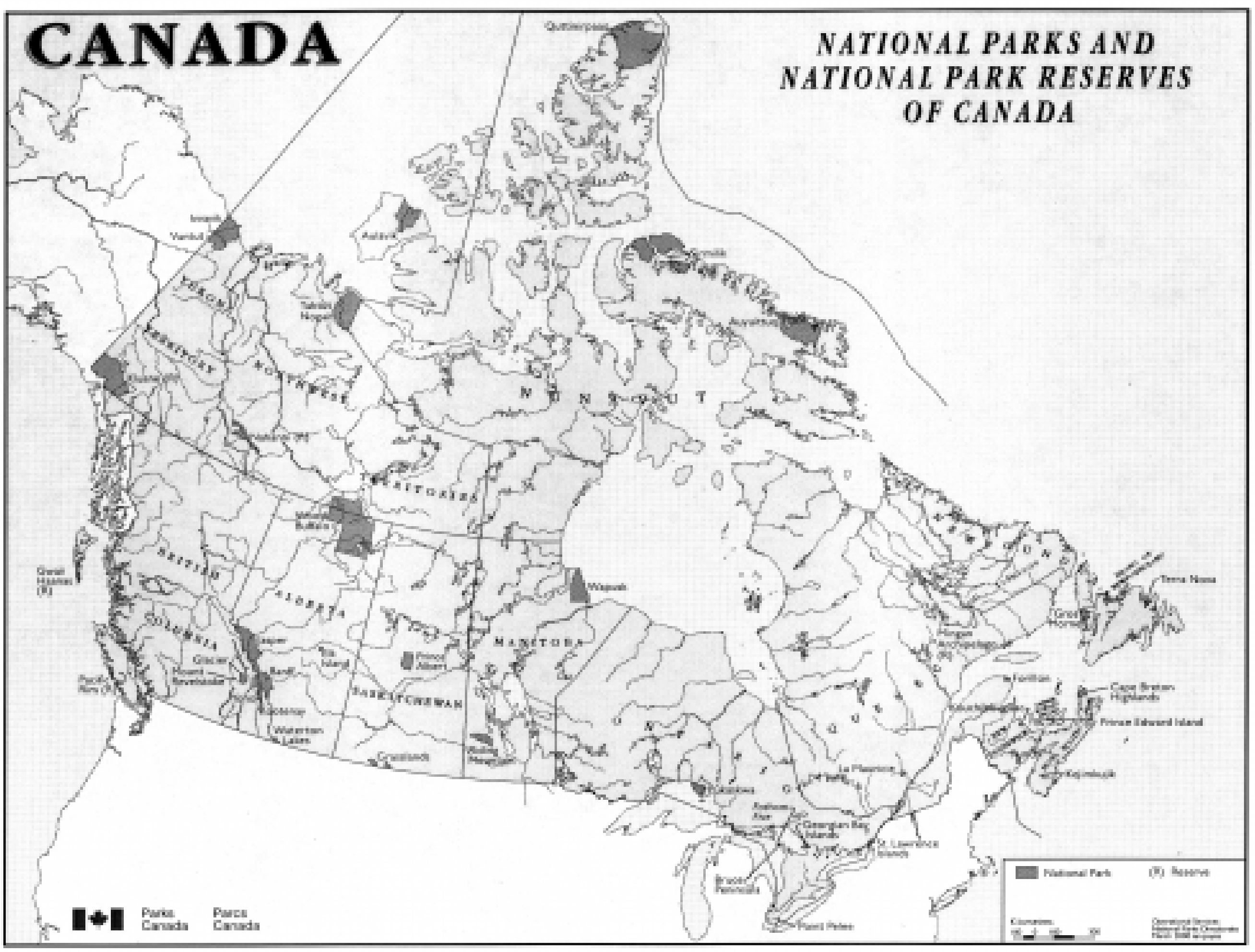
Look under "Legislation and Regulations", "Acts", "Canada National Parks Act" (or type the direct address: http://parkscanada/Library/DownloadDocuments/DocumentsArchive/acts-regs/c27_e.pdf).

The following is a summary of the changes to the act as presented in this document:

SUMMARY

The purpose of this enactment is to revise and consolidate the National Parks Act and, in particular, to:

a) provide a procedure for the future establishment of new parks and the enlargement of existing ones;
b) add several new parks and park reserves and adjust the land descriptions of certain existing parks;
c) enhance protection for wildlife and other park resources;
d) provide for the continuation of traditional resource harvesting activities in keeping with comprehensive land claim agreements and federal -provincial agreements to establish parks;
e) fix the boundaries of communities in parks and restrict commercial development in those communities; and
f) make miscellaneous technical and housekeeping amendments.



This figure is available in the Parks Canada "Map Cabinet"
http://parkscanada.pch.gc.ca/mapcab/Maps_e.htm

Detailing a Natural History Collection

- continued from page 3 -

Collections of bones, pelts, assorted body parts, small animal specimens, fossils, geological specimens and cultural artifacts are stored in metal cabinets with drawers, where they slide back and forth as the drawers are opened and closed. Specimens break, related pieces are separated, and specific pieces are difficult to find. To prevent items from sliding in the drawers, dividers similar to those in liquor boxes are constructed from Coroplast (which is chemically safe for the drawers and the specimens).

Supports were needed to keep the pieces of Wood Buffalo's skull collection together and protect them from handling accidents. Mat board or Coroplast, was cut to extend 1" beyond the specimen in each direction, allowing users to handle the card and not the skull. A piece of polyethylene foam is custom fit around the base of the skull and lower jaw, then glued to the card. The skull rests in the hollow, but is not physically secured. Extra foam can be added to provide additional support to protect the specimen at the back of the skull or the lower jaw to prevent it from sliding off the support. Twill tape replaces short-lived elastic bands to hold the upper and lower jaws together (Figure 2).

On a different tack, a couple of desiccated bats used in the Visitor Reception Centre were liberated from mayonnaise jars. Visitors shook the jars to get the bats to roll over so they could see the other side, which damages the specimens over time. To solve the problem, we constructed a "Bat Book" for each bat, that allows the bat to be viewed from both sides (Figure 3). The book, about the size of a cigarette package, is made of polyethylene foam. A hole cut through the centre of the foam contains the bat. Plastic (Mylar) windows and matboard attached to the foam hold the bat in place. The book's cover protects the bat from light and accidental crushing, and gives people the sense of discovery when they open the "Bat Book".

The result of these improvements to storage conditions is a collection of specimens that are protected from damage while in storage, and readily available for individual study or interpretive use. While time and materials were not available to treat the whole collection during this short review, we hope the ideas we left behind will promote further projects in this area.

Lorrie Storr is a conservator with Cultural Resource Services, Western Canada Service Centre, Winnipeg. e-mail: lorrie_storr@pch.gc.ca

Figure 3. "Bat Book"

Research Highlights

Workshop Report:
MANAGING FOR BEARS IN FORESTED ENVIRONMENTS
October 17-19, 2000, Revelstoke, BC

Concern for bear populations brought over 270 researchers, educators, and land use managers from across North America and Norway to this event conducted by the Columbia Mountains Institute.

First day sessions featured case studies and the latest DNA sampling techniques to monitor bear populations. This session was complemented by a field trip on the third day where participants received hands on training with setting up hair corrals of barbed wire for gathering samples in a forested site.

The second session examined bear management in regards to forest industry issues such as habitat evaluation, access planning, berry production and silvicultural practices. A field trip to harvesting sites with local foresters complemented the presentations.

Session 3 presenters outlined their problems and solutions for co-existence in bear country. Solutions ranged from sophisticated garbage handling, to public education campaigns and aversion conditioning of bears. Some of these topics were studied on site as the Revelstoke Bear Aware Committee members lead participants on a tour of local examples of dealing with chronic bear attractants in the community.

In an evening session open to the public, Stephen Herrero spoke of his 30 years' experience studying bear interactions with humans. He concluded that biologically sustainable grizzly bear hunting doesn't address the primary cause of grizzly bear-inflicted injury, which is sudden encounters with females with young. This is because grizzly bear hunting tries to select for males. Hunting of black bears may target the most dangerous cohort,— male black bears. However, injury rates to

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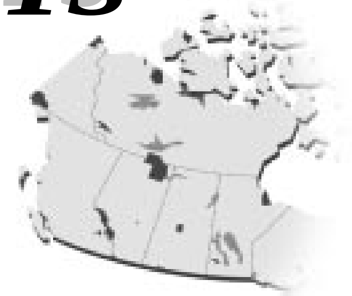
RESEARCH HIGHLIGHTS



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humans inflicted by bears are so low as to make hunting an imprecise tool to manage this danger. Widely recommended safety and encounter avoidance measures, coupled with human-related attractant management, are sufficient to minimize danger. Management actions that remove identified human-aggressive individual bears are also an important part of safety in bear country. Increases in bear-inflicted injuries have occurred in BC during the past 3 decades, most likely because of increased numbers of people in grizzly habitat.

Visit cmiae.org for a summary of presentations, references and contact addresses for presenters.

Michael Morris, Mount Revelstoke and Glacier National Parks, Tel: (250) 837-7528, michael_morris@pch.gc.ca

WEST SLOPES BEAR RESEARCH PROJECT

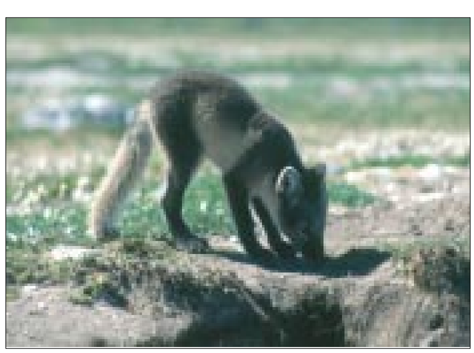
AVALANCHE PATHS AS HABITAT FOR GRIZZLIES

Avalanche paths are an important type of habitat for grizzly bears in mountainous areas. In Glacier National Park, located in southeastern British Columbia, grizzly bears are frequently seen in avalanche paths during spring and again in the fall. How important are avalanche paths to grizzly bears? What parts of avalanche paths do grizzly bears use most? And what do grizzly bears do in avalanche paths? With answers to these questions, Parks Canada may be able to plan hiking trails that cross avalanche paths in a manner that is safe for people and not disruptive to grizzly bears.

The West Slopes Bear Research Project, a long-term research programme based in Revelstoke, B.C., addressed these questions and many others. We tracked over 60 radio-collared grizzly bears for 5 years, documenting patterns of habitat use, diet, feeding, and bedding activity. We found that avalanche paths were so important to grizzly bears in our study area that 54% of all spring telemetry locations were in avalanche paths, even though paths make up only about 15% of the study area. East and south facing paths were used most frequently. We also found that within paths, bears preferred to use areas dominated by grasses and forbs, and also areas with grasses and forbs interspersed with shrubs. Areas within paths that were dominated by shrubs were rarely used. This pattern of use of areas within paths was driven by foraging activity, as most telemetry locations that we visited on the ground revealed evidence of foraging on grasses and forbs. Bedding activity occurred both within avalanche paths and the adjacent forests.

The frequent use of avalanche paths by grizzly bears and the patterns of use of certain areas within paths for feeding and bedding activity demonstrated in our study will assist Parks Canada in making hiking trails safer for hikers and less disruptive to grizzly bears.

Roger Ramcharita is a wildlife biologist with the Alberta Natural Resources Service in Ft. McMurray, AB. Tel: (780) 743-7470; e-mail: roger.ramcharita@gov.ab.ca



ARCTIC AND RED FOX DEN SITE SELECTION IN CHURCHILL,MANITOBA

During the summers of 1998-1999, 22 arctic fox and 22 red fox dens were studied in Wapusk National Park and the adjacent Cape Churchill Wildlife Management Area for a multi-scale habitat analysis of fox dens. Habitat characteristics were measured at den sites, including percent cover of plant species, soil attributes and the number and size of the entrances. A Geographic Information System (GIS) was used to analyze the habitat composition at a variety of spatial scales around each den site using an existing vegetation map (see Brook et al. this issue). Results indicate that the two species overlap in their habitat selection at the fine scale, selecting elevated sand and gravel ridges for den sites. They show regional differences in the distribution of their dens, with arctic foxes being more common in close proximity to the Hudson Bay coast on beach ridges. In contrast, red foxes are more closely associated with tree cover, denning in eskers and kames. Both species den in sand and gravel deposits that are also used as travel corridors by local users and tourism operators. Due to the limited availability of potential denning habitat and the ongoing use of den sites by foxes, these areas require protection and ongoing monitoring. Movement of red foxes into arctic fox range has been observed in other parts of the circumpolar region, but has not yet been documented in this region.

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⬅ *Arctic Fox*

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The Land That Lies Between:

A History of Land Use in Wapusk National Park

Patrick Carroll

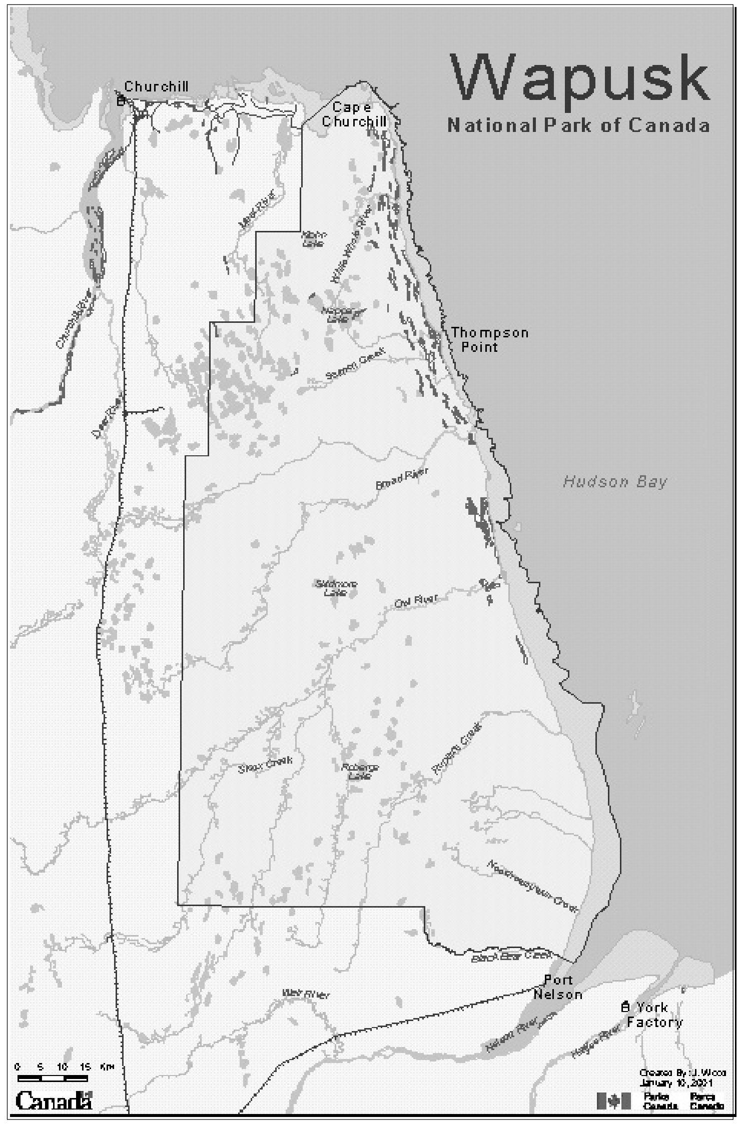
Since 1998 archaeologists and historians at the Western Canada Service Centre in Winnipeg have compiled data to create a Cultural Resource Inventory (CRI) for Wapusk National Park. To date, archaeologists have conducted 2 seasons of field work and produced a report on the history of land use and occupation. This article is intended as a summary of the history of land use and cultural occupancy of Wapusk based upon the results of the first 2 years of research. A synthesis of the 3-year project is scheduled for completion in the spring of 2001.

The history of land use and occupation of Wapusk is ultimately the history of a marginal area, and to understand the history of the park one must look to the historical events of the surrounding region. Located at the southern extent of Inuit territory, and the northern extreme of Cree territory this area was a periphery for human occupation even before the arrival of Europeans. Since the arrival of Hudson's Bay Company (HBC) in the 17th century, the park area has functioned primarily as a travel corridor between the Nelson River in the south and the Churchill River in the north. Situated between two important HBC posts, York Factory and Churchill, the Wapusk "corridor" has had an interesting history as "the land that lies between," providing passage and a regular source of natural resources for local residents.

Little was known of the human history of the coastal region encompassed by Wapusk prior to the establishment of the park in 1996. Although research had been done into the precontact and historic occupations surrounding Churchill and York Factory, no comprehensive survey had ever been conducted on the strip of land that linked the two. An archaeological survey of the Tyrrell Sea Beach Ridge in 1976 failed to record any sites, and noted that:

> "before we can hope to understand the prehistory of northern Manitoba, much additional fieldwork is required. Looming most important among these are...the lower Churchill and Nelson rivers and the west coast of Hudson Bay south of Churchill" (Wood et al. 1976).

The Wapusk Cultural Resource Inventory project will help bridge this gap in the archaeological and historical record.



Prior to Parks Canada's research there were only three archaeological sites recorded within Wapusk. The eighty-four sites recorded during the 1998 and 2000 archaeological surveys have added to our knowledge of human history in the region. The majority of sites represent habitations composed of either stone rings or cabins. Many of the "stone rings" have been tentatively evaluated as belonging to the precontact period but were noted as having:

> "insufficient remains to identify either their cultural affiliation or period of occupation" (Adams 1999).

Cabin construction includes log structures and buildings constructed from milled lumber. Most of the log structures probably date to the influx of trappers to the region between 1920 and 1940, although some may relate to HBC subsistence activities from the nineteenth century. Some structures, dating to the latter half of the twentieth century, are research trailers.

PRECONTACT OCCUPATIONS

Previous archaeological research in the Churchill region has focussed on the West Peninsula, Churchill River, and Twin Lakes, and generally supports a marine-oriented, arctic–based adaptation to the Churchill area during the precontact period. The majority of precontact sites in Wapusk were recorded during the year 2000 archaeological survey (report in progress), which focussed on the southern and more remote inland portions of the park. The existence of a number of precontact sites associated with ancient beaches well removed from the present shoreline is an important addition to the record of human occupation in the northern portion of the Hudson Bay Lowlands. Several lithic sites were associated with relict beach ridges at

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The Land That Lies Between

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an elevation consistent with some precontact sites at Sea Horse Gully on the West Peninsula. Unfortunately, the lack of diagnostic artifacts means the period of occupation and the cultural affiliation for these precontact resources has yet to be determined. The results of the recent survey suggest the park contains a number of locations with good archaeological resource potential. Future research could greatly illuminate our understanding of the precontact period.

POSTCONTACT OCCUPATIONS

Most of the history relating to the early postcontact occupation of Wapusk is derived from the voluminous fur trade records relating to Churchill and York Factory. Unfortunately these records provide limited information on people and activities beyond the post. Early historic references to the park generally describe a vague area seasonally occupied by Cree and Dene Homeguard, and twice annually traversed by individuals carrying mail and supplies between the coastal posts.

The fur trade at Churchill initiated a number of changes in traditional territories for the Dene, Cree, and Inuit. Trade brought the Cree further into the north and west, while it drew the Dene east from Lake Athabasca into southern Keewatin. The Inuit withdrew from the Churchill area at the outset of trade and do not appear to have reoccupied areas south of the West Peninsula until the late nineteenth century.

Historic records from the nineteenth century represent a greater diversity in the number of groups traversing the coastal region. The HBC posts functioned as points of entry for missionaries and settlers travelling to the Canadian northwest, as well as emergency accommodations for seamen forced to winter on the bay. When the Prince Rupert wintered at Churchill in 1833, a lack of accommodations meant the sailors had to walk overland to York Factory. During the trip one of the men died and several suffered severe frostbite. A similar incident occurred in 1813 when the second group of Selkirk Settlers were forced to winter at the Churchill River. The following spring those healthy enough to travel walked to York Factory then continued upriver to the Red River Colony.

Remains of a cabin, possibly constructed by Cliff Cochrane during the winter of 1928.

By the end of the nineteenth century the northwest had fallen under the jurisdiction of the Canadian Government, which organized researchers to explore and report on the newly acquired territory. Formal exploration and promotion of the northwest generated public interest and fuelled the public's imagination for stories from the "new north." Various expeditions made use of the existing infrastructure of HBC posts, and some mention travelling through the park area en route to a final destination.

TWENTIETH CENTURY

The twentieth century is a period of increased commercial development and government jurisdiction in Wapusk. The Hudson Bay Railway and corresponding sea port were built to facilitate the shipment of prairie grain to European markets via Hudson Bay. Construction of the original railway terminus, at Port Nelson, began in 1913. It was partially completed before construction ceased in 1918. By 1927, the decision was made to re-route the line to the Churchill River and Port Nelson was abandoned. While construction of the railway brought new people to the region, changes in the fur trade lead to a major decline in trade and population at Port Nelson and York Factory.

Rev. Joseph A. Lofthouse camped on the coast somewhere between Churchill and York Factory, circa 1890.

Changes in the local economy made it necessary for the Federal Government to assert its jurisdiction in the region. As a result, the Royal Northwest Mounted Police established a headquarters at Churchill in 1905. The post was moved to Port Nelson for several years before ending up at Split Lake. The RCMP undertook many of the official duties previously conducted by the HBC. The HBC's mail route between the coastal posts had been operating since 1717. The RCMP replaced it with an alternate route between Split Lake and Churchill following the Churchill River, west of the park's boundary.

With the decline of the fur trade at York Factory and Churchill, and the building of the Hudson Bay Railway, Wapusk was again a marginalized land. Trappers and traders arriving in the 1930s and 1940s temporarily occupied the region, before travelling to the barren lands north of Churchill.

The second half of the twentieth century is characterized by increased government

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The Land That Lies Between

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regulations over the use of the park area. In 1942 the United States War Department approached the Canadian Government to propose the joint construction of a TransAtlantic aerial ferry route code-named “Crimson.” Agreement gave the US Military authority over a large portion of the surrounding region, including Wapusk, and restricted local access. Following the 1940’s decline in fur-bearing animals, the Provincial Government established Community and Registered Traplines. This action further regulated local access and created a pattern whereby the northern portion of Wapusk would be accessible for recreational use by the community of Churchill. In 1978 the Cape Churchill Wildlife Management Area (CCWMA) was created in response to a growth in the provincial tourism industry. The CCWMA was created to manage, conserve, and enhance wildlife resources and provide a variety of wildlife related forms of recreation. Meanwhile scientific research was being conducted at the Churchill Rocket Range and remote stations along the coast as the unique ecological attributes of the “near north” were attracting researchers from around the world. The establishment of Wapusk National Park is the most recent stage in the process of government involvement in the preservation of the natural and cultural heritage of the Lowlands region.

As with the people who have occupied the region, the history of Wapusk is elusive. The results of the Wapusk Cultural Resource Inventory are helping to bring forth the stories and put a face to the “land that lies between.” The history of Wapusk illustrates the importance of peripheral areas in defining the contextual history of a region. Overshadowed by the voluminous history of the National Historic Sites at Churchill and York Factory, Wapusk may be better suited to tell the story of the “little guy”; the mail carrier, provisioner, homeguard, trader, trapper, settler or missionary; the people whose stories might otherwise not be told.

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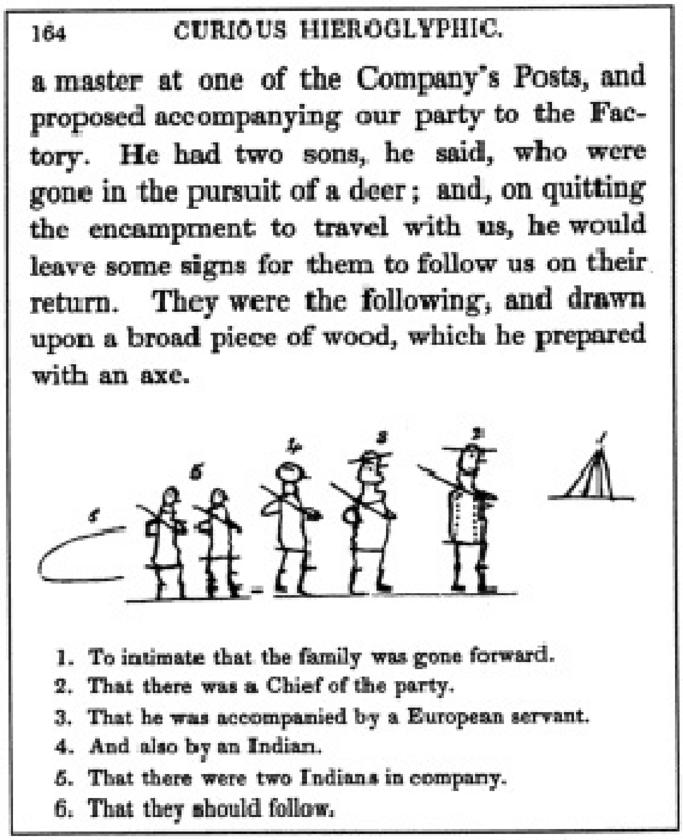

164 CURIOUS HIEROGLYPHIC.

a master at one of the Company's Posts, and proposed accompanying our party to the Factory. He had two sons, he said, who were gone in the pursuit of a deer; and, on quitting the encampment to travel with us, he would leave some signs for them to follow us on their return. They were the following, and drawn upon a broad piece of wood, which he prepared with an axe.

1. To intimate that the family was gone forward.
2. That there was a Chief of the party.
3. That he was accompanied by a European servant.
4. And also by an Indian.
5. That there were two Indians in company.
6. That they should follow.

This drawing was made by Rev. John West during his walking trip from York Factory to Churchill on July 16, 1823

George Simpson McTavish dressed for winter travel in Wapusk circa 1880.

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MEETINGS OF INTEREST

June 21-26, 2001
Second Symposium on Marine Conservation Biology. San Francisco State University. Hosted by the Marine Conservation Biology Institute (MCBI). This will be an international forum for established researchers and students in natural and social sciences, and managers and others interested in the science of protecting, restoring and sustainability of the world's estuaries, coastal waters, enclosed seas and open oceans. Contact Julie Morgan, conference coordinator, Tel: (877) 712-3777, e-mail: jmevents@bigsky.net; www.mcbi.org

July 14-18, 2001
38th Annual Meeting of the Animal Behaviour Society. Corvallis, Oregon. Symposia include aggregation and group organization in animal societies, behavioural genetics for the next decade, detecting and measuring mating preferences, and song learning. Contact Andy Blaustein or Linda Houck: blaustea@bcc.orst.edu or houckl@bcc.orst.edu; www.animalbehaviour.org/ABS/Program

July 29-August 1, 2001
2001 Society of Conservation Biology Annual Meeting. University of Hawaii, at Hilo. Hosted by the Pacific Island Ecosystems Research Centre (PIERC). The meeting theme is Ecological Lessons from Islands. Islands have served as "natural laboratories" since the seminal works of Darwin and Wallace in the 19th century. Studies of island biota have generated ideas, theories and models that have played central roles in the development if mainstream biogeography, evolutionary biology, basic and applied ecology. This conference will address conservation challenges for islands and mainland environments: exotic species, habitat loss, isolation, reserve planning, balancing conservation needs with the rights of indigenous peoples., and finding ways to ensure sustainability of ecosystem functions. Contact: Bethany Woodworth or Kristie Trousdale, Kilauea Field Station PO Box. 44. Bldg. 344 Hawaii National Park, HI, 96718. Tel: (808) 967-7396 x237; e-mail: Bethany_Woodworth@usgs.gov or Kristie_Trousdale@usgs.gov; www.uhh.hawaii.edu/-SCB

September 10-14, 2001
Geoindicators for Ecosystem Monitoring in Parks and Protected Areas. Discovery Centre, Gros Morne National Park., Nfld. This International workshop is a scientific consultation organized by the International Union of Geological Sciences (IUGS), and involving Canadian Parks Service, US National Park Service and other personnel working to monitor the abiotic components of ecosystems in protected areas. This workshop will review approaches to monitoring, assessing and predicting rapid geological processes and parameters that may be important for park ecosystem management. It will provide an opportunity to discuss ways in which geoindicators can be applied in a wide range of natural settings, even where there are no resident geologists. The meeting will concentrate on the physical components of the landscape and ecosystems. Contact: Tony Berger, Co-director IUGS Geoindicator Initiative, 528 Paradise Street, Victoria, BC, V9A 5E2: Tel: (250) 480-0840; e-mail: aberger@uvic.ca

November 2-8, 2001
"Wilderness and Human Communities." The 7th World Wilderness Congress. Port Elizabeth, Eastern Cape, South Africa. Organized by the Wilderness Foundation (South Africa) and the WILD Foundation (USA). The Aldo Leopold Wilderness research Institute invites you to participate in the technical session, "Science and Stewardship to Protect and Sustain Wilderness Values." The symposium will be structured to enhance international and inter-cultural communication, and will integrate poster discussion presentations into each session to increase one on one dialogue. Contact: Alan Watson and Janet Sproull, Leopold Institute, Tel: (406) 542-4196; e-mail: awatson@fs.fed.us; jsproull@fs.fed.us; www.wilderness.net/leopold

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