



**Wapusk
National Park**
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Report on Research and Monitoring in Wapusk National Park

2015-2016



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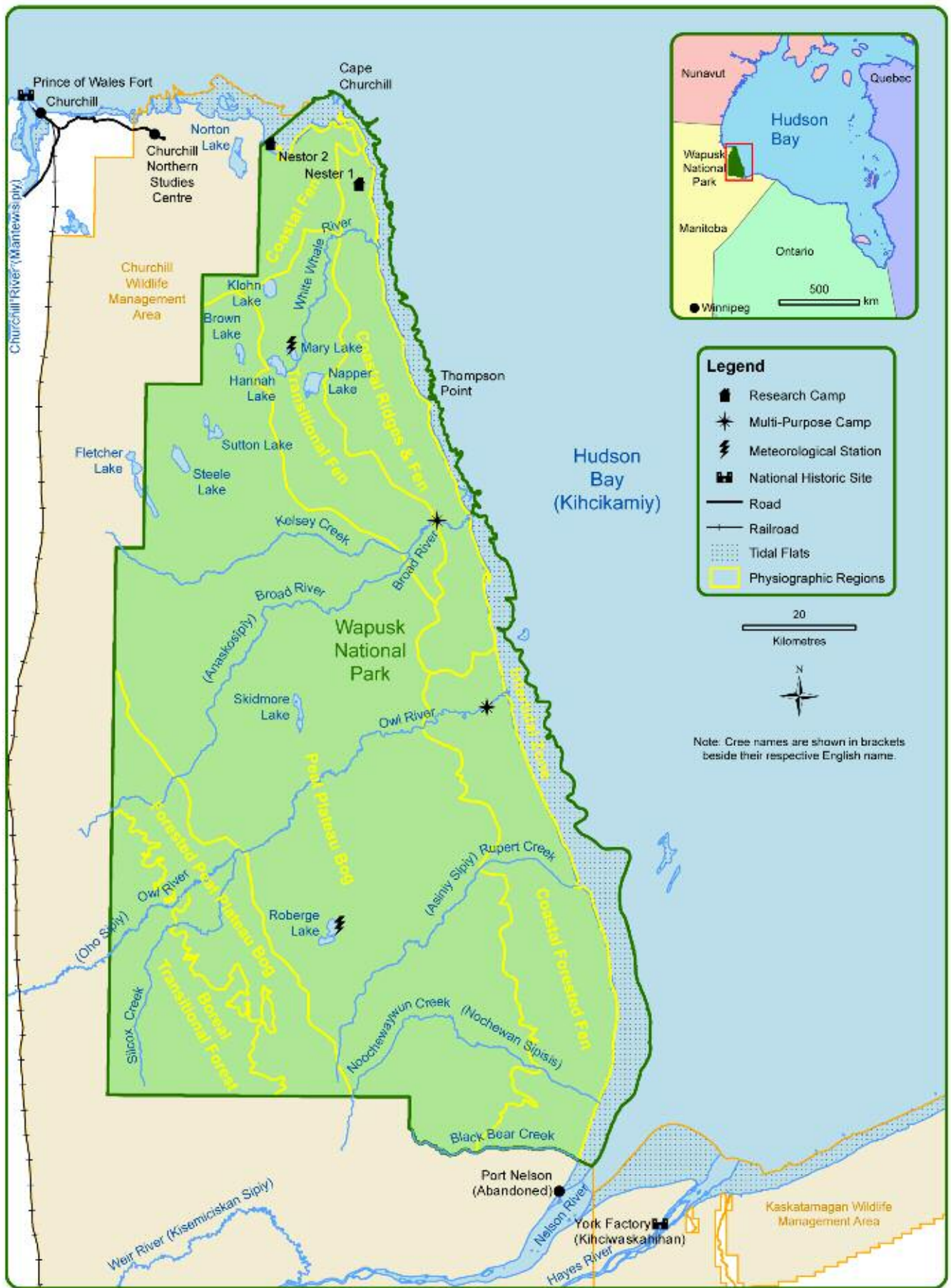


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We are pleased to share this research and monitoring report for Wapusk National Park. Scientists have been conducting a variety of projects in the area now known as Wapusk National Park for nearly half a century, and hundreds of papers can be found in the scientific literature detailing their results.

As we prepare for the 20th Anniversary of Wapusk National Park, this 2015-2016 research and monitoring report highlights a number of projects taking place in the park. It includes papers shared at the 2014 Wapusk Research Symposium. Both the symposium, and these reports, provide opportunity to share information with the research community and the public. We are excited to see the park continue to grow as a hub for northern research.

The Wapusk National Park Management Plan, along with the newly approved Ecological Integrity Monitoring Plan, asserts Parks Canada's responsibility for maintaining and monitoring the ecological integrity (EI) of the Park. Research and monitoring in remote parks is both challenging and costly. Integration of data gathered through a collaborative approach, citizen scientists, and traditional and Indigenous knowledge, can strengthen a research program. Research collaborations enhance our ability to monitor issues that may affect EI in the Park, and to better understand them. Many of these projects contribute to park management, as well as regular reporting to Canadians on the conditions of the Park, via a State of the Park Report.

As new visitor opportunities are implemented and infrastructure is developed or upgraded to support these activities, Parks Canada will monitor EI to ensure that this development minimizes impact on park ecosystems. With more people in proximity of polar bears, we anticipate an increase in human –

polar bear interactions. By distributing human-bear interaction forms to visitors, staff and commercial operators, we simplify the collection of information, and will be able to track changes over time. The collection of these forms, other wildlife observations, and monitoring EI and other processes within the park boundary, will help guide management decisions, and achieve strategic goals within our management plan; *“Ecological Integrity is maintained by keepers of the land”*.

This report provides a glimpse into the diversity of research and monitoring programs carried out in Wapusk National Park and the greater Churchill region over the past several years. We invite you to contact the lead researcher listed for the project if you would like to learn more about a specific project. If you wish to contribute to a future report please contact Parks Canada staff in Churchill. We welcome any questions or feedback on this report.



Melissa Gibbons (L) (Resource Conservation Manager) and Chantal Ouimet (R) (Ecologist)



IN MEMORIAM

On August 23 2015, the Hudson Bay Project lost one of its' innovative young members. Dr. Linda J. Gormezano was a valued student in the Department of Ornithology at the American Museum of Natural History and member of the Hudson Bay Project.

Linda's PhD work centered on understanding how polar bears were responding to climate change and determining whether their responses would be sufficient to sustain them. Insisting on a passive sampling approach that did not disturb the bears, Linda trained a Dutch Shepard (Quinoa) to find polar bear scat along the shores of Hudson Bay and on the more inland highlands adjacent to rivers and lakes in Wapusk National Park. She found that polar bears are opportunistic and flexible foragers that have altered their diet to match currently available food.

Linda and Quinoa collected more than 1200 scat piles over three years. Each of these was sorted to identify and quantify the contents. This data formed the core of her dissertation and allowed her to provide insights on several novel aspects of polar bear foraging and nutrition. In addition, Linda was able to alter and expand the work of the Hudson Bay Project team. When she first joined the Hudson Bay Project as a student, she worked to convince Drs. Robert (Bob) Jefferies and Robert (Rocky) Rockwell, that the team should expand their research effort: from simply looking at the interplay of an herbivore (snow geese) and its forage plants to a community level and incorporate research on polar bears that, because of climate change, were becoming an increasingly important player in the ecosystem. They listened, gave her a chance and the rest is history, well documented in her published collection of scientific papers.

Thanks to Linda's perseverance, the world view on the fate of polar bears is changing. Many scientists are duplicating her results and more are challenging the way we look at climate change impacts on polar bears. Linda always ended her papers with admonitions that we do not know enough and that there is still more to learn.

After completing her doctorate, Linda remained a member of the Hudson Bay Project and oversaw their polar bear research program. Members of the Hudson Bay Project are committed to continuing and building on her work; a fitting and well-deserved tribute.

R.F. Rockwell



Linda and Quinoa

Manitoba Breeding Bird Atlas

Rationale:

The Manitoba Breeding Bird Atlas surveys are designed to provide useful data to Parks Canada on bird distributions and the relative abundance of species. All Species at Risk data will be georeferenced and provided to Parks Canada and the Manitoba Conservation Data Centre. Special efforts are made to record Species at Risk. These surveys will serve as a baseline for long-term monitoring or future efforts to monitor changes in distribution and abundance of Wapusk's birdlife.

Objectives:

- Complete avian survey of park over 4 years
- Establish basis for effective long-term monitoring
- Document avian communities and Species at Risk distribution throughout park

Methods:

- Survey protocols detailed at: http://birdatlas.mb.ca/pdfkit_en.jsp
- Point count surveys and general atlassing surveys conducted in most atlas grid squares (10km x 10km UTM grid squares) along prescribed routes (Owl River in 2011, Broad River and portion of coast in 2012), as well as some special (playback) surveys for Yellow Rail (Special Concern) in suitable habitat

Years of data collection:

Years 3 and 4 of a 4-year project; however, note that results presented below encompass the entire four-year survey window.

Year	General Atlassing				Point Counts		
	# Hours	# Species	# Squares	# Records	# Points	# Species	# Records
2011	244.8	109	21	1322	290	97	2501
2012	334.5	123	33	1148	448	97	3640
2013	428.2	124	23	926	329	111	2664
2014	125.8	87	16	612	226	78	2425
Total	1,133	134	93	4,008	1,293	124	11,230
Adjusted	1,413	134	118	5,137	1,363	124	11,842

Total is the sum of the reported hours (four annual reports made to Parks Canada). The adjusted total accounts for extra records provided by importing data from other researchers into the atlas database (especially around Nester 1) and some records made from helicopter in otherwise unsurveyed squares.

Partners:

- Bird Studies Canada
- Parks Canada
- Environment Canada
- Manitoba Conservation
- Manitoba Hydro
- Nature Manitoba
- The Nature Conservancy of Canada
- The Manitoba Museum

Results:

- Total effort over four years was 1,071 hours of survey effort and 1,118 point counts in 84 squares within the park plus 342 hours and 245 point counts in 34 squares adjacent to the park (Tables 1, 2 and 3).

Table 2. Summary of Survey Effort in Wapusk National Park by Atlas Square

Square	General Atlassing			Point Counts		
	# Hours	# Species	# Records	# Points	# Species	# Records
84	1,072	134	3,692	1,118	124	9,817

Table 3. Summary of Survey Effort adjacent to Wapusk National Park by Atlas Square

# Squares	General Atlassing (Adjacent to WNP)			Point Counts		
	# Hours	# Species	# Records	# Points	# Species	# Records
34	342	141*	1,445	245		2,025

- In addition to the 134 species found within the park, seven species were found in the above squares but not inside the park, viz. Sharp-tailed Grouse, Sharp-shinned Hawk, Boreal Owl, Blue-headed Vireo, Clay-colored Sparrow, Common Grackle and Pine Siskin (hence total reported here as 141). Another 11 species were found in the Churchill are but not in or adjacent to the park: Blue-winged Teal, American Kestrel, American Coot, Little Gull, Great Horned Owl, Northern Hawk Owl (west of Churchill), Long-eared Owl, Brown Creeper, Red-winged Blackbird, Yellow-headed Blackbird and House Sparrow.
- The square 15VE59 was surveyed from Churchill (end of Twin Lakes Road). Although other Churchill squares are not included here, this square was included because it is so close to the park boundary.

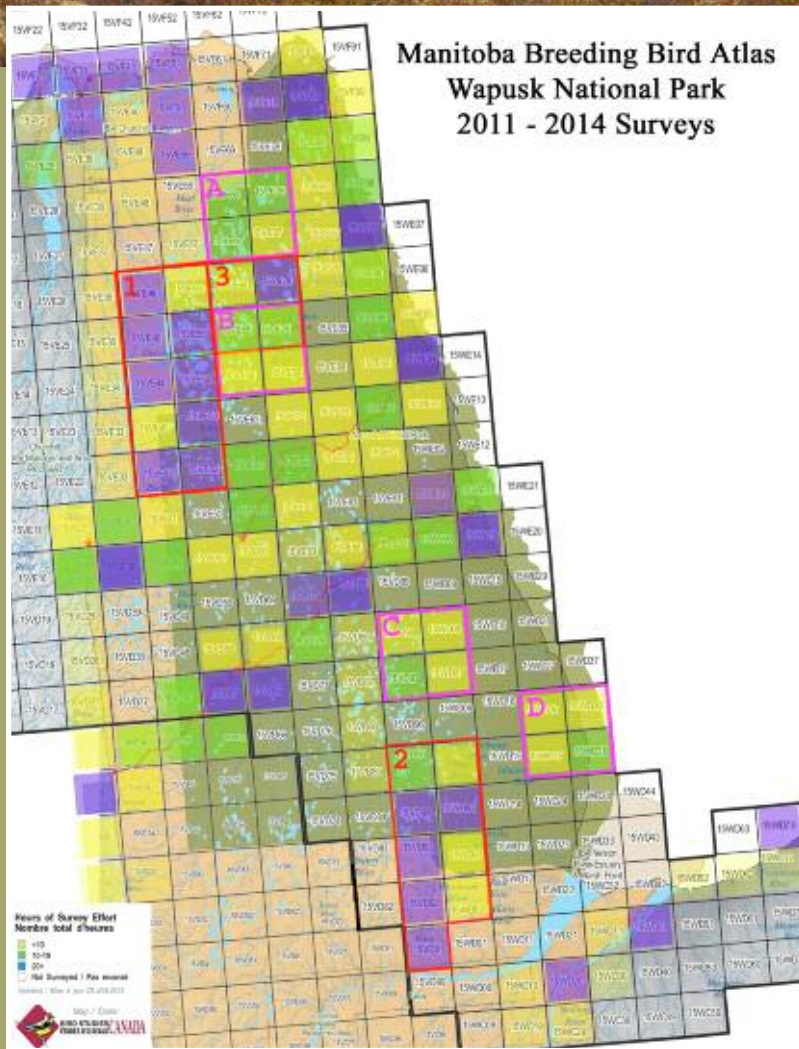
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Campsite
Credit: Ryan McDonald



Map of Wapusk National Park showing Manitoba Breeding Bird Atlas total survey effort from 2011 to 2014. The two red lines represent the Owl River (southern red line, surveyed in 2011) and the Broad River (northern red line, surveyed in 2012). The two asterisks mark the departure point from the railway line near McClintock (west) and the canoe cache site (east). Nestor One is marked with a red "N". 2013 survey squares are outlined in red and numbered in the three sections. 2014 surveys squares are outlined in pink with letters A, B, C and D. The overlap between region 3 (2013) and region B (2014) was designed to finished the two squares that were left incomplete in 2013 due to lightning storms. Squares with blue fill have >20 hours of survey effort, squares with green fill have 10 – 19 hours of survey effort and squares with yellow fill have <10 hours of survey effort.



Dunlin
Credit: Ryan McDonald

Management of Eastern Prairie Population (EPP) Canada geese

Rationale:

Eastern Prairie Population (EPP) Canada geese breed in northern Manitoba and migrate through Manitoba, Minnesota, Iowa, Illinois and Missouri where they are harvested during fall and winter. Annual information on population size and harvest rates are used to establish harvest strategies (hunting season lengths and bag limits) in Canada and the USA. Since the late 1960s and early 1970s, annual management programs have included aerial breeding ground surveys and marking of flightless geese throughout the breeding range.

Objectives:

- Estimate breeding population and trend in components of population (transect-based aerial survey stratified by habitat type)
- Estimate harvest rate of juvenile and adult EPP Canada geese and trends (banding of flightless adults and their young through breeding range)

Methods:

- Using a Partenavia P68 Observer (USFWS), fly survey transects stratified by habitat type established in the early 1970s to count pairs, singles, and groups of Canada geese during approx. mid-incubation, throughout the breeding range (Figure 1). Estimates are corrected for visibility bias using a correction factors established on the study area using a double sampling technique. Estimates for all population components include measures of precision.

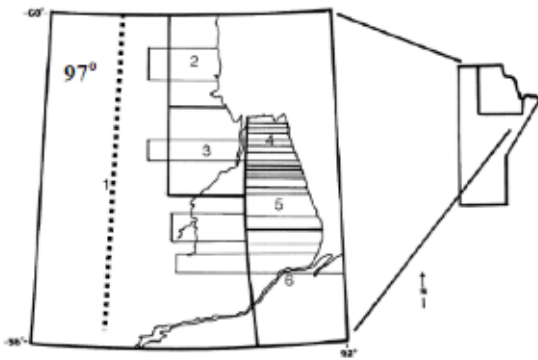


Figure 1. EPP breeding population survey strata and transects.

- Using a helicopter, 4 personnel and drive nets, family groups of Canada geese are captured and banded during their flightless period. Sample size analyses for this population indicate 700 adult and 1800 juvenile geese marked annually produce acceptable levels of precision without over-investment of banding effort. Harvest rate is corrected for reporting bias using estimates produced from reward banding efforts.

Years of data collection:

- Operational aerial surveys since 1972
- Nest density and productivity at Nestor One since 1976, but discontinued in 2010
- EPP breeding grounds banding since 1968
- Aerial surveys and banding are expected to continue indefinitely

Partners:

- Manitoba Conservation and Water Stewardship
- U.S. Fish and Wildlife Service
- Canadian Wildlife Service
- Minnesota Department of Natural Resources
- Iowa Department of Natural Resources
- Missouri Department of Conservation
- Illinois Department of Natural Resources

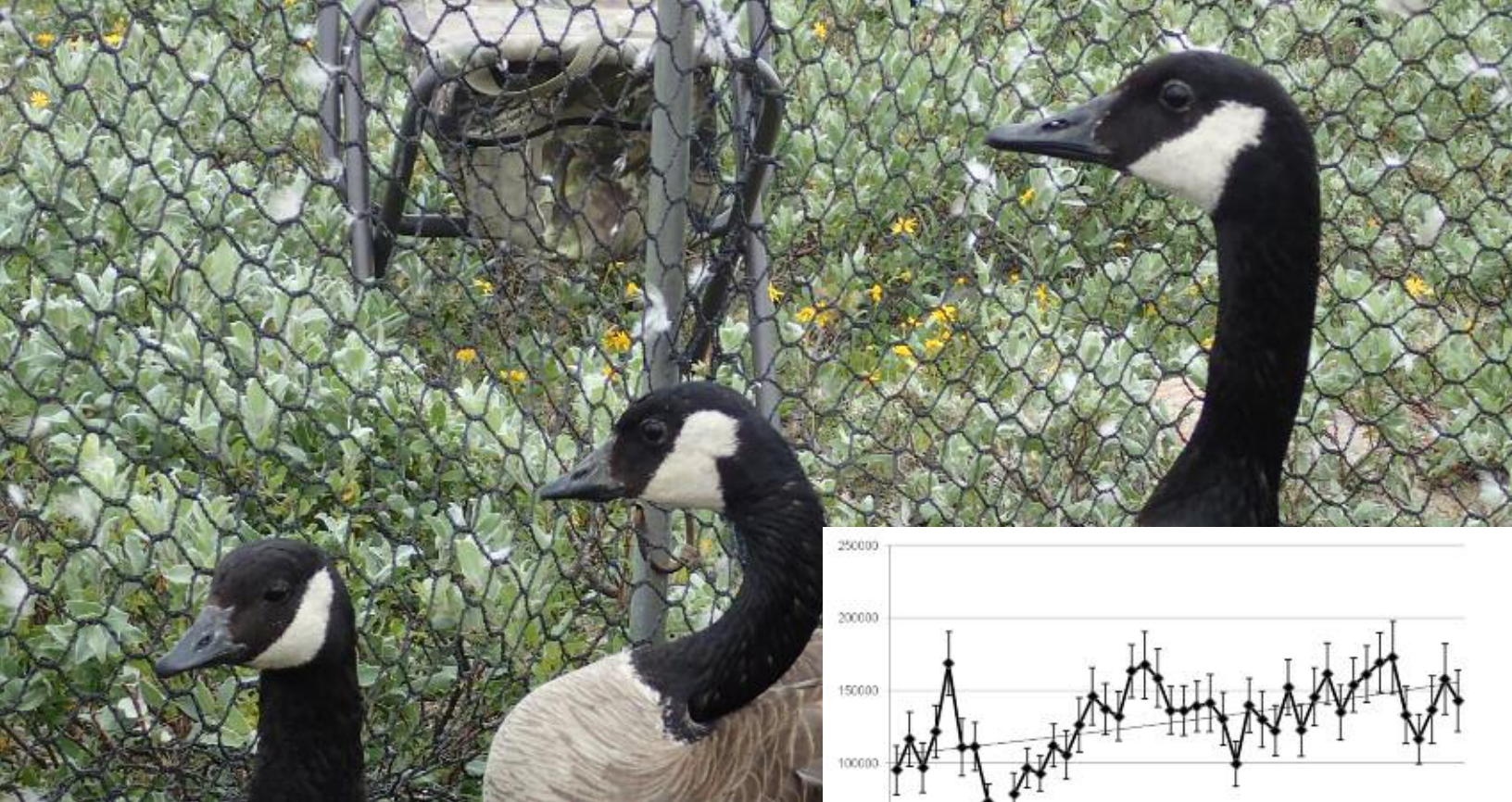
Results:

- Aerial survey was conducted May 31- June 6, and yielded a breeding population estimate of $142,900 \pm 21,200$, which was statistically similar to the 2014 estimate ($157,800 \pm 24,100$) and the long-term average (Figure 2).
- Long term estimates of the breeding population have remained fairly stable (Figure 2).
- 2015 banding occurred July 31-August 6, with a total of 2820 Canada Geese banded (899 AHY [after hatching year] and 1921 HY [hatching year]) at 35 sites between Rupert Creek (57 32.7 latitude) and Seal River (59 13.0 latitude). Recaptures totalled 127 individuals.
- 2014 banding occurred July 29-August 4, with a total of 3627 Canada Geese banded (1111 AHY [after hatching year] and 2516 HY [hatching year]) at 38 sites between Rupert Creek (57 32.7 latitude) and Seal River (59 13.0 latitude). Recaptures totalled 162 individuals.
- Long term estimates of harvest rate (~10% for juveniles and ~5% for adults in last 5 years), which have been stable in recent years, and have been unaltered by recent harvest liberalizations in Canada and the USA (Figure 3).
- Long term distribution of band recoveries is shown in Figure 4.
- During field work, significant improvements (height extension) to the polar bear fence at Nester One were completed.

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White-cheeked Goose Trifecta: Cackling Goose, Interior Canada Goose, Giant Canada Goose
Credit: Frank Baldwin

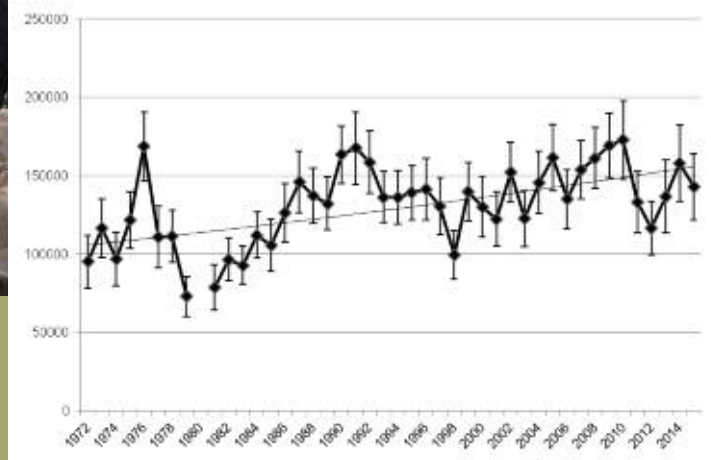


Figure 2. Breeding population estimate and 95% CL for EPP Canada geese, 1972-2015.



Figure 4. Map showing nesting area and band recoveries of EPP Canada geese.

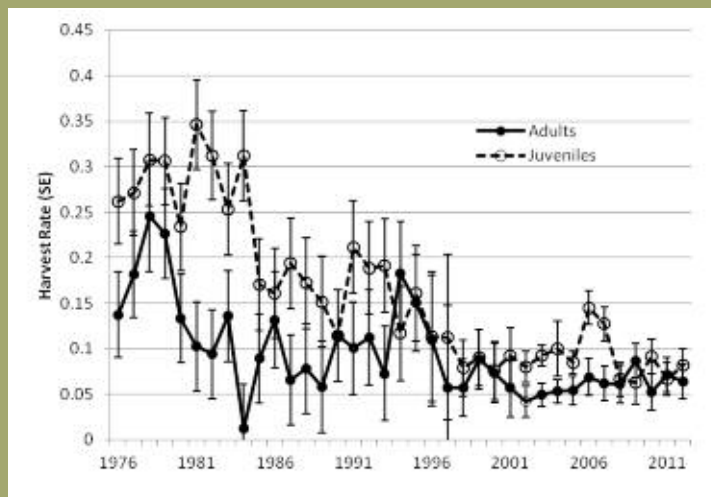
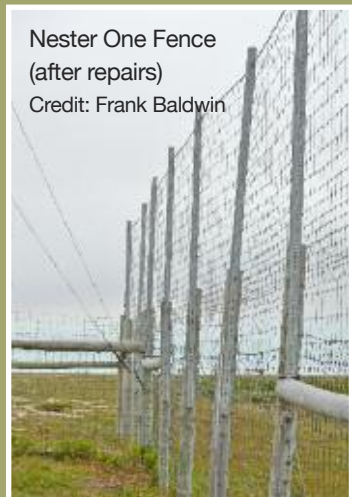


Figure 3. Harvest rates of EPP adults and juveniles, 1976-2012 (full time and age dependency model. AICw=1.0).



Nester One Fence (after repairs)
Credit: Frank Baldwin



Nester One Fence
Credit: Frank Baldwin

Evaporation and desiccation of shallow tundra lakes under conditions of low snowmelt runoff

Rationale:

Shallow ponds and lakes (typically $\leq 1\text{m}$ depth) are a dominant feature of Wapusk National Park (WNP) and provide key habitat for wildlife. In this landscape, spring snowmelt is an important hydrological event that controls many ecological and geomorphological processes, and offsets evaporative losses from lakes during summer. However, climate models predict that snowfall will decrease at some mid- and high-latitude regions, which will have associated hydroecological consequences. Here, we use lakewater isotope data across gradients of terrestrial vegetation cover (open tundra to closed forest) and topographic relief to explore the sensitivity of shallow lakes in WNP to one hydrological outcome: evaporative lake-level drawdown and desiccation following winters of low snow accumulation. Findings provide information to help predict future hydrological conditions of shallow ponds and lakes with continued warming and landscape changes.

Objectives:

- Identify the characteristics of shallow lakes that are most vulnerable to evaporation and desiccation under conditions of low snowmelt runoff.
- Characterize relationships between recent climate (especially snow precipitation) and lakewater balances along a boreal forest-arctic tundra gradient.
- Anticipate future hydrological conditions of ponds and lakes under conditions of longer ice-free seasons.

Methods:

- Water samples were collected from 37 lakes spanning vegetation gradients (boreal spruce forest, interior peat plateau, coastal fen) in June, July and September of 2010-2012.
- Surface-sediment samples (upper 1-2 cm) were collected in the same lakes in September 2012.
- Oxygen isotope composition ($\delta^{18}\text{O}$) was determined for lakewater samples and cellulose extracted from surface-sediment samples.
- To provide a temporal perspective of hydrological changes during the past ~ 200 years, lakewater $\delta^{18}\text{O}$ was reconstructed from a 25-cm-long sediment core retrieved from one tundra lake that had almost completely desiccated during mid-summer 2010.

Years of data collection:

2010-2013

Partners:

- Parks Canada
- Natural Sciences and Engineering Research Council of Canada (NSERC)
- Polar Continental Shelf Program (PCSP)
- Northern Scientific Training Program (NSTP)

- Churchill Northern Studies Centre – Northern Research Fund (NRF)
- Arctic Development and Adaptation to Permafrost in Transition (ADAPT)
- EnviroNorth (NSERC CREATE Training Program in Northern Environmental Sciences)

Results:

- Lakes located in low-relief, open-tundra catchments (mostly the coastal fen ecozone) displayed a systematic, positive offset between directly measured lakewater $\delta^{18}\text{O}$ over multiple sampling campaigns and lakewater $\delta^{18}\text{O}$ inferred from cellulose in recently deposited surface sediments.
- This offset is likely due to a strong evaporative ^{18}O -enrichment response to lower-than-average snowmelt runoff in recent years.
- Many of these tundra lakes underwent near-complete desiccation during mid-summer 2010 following a winter of very low snowfall, and this was observed again during mid-summer 2013.
- Based on the paleolimnological record of one such lake, the extremely dry conditions in 2010 (and 2013) may be unprecedented in the past ~ 200 years, fuelling concerns that a decrease in snowmelt runoff will lead to widespread desiccation of shallow tundra lakes in these landscapes.
- For more details, see: Bouchard F, KW Turner, LA MacDonald, C Deakin, H White, N Farquharson, AS Medeiros, BB Wolfe, RI Hall, R Pienitz and TWD Edwards. 2013. Vulnerability of shallow subarctic lakes to evaporate and desiccate when snowmelt runoff is low. *Geophysical Research Letters* 40: 6112-6117.

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Typical view of shallow-lake-rich permafrost landscape in Wapusk National Park
Credit: Frédéric Bouchard



Tundra lakes and raised sand beaches in the coastal fen ecozone
Credit: Frédéric Bouchard



Lauren MacDonald and Hilary White collecting water samples and performing limnological and biogeochemical surveys, September 2012
Credit: Frédéric Bouchard



Dr. Frédéric Bouchard collecting surface sediments with a simple device (hand-held coring tube), September 2012
Credit: Lauren MacDonald

Long-term student-led permafrost, vegetation, microbial community, and snow monitoring in the greater Wapusk ecosystem

Rationale:

While over 100 students from Canada and the US participate in weekly meetings during the academic year, only twenty each August get to experience, first hand, the Hudson Bay Lowlands Ecosystem. Since its inception in 2006, over 200 high school students have experienced the wonders of Wapusk National Park while immersing themselves in the lessons only field research can teach. Students lead this annual, long-term program from nuts to bolts. Which questions to ask, which methodologies to use for data collection, what statistical analysis can and should happen – these are decisions the students mull over with guidance from a team of professors and teachers. By experiencing Wapusk National Park, students get a visceral sense of the impact climate change can and are having on places they love. By presenting annually at international science conferences, students realize the importance for this type of research and become contributors to the scientific community with questions, passion, and perseverance.

Objectives:

- Promote hands-on, student-led science by investigating the flora and fauna in the Greater Wapusk Ecosystem. Active participation by students in research enriches educational experiences, encourages students to pursue science related careers, and ultimately makes better scientists and a science-educated public.
- Guide collaborative scientific exploration among groups of students from southern and local Manitoba communities, including international collaborations, recognizing that these kinds of collaborations are the ‘new normal’ for science.
- Present the results of this research annually through presentations, papers and posters at annual Arctic Research meetings.

Methods:

- Students spend a total of 14 days in the Greater Wapusk Ecosystem; about 5-7 days at the Churchill Northern Studies Center and 7-9 days at Nester One.
- Permafrost active layer measurements are taken at approximately 4-7 sites each within walking distance of Nester One. Each site consists of 2-50 meter transects and a total of 104-208 ALT measurements are gathered depending on if the site is randomly chosen for validity measurements as well.
- Vegetation is identified to the species level through two different methods (percent cover and pin dropping) and analyzed for statistical differences between the methodologies.
- Microbial communities are assessed by extracting DNA in the field for further processing by PCR. Genetic sequencing of the 16S rRNA genes is compared between different habitats.

- In March, snow monitoring happens at the same sites sampled in August to help create a soil moisture algorithm for ALT prediction modeling.

Years of data collection:

Ongoing Project since 2006

Partners:

- Parks Canada
- Manitoba Conservation
- Churchill Northern Studies Centre
- University of Manitoba
- University of Saskatchewan
- Johns Hopkins University
- NSERC

Results:

- From 2006 to 2015, 205 high school students have visited Wapusk National Park as part of the ISAMR program collecting data for permafrost monitoring, vegetation identification, soil microbial DNA analysis, and snow monitoring.
- ISAMR has contributed over 10,000 new data points annually to existing ALT, vegetation cover, and snow monitoring data bases at 9 different sites within the Greater Wapusk Ecosystem.
- This data set compliments the work of Dr. Brook on truthing remote imaging in an effort to detect change over time in the region.

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ISAMR student and instructor sampling at the mouth of the White Whale River in Wapusk National Park, with a caribou in the foreground and a polar bear in the background.
Credit: Jill Larkin



ISAMR students setting up transects just south of West Camp Lake in Wapusk National Park.
Credit: Julie Rogers



ISAMR students and instructor identifying plants to the species level 0.5 km south of Nester One, in Wapusk National Park.
Credit: Natalie Rudin



ISAMR students sampling permafrost active layer thickness, and having fun, about 4Km south of Nester One in Wapusk National Park.
Credit: Johanna Busch

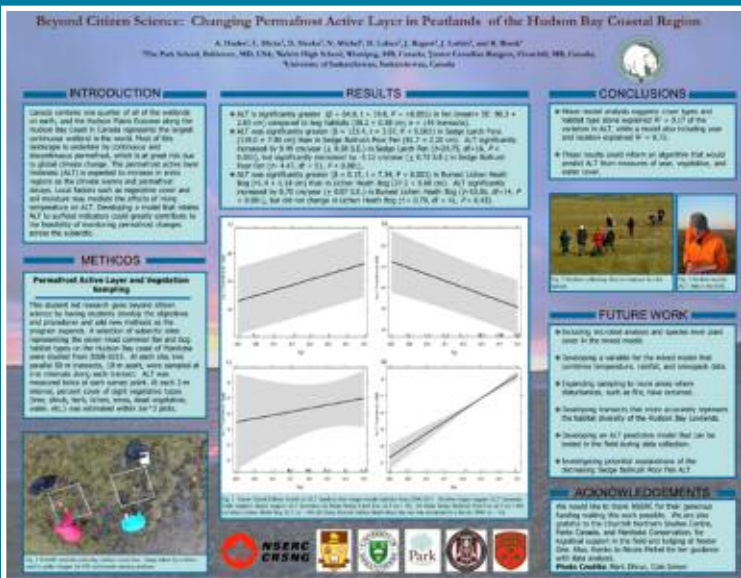


Figure 1. ArcticNet 2015 Annual Meeting Permafrost Poster, Dec 7-11, Vancouver, BC.

University of Saskatchewan and University of Manitoba wildlife and ethnoecology field course in Wapusk National Park

Rationale:

While classroom learning provides an important basis for understanding ecological processes and the role of humans in the environment, practical hands-on fieldwork is a critical component of training the next generation of researchers and park managers. The Wildlife and Ethnoecology program provides the opportunity for students to immerse themselves in the Hudson Bay Lowlands Ecosystem and learn from local people. Participants in the program work together as an interdisciplinary team of researchers to produce outcomes that are of real value to natural resource managers and the local community.

Objectives:

- Expose students to the unique ecology, wildlife, human impacts, and challenges of working in Wapusk National Park.
- Develop critical thinking, communication, and practical field research skills.
- Consider the role of protected areas in tourism and conservation and identify ways to use science as a tool to support management.
- Present the results of our research to Parks Canada, Manitoba Conservation, and the broader scientific community through presentations and written reports.

Methods:

- Students spend approximately one week at the Nester One research camp in Wapusk National Park and one week at the Churchill Northern Studies Centre learning and conducting research.
- Permafrost active layer thickness is measured at three sites annually and associated vegetation cover is described.
- Sites are sampled and re-sampled to determine species and life form cover to support vegetation mapping and change detection.
- We assess tourism options for Wapusk National Park.
- Students choose individual or group research projects to be conducted in an area of interest and these include studies of habitat, wildlife, traditional knowledge and land use.

Years of data collection:

Ongoing Project since 2005

Partners:

- Parks Canada
- Manitoba Conservation and Water Stewardship
- University of Saskatchewan
- University of Manitoba

Results:

- From 2005 to 2015, 174 undergraduate and graduate students visited Wapusk National Park as part of the course and contributed individual projects and collected field data for the permafrost active layer and vegetation datasets.
- We have >2400 measurements of active layer thickness and we have documented the associated vegetation cover.
- We have developed a database of vegetation communities and permafrost active layer thickness for a total of >1500 sites within the Greater Wapusk Ecosystem.
- Each year a summary report is made that includes the results of the student research projects and these are available on our website at:
<http://northernfieldschool.wix.com/home>

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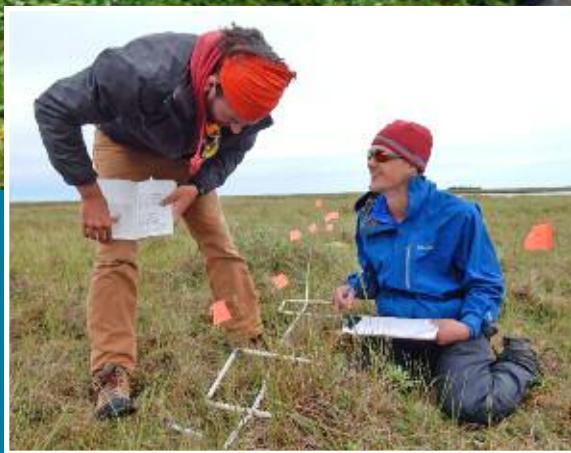
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Polar bear observed at Cape Churchill in Wapusk National Park, August, 2015.
Credit: Ryan Brook

Students collecting vegetation data in Wapusk National Park near Nester One field camp.
Credit: Ryan Brook



Two student participants high five after a 12 km hike from Nester One field camp to Cape Churchill in Wapusk National Park, August, 2015.
Credit: Ryan Brook

Table 4.1 Standard criteria chart for characterizing Cape Churchill Caribou Herd calving grounds and range

Standard Criteria	Information Known about Cape Churchill Caribou Herd
Topography	very flat
Landform	Dominated by un-vegetated shoreline and poor fen
% Water cover	15
Major vegetation	<i>Carix Salix Betula</i>
Minor vegetation	Blueberries, cranberries, lichen, <i>Dryas integrifolia</i>
Presence of salt licks	None. Research suggests that kelp and lemmings may serve as replacements
Proximity of industrial development to calving grounds	None
Peak calving	June 1 – 15 approximately
Provides insect relief	Yes, high grounds provide protection with high winds
Major predators	Wolves, polar bears
Population trend	Stable
Historical changes in calving grounds	None



Figure 1. Summary analysis of range assessment for the calving grounds of the Cape Churchill caribou herd, August, 2015.
Credit: Ryan Brook



Caribou observed at Cape Churchill in Wapusk National Park, August, 2015.
Credit: Karlynn Dzik

Non-invasive methods for detection and analysis of polar bear-human interactions at field camps in Wapusk National Park

Rationale:

Conserving polar bears and ensuring the safety of visitors, staff, and local users are important in Wapusk National Park. When the Broad River and Owl River camps were built in 2008–2009 they were placed inland to get away from bears on the coast, but park staff reported bears at those new camps soon after they were used. Parks Canada invited the University of Saskatchewan to collaborate on a project to determine why bears were coming to these camps, how often, and whether the bears' visits were related to human activity at the camps.

Objectives:

Our research questions are:

- Are bears attracted to the new camps at greater frequency than established camps (e.g. Nester One), and if so, why?
- Are there relationships between specific parameters of human activity at these camps and polar bear-human interactions?
- What can be done to minimize the likelihood of polar bear-human conflicts at these camps?
- What, if anything, can be learned about the causal mechanisms of polar bear-human interactions and polar bear behaviour at these camps?

Methods:

- We set up four to eight (eventually power analysis showed five was the optimal number) professional-grade remote cameras at each of the three camps: Broad River (2011 to present), Owl River (2012 to present), and Nester One (2011 to present) to monitor polar bear visits. These cameras detect and photograph polar bears as they approach within 30m and have infrared flashes that are not visible to animals. Batteries and memory cards are changed each spring.
- Bears were visually assessed for body condition and age/sex class, and because we often cannot distinguish between individual bears we count and analyze bear-visits.
- To assess the effects of human activity – as opposed to simply the presence of infrastructure – on the behaviour of polar bear we tested a commercial infrared trail counter system in a range of locations at Broad River, Nester One, and Nester Two.

Years of data collection:

Ongoing Project since 2011

Partners:

- University of Saskatchewan
- Parks Canada
- Social Sciences and Humanities Research Council of Canada

- Churchill Northern Studies Centre, Northern Research Fund
- EarthRangers
- Manitoba Conservation
- The Hudson Bay Project

Results:

- We recorded a total of 247 bear visits, mostly at Nester One (58%), followed by Broad River (35%), and Owl River (7%). Between 2011 and 2014 visits were low in May–July, increased sharply through August–November, and then dropped to virtually zero in December when the bay froze. This pattern (Figure 1) closely matches results of other studies.
- Adult males were most common at Nester One but the two more inland camps were visited more frequently by females with cubs. Few sub-adults were seen.
- Body condition declined consistently throughout summer and autumn, and our results closely match the measurements from other studies that captured and handled bears.
- This method of monitoring polar bear visits is reliable, economical, and apparently non-invasive.
- We observed little overlap between people and bears so we can't yet determine whether people in a camp attracts bears or repels them. Also, ice conditions in Western Hudson Bay varied little between 2011 and 2014, so we can't say what effect an early or late breakup would have on the patterns we've described.

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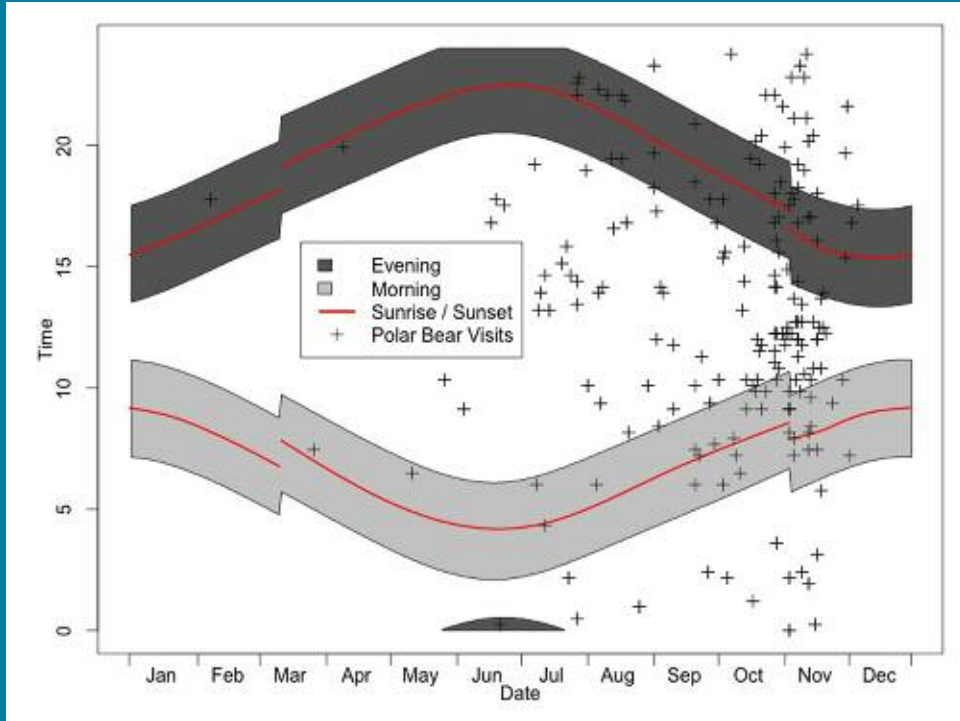
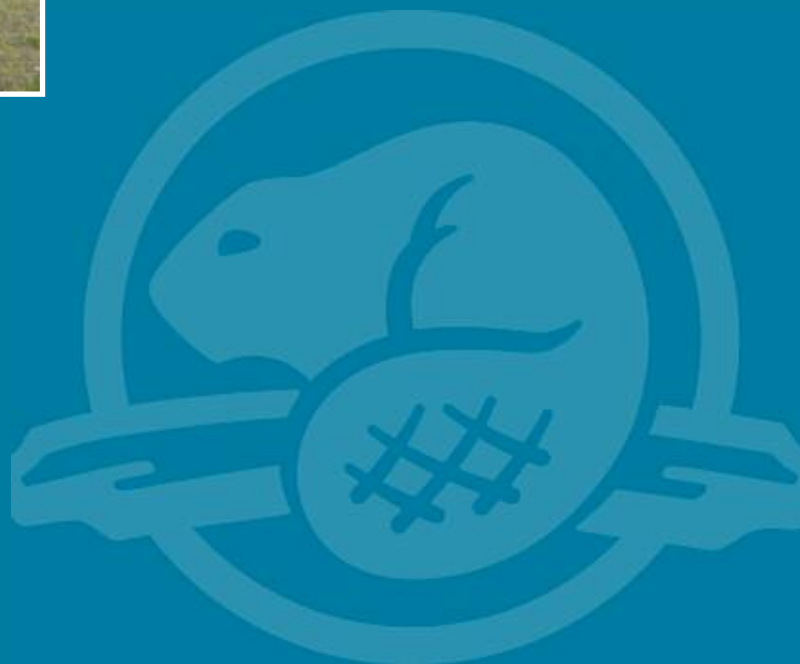


Figure 1. Date and time of polar bear visits to camps, 2011-2014. The red lines represent sunrise and sunset times, with grey polygons representing morning and evening (two hours before and after sunrise and sunset).



Parks Canada staff repairing remote camera on fence.
Credit: Parks Canada



The development and deployment of unmanned aviation vehicles (UAV) to examine and monitor the ecological integrity of Wapusk National Park

Rationale:

Unmanned aviation vehicles (UAV) are a new tool that may allow scientists to examine and monitor ecosystems, in a minimally invasive and low carbon footprint fashion. Survey type aircraft allow the formation of georeferenced images that can be ground-truthed and provide a permanent record of vegetation and habitat conditions. They also allow for rapid enumeration of nesting density of geese and ducks over a broad expanse of nesting habitat.

Key to the initial development and application is to establish flight altitudes that allow operations in a way that is minimally disruptive to the region's wildlife. In addition, procedures must be established to allow for safe operation around both the ground crew and any aircraft in the area.

Objectives:

- Determine optimal flight scenarios to minimize impacts on birds but allow the resolution of imagery necessary to count birds and assess habitat characteristics.
- Evaluate the effectiveness of a UAV for counting nesting birds (snow geese and common eiders) compared to historical ground counts.
- Determine what information could be obtained from UAV imagery to evaluate plant phenology and vegetation damage caused by snow geese.

Methods:

- Use pre-programmed flight lines over several well-studied areas near the La Pérouse Bay Research Station and north of Thompson Point.
- Record images with both RGB and near-infra-red (IR) camera systems.
- Deploy sound and video recorders on the ground to monitor any response of nesting snow geese.
- Fly the aircraft at 75m, 100m and 120m AGL (above ground level) and evaluate both image quality and the reaction of snow geese.

Years of data collection:

Year 1 of an ongoing project

Partners:

- University of North Dakota
- American Museum of Natural History (AMNH)
- Wapusk National Park

Results:

- Conducted 87 flights equating to almost 55 hours of flight time and approximately 80,000 images over 17 days of actual flight operations in June and July 2015.
- Anecdotal evidence suggested geese were aware of research teams, but would often resume nesting activities after UAV setup was complete and were tolerant of the UAV landing (see attached figures).
- Preliminary results from nest cameras suggest nesting snow geese notice the aircraft flying overhead at all three altitudes, but do not appear to exhibit extreme stress behaviors as they do when a predator is in the area.
- Preliminary results demonstrated researchers could locate nesting snow geese; however, blue morph snow geese are more difficult to discern from the background vegetation than white morphs and were easiest at 75 m. Additional comparisons are currently being conducted relative to ground counts of nests.
- We found flights at 75 m appeared sufficient for basic classification of barren, water, graminoid (grass-like plants), and shrub classifications using RGB cameras. Additional comparisons are currently being conducted relative to 75 ground-truthed points.

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Launch of the Trimble UX5
Credit: R.F. Rockwell



Image taken from the UAV at 75 m above ground level showing nesting geese in a colony about 6.5 km east of Nestor 2 (Peter's Rock area)
Credit: Hudson Bay Project and UND Biology



The Trimble UX5 lands safely at the La Pérouse Bay Research Station
Credit: R.F. Rockwell



The Trimble UX5 UAV landing at La La Pérouse Bay Research Station helicopter pad with family of geese watching
Credit: C.J. Felege



Ground crew sets off to Peter's Rock with all the gear
Credit: R.F. Rockwell

Monitoring Polar Bear-Human Interaction in Wapusk National Park

Rationale:

The ice on Hudson Bay melts annually, forcing polar bears ashore from approximately July to November each year. The bears of the Western Hudson Bay sub-population can be observed on the three sites managed by Parks Canada in northern Manitoba: Wapusk National Park (WNP), York Factory National Historic Site (YFNHS) and Prince of Wales Fort National Historic Site (PWFNHS; includes Cape Merry, Sloop Cove and Prince of Wales Fort). Polar bears can be seen in Wapusk National Park at any time of the year, although the chance of observing a bear during the ice-free period is much higher. These interactions present a safety risk that must be monitored and managed.

To ensure the safety of both humans and bears, everyone visiting or working on these Parks Canada sites must be prepared to deal with the risk of encountering polar bears. The Manitoba Field Unit has a polar bear safety plan in place, which includes information about polar bears, training requirements and methods of polar bear management. Implementing effective risk management strategies is essential for Parks Canada staff, researchers and commercial operators working in the park.

Objectives:

- To engage Parks Canada staff, researchers and commercial operators in recording the number of polar bears observed as well as the number of human-polar bear interactions in Wapusk National Park. Expand this program in the future to include all visitors to the park.
- To monitor the number of bears observed over time, including their locations as well as the number of human-polar bear interactions.
- To use the information collected to develop relevant safety information and for risk management purposes.

Methods:

- Bears observed from the ground are classified into two broad categories: those where there was no deterrent action (encounters) and those where one or more deterrent actions were taken (occurrences). These observations are recorded on standard forms.
- Sightings and aerial observations are recorded along with GPS locations when possible.
- Information on deterrent use is tracked to look at trends.
- A database has been established to manage this information.
- The information is summarized in an annual report.
- Occurrences are shared with the Polar Bear Range States Polar Bear Human Information Management Database.

Years of data collection:

Ongoing Project since 2007

Partners:

- Wapusk National Park Researchers
- Parks Canada

Results:

- In 2014 and 2015, there were 605 and 327 bears observed, respectively, at Parks Canada sites in northern Manitoba. Within Wapusk, 418 and 260 observations were reported in the park (Figure 1).
- In 2014, there were three occurrences and one encounter in the park. There were three occurrences in 2015, each involving one of the three species of North American bears (polar, grizzly and black).
- All three species of bears were observed in Wapusk National Park in 2015, with grizzly bears sighted annually since 2009.
- The number of grizzly bear and black bear sightings on three Parks Canada sites in northern Manitoba, has been increasing since Park staff and researchers have been formally tracking observation data.
- Data for this project were provided by Parks Canada employees, researchers and commercial operators who collectively spent over 2000 user days annually in the park.

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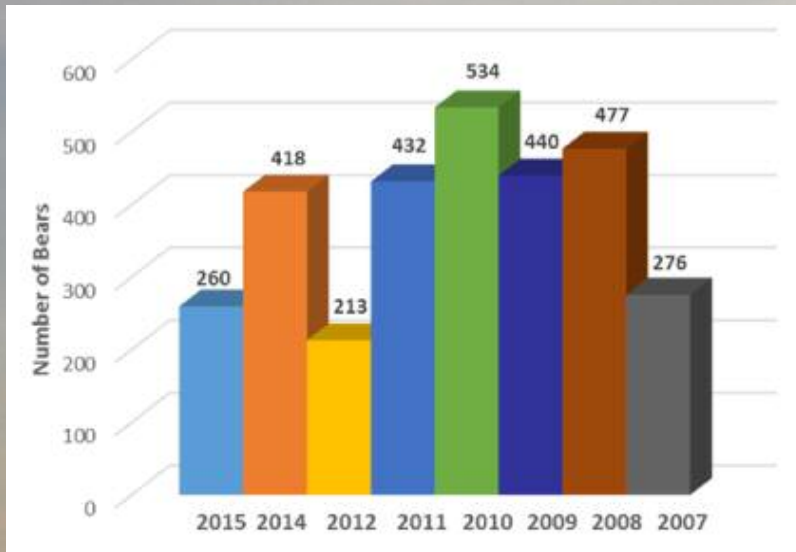


Figure 1. Wapusk National Park bear observations by year (2007-2015)



Female polar bear and cub on the frozen tundra
Credit: Parks Canada



Grizzly bear captured on remote camera in Wapusk National Park, April 2013
Credit: Parks Canada



Female bear with cub of the year outside the fence at Broad River camp
Credit: Parks Canada

Coastal surveys for polar bear management

Objectives:

- To determine the number, general health, and distribution of polar bears along the Hudson Bay coastline during the ice-free period.
- Results of surveys are presented each year at the Polar Bear Technical Meeting.

Methods:

- There may be three separate surveys completed each season.

Partners:

- Manitoba Conservation
- Polar Bears International

Results:

- Fall, 177 polar bears counted
- 18 females/family groups counted
- One dead polar bear was observed near Broad River
- An additional 65 bears were observed between the Nunavut border to the East Pen Islands (59 males,

Polar Bear Survey Western Hudson Bay Coastline				
Observers: D.Hedman, K.Walkoski, D.Henry Pilot: B.Ferguson, MWD				
Date Weather	Churchill Coastline 3-Sep-15 Clear, 10d C		Kaskatamagan Coastline 4-Sep-15 Clear, 10d C	
	Churchill-Broad River	Broad River-Pt Nelson	Marsh Pt-Kaskatamagan	Kaskatamagan-Ontario
Adult Male	31	57	19	20
Female/1 COY	2 / 4	4 / 8	2 / 4	3 / 6
Female/2 COY	0	0	0	0
Female/1 Yearling	1 / 2	2 / 4	0	0
Female/2 Yearling	0	0	2 / 6	0
Female P	1	0	0	1
Unknown (U) Bear	4	8	8	0
SUBTOTAL BEARS	42	77	31	27
TOTAL BEARS	119		58	

- The survey is performed by a Bell 206L, consisting of a front navigator and two back observers.
- The fall survey, which includes Wapusk National Park, Churchill Wildlife Management Area and Kaskatamagan Wildlife Management Area, is completed the 1st week of September.
- The Ice-Out and Ice-Up surveys are completed immediately after the ice is off Hudson Bay, and immediately prior to the Hudson Bay freezing over.
- The survey line is approximately 300m inland from the high tide mark of the Hudson Bay coast. Observations are made on both sides of the helicopter, including the tidal flats.

Years of Data Collection:

- Fall survey ongoing since the 1970's

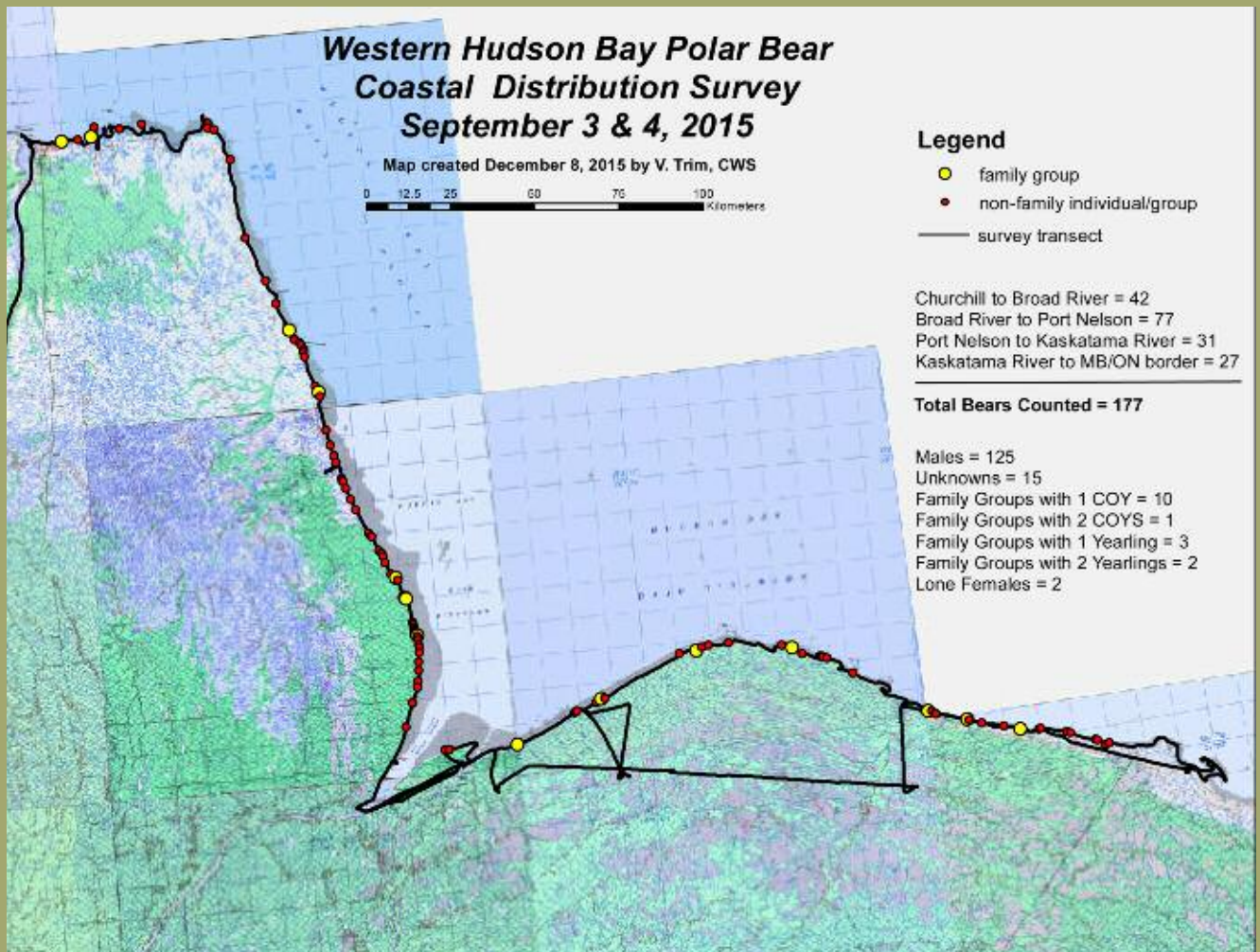
3 females/1 COY).

- There were twice as many polar bears observed within Wapusk National Park than east in the Kaskatamagan Wildlife Management Area.

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A celebration of polar bears in Wapusk National Park
 Credit: Parks Canada



Understanding daily and seasonal trends of Arctic wolves in Wapusk National Park through the use of trail cameras

Rationale:

Relatively little is known about the seasonal trends of arctic wolves in Wapusk National Park. Information compiled from other studies on arctic wolf kill sites, socialization, prey relation, climate/season and habitat selection and movement bring insight to the seasonal and daily trends of arctic wolves in Wapusk. With the aid of trail cameras information was collected at three permanent camp sites in Wapusk. The images were analyzed for the time, day, temperature, lunar cycle, and body condition score of the wolves.

Objectives:

- This study was to better understand daily and seasonal trends of arctic wolves in Wapusk National Park along with body condition.

Methods:

- Information collected from the trail cameras were used to relate the physical land data to the arctic wolves' movements and behaviours.
- Using the observations of body composition of the arctic wolves recorded on trail cameras, as well as known data from other studies completed, the overall body condition scores of the wolves from the photographs were approximated.
- Characterizing the time of day and seasonal trends recorded from the cameras at the 3 research stations at Nester One, Broad River and Owl River in Wapusk National Park.
- Using trail camera data to see if a link between lunar phases and wolves exist. Trail cameras were placed in Nester One in 2011, Broad River in 2010 and Owl River in 2012.

Years of data collection:

Trail cameras are ongoing since 2010, data used from 2010 through August 2013 for this project.

Partners:

- Parks Canada
- Manitoba Conservation
- Canada Centre for Remote Sensing
- University of Manitoba
- University of Saskatchewan

Results:

- Of the 491 photos identified to have been wolves, 95 have been identified as separate sightings.
- Table 1 shows the average number of wolves seen on each of the trail cameras at each location, as well as the average body condition score on all possible wolves.

Row Labels	Average # of Wolves	Average of Body Condition
Broad River E	1	3
Broad River N	1	3
Broad River NE	1	2.75
Broad River NW	1.1	2.8
Broad River S	1	3.5
Broad River S	1	N/A
Broad River SW	1	3.5
Broad River W	1.2	3.67
Broad River W Angle	1	3.5
Nester One	1	2.5
Nester One E	1	N/A
Nester One NW	1	N/A
Nester One S	1	N/A
Nester One W	1	N/A
Nester One W Angle	1	2.75
Owl River E	1.56	2.92
Owl River N	1.23	2.86
Owl River SE	1.25	2.95
Owl River W	1	3
Grand Total	1.18	3.02

- Figure 2 shows the number of wolf visits at each of the three locations during the study.
- August had the greatest number of occurrences and there were two months with no occurrences. This may be due to weather conditions (ie. snow covering cameras) (Figure 3).
- During the lunar cycle, we saw a significant decrease of observations during the full and new moons compared to waning, waxing, and half-moon (Figure 4).
- During the summer months, cameras captured more individual visits during the late evening, 20:00-24:00, while in the winter months we observed an increased number of wolf visits during mid-day from 12:00-16:00 (Figure 5).
- Changes in daily patterns were noticed to change with season (Figure 5).

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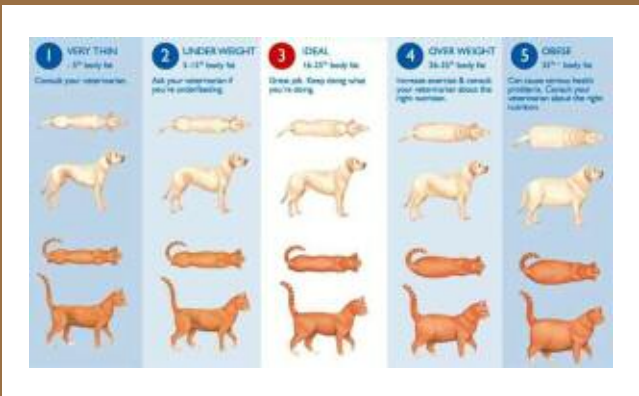


Figure 1. Body condition system (modified from original)

Credit: Sabal Chase Animal Clinic web page

Table 1. Average number of arctic wolves photographed per visitation and body condition scores

Credit: Melissa Krueger & Michael Hockett

Figure 2. Number of wolf visits to each camp according to the year.

Credit: Melissa Krueger & Michael Hockett

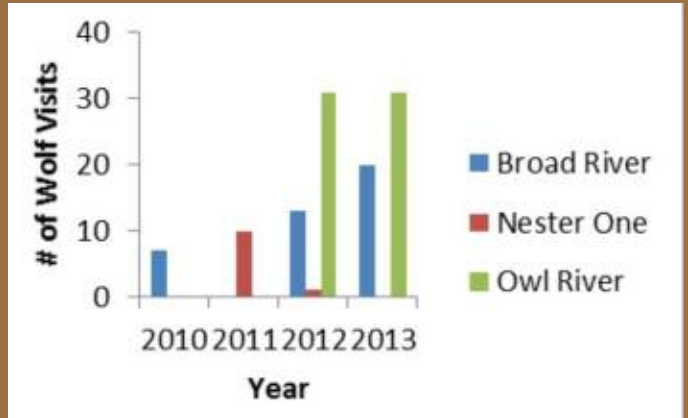


Figure 3. The number of wolf visitations in accordance to the month.

Credit: Melissa Krueger & Michael Hockett

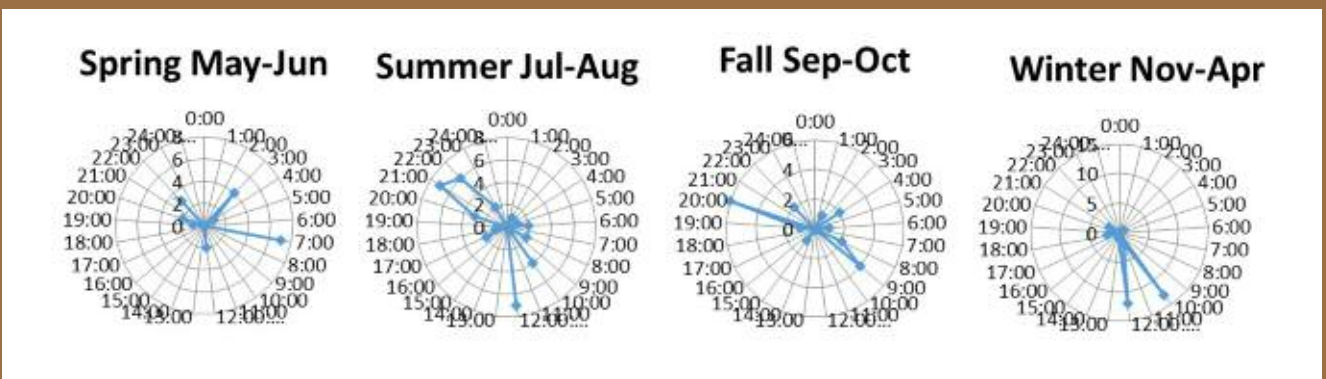
Figure 4. The number of wolf visits photographed on trail cameras in relation to the lunar phase.

Credit: Melissa Krueger & Michael Hockett



Figure 5. The time of the seasonal wolf visitation

Credit: Melissa Krueger & Michael Hockett



Polar bear visitation to camps in Wapusk National Park

Rationale:

This study was done to fulfil the requirements of a summer field course offered through the Universities of Manitoba and Saskatchewan in August 2013.

We analysed trail camera images at three permanent camps in Wapusk to observe short-term trends in polar bear visitation across those camps.

Objectives:

Investigate factors that may influence bear visitation, including:

- Location of camp
- Time of day
- Human presence
- Time of year

Methods:

- Images were obtained from Reconyx Hyperfire 900 trail cameras mounted on perimeter fence posts at three camps within Wapusk.
- 161 captures of polar bears were sorted out of 41 000 images taken between summer 2010 – spring 2013.
- Details on location, camera ID, date, time of first and last capture, number of bear and weather were recorded for each polar bear image.
- Trends in the timing and location of polar bear visits were investigated using filter functions in Microsoft Excel.

Years of data collection:

- Pilot study initiated by Parks Canada at Broad River in 2010
- Project continued by Dr. Clark 2011 – present
- Nester 1 added in 2011
- Owl River added in 2012

Partners:

- University of Saskatchewan
- Parks Canada

Results:

- Nester One receives the highest level of polar bear visitation.
- More bears were captured on cameras during the months of October and November.
- Bear activity was highest when stable sea ice was unavailable.
- Little activity was observed between 11:00h and 22:00h during the month of November: 2011 and 2012.
- The majority of polar bear visits did not overlap with human occupancy of camps (including a 24 hour period post-vacating camp), which suggests human presence does not equal more polar bears.

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Polar Bear Visitation to Camps in Wapusk National Park



Jessica Lankshear, MSEM & Almee Schmidt, PhD student

Dr. Ryan Brook, University of Saskatchewan; Kristina Hunter, University of Manitoba; Dr. Douglas Clark, University of Saskatchewan; Shaleen Kowachuk, Wapusk National Park of Canada

Background & Objectives

Background

There are four permanent camps within Wapusk National Park (NP): Naska 1 (N1), Naska 2 (N2), Broad River (BR) and Owl River (OR). N1 and N2 were constructed long before the establishment of the park. Two new camps, BR and OR, were completed quite recently (in 2010 and 2011, respectively). N1 is not surrounded by a perimeter fence and was therefore not included in this study. Of the three camps studied, N2 consistently has the highest rate of human use.

Objectives

1. Determine when trends in polar bear visitation to research camps
2. Determine whether trends in polar bear visitation vary across camps (length of time bears were observed at camp)
3. Investigate factors that may influence bear visitation, including:
 - Location of camp
 - Time of day
 - Amount of light (night versus day)
 - Human presence/absence
 - Time of year (month)



Figure 1. A polar bear near the Broad River camp in Wapusk National Park.



Figure 2. A polar bear looking at the camera at the Broad River camp.

Results

- OF THE THREE CAMPS STUDIED IN WAPUSK NATION PARK, N2 RECEIVED THE HIGHEST LEVEL OF POLAR BEAR VISITATION (Figure 3).
- THIS ACTIVITY WAS OBSERVED BETWEEN 22:00H AND 11:00H DURING NOVEMBER 2011 AND 2012 (Figure 4).
- MORE BEARS WERE CAPTURED ON CAMERAS DURING THE MONTHS OF OCTOBER AND NOVEMBER (Figure 5).
- SUGGEST HUMAN PRESENCE DOES NOT EQUAL MORE POLAR BEARS (Figure 6).

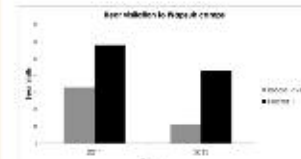


Figure 3. Number of polar bear sightings per month at three camps (N1, N2, BR) in Wapusk National Park.

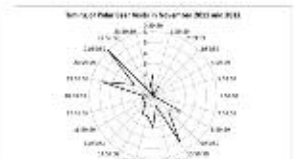


Figure 4. Number of polar bear sightings per month at three camps (N1, N2, BR) in Wapusk National Park.

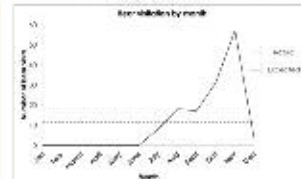


Figure 5. Number of polar bear sightings per month at three camps (N1, N2, BR) in Wapusk National Park.

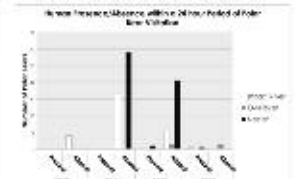


Figure 6. Number of polar bear sightings per month at three camps (N1, N2, BR) in Wapusk National Park.

Methods

- Images were collected from Sony Cyber-shot RX100 cameras mounted on perimeter fence posts at three camps within Wapusk (Figure 1 & Table 1).
- 167 captures of polar bears were sorted out of 41,000 images taken between summer 2010–spring 2013 (Figure 2).
- Details on location, camera ID, date, time of day and last capture number of bear and what was the recorded for each polar bear (Table 1).
- Trends in the timing and location of polar bear visits were investigated using chi-square tests (StatCrunch, Excel).



Note: Number of polar bear sightings

Location	2010	2011	2012	2013
Broad River	0	0	0	5
Naska 1	0	0	0	0
Naska 2	0	0	0	0

Year	Month	Day	Time	Location	Camera ID	Number of sightings
2010	Jan	15	10:00	N2	1001	1
2010	Jan	15	10:00	N2	1002	1
2010	Jan	15	10:00	N2	1003	1
2010	Jan	15	10:00	N2	1004	1
2010	Jan	15	10:00	N2	1005	1
2010	Jan	15	10:00	N2	1006	1
2010	Jan	15	10:00	N2	1007	1
2010	Jan	15	10:00	N2	1008	1
2010	Jan	15	10:00	N2	1009	1
2010	Jan	15	10:00	N2	1010	1

Discussion

- The three camps have different microhabitats, which could influence timing and choice of seasonal habitat of different age and sex classes (we were not able to determine the highest number of bears visiting Naska 1), which is near an area of high concentration of prey (see Table 2).
- There is less bear activity at camps who had no (or available) ice (see Table 2).
- Bears that showed up at the fence may not necessarily be captured on camera (capacity of a distance greater than 80m is less than 100m).
- Factors that may influence results: (1) Snow covering camera location or camp (2) Number of cameras per camp and angle of camera (3) Length of data collection.

Special thanks to:

- Ryan Brook
- Kristina Hunter
- Douglas Clark
- Shaleen Kowachuk

References:

Brook, R.J., Hunter, K., Clark, D., & Kowachuk, S. (2013). Polar bear visitation to research camps in Wapusk National Park, Canada. *Journal of Great Lakes Research*, 39(1), 1-10.

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Brook, R.J., Hunter, K., Clark, D., & Kowachuk, S. (2011). Polar bear visitation to research camps in Wapusk National Park, Canada. *Journal of Great Lakes Research*, 37(1), 1-10.



Challenged by corporations: local perspectives on land use and natural resource management in Churchill, Manitoba

Rationale:

This study contributed to a larger initiative called TUNDRA. The goal of TUNDRA is to better understand how environmental decision-making and resource management, as well as social and economic conditions, affect ecosystems and resources that arctic communities depend upon locally. Churchill is one of four Canadian communities selected for comparison as part of the project.

Objectives:

- Develop a problem definition from quotes and direct responses to TUNDRA interview questions: investigate challenges local people must deal with when engaging in harvest and outdoor recreational activities.

Methods:

- Seventeen in-person interviews with residents of Churchill took place between September and November 2013.
- Respondents had been living in the community for over a decade and were avid users of the land and water: hunters, trappers and/or recreationists.
- Questions from the TUNDRA interview guide were adapted to fit the local context where necessary. In general, they focused on:
 - (1) What activities people partake while out on the land (and water);
 - (2) What resources are important to residents and how successfully these resources are being managed; and
 - (3) Local observations of decision-making processes and whether or not they are working.

Years of data collection:

Single year project, 2013

Partners:

- TUNDRA
- University of Saskatchewan
- University of Tromsø

Results:

- Results indicate that the challenges residents of Churchill deal with are a result of decisions made by large corporations.
- Local people are affected financially due to high costs associated with freight through OmniTRAX.
- The Churchill River diversion by Manitoba Hydro in the 1970's resulted in ecological challenges caused by unnatural water levels and a loss of important resources.
- Participants indicated they had little to no trust in OmniTRAX owned companies (Hudson Bay Railway and the Port of Churchill) or Manitoba Hydro.
- The majority of participants (15 out of 17) indicated that they had not provided input in decision-making in the past three years, because they felt that opportunities to get involved did not exist (47%), it was too much bother (40%), or were reluctant to get involved (13%).
- Most respondents felt that they were not informed after management decisions were made (70%), and the opportunity to be consulted, weigh in on those decisions and have an influence on the outcome was not there (80%).

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Participants were interviewed one-on-one. Interviews took on average two hours to complete. Questions were both closed and open-ended
 Credit: J. Lankshear

Interviews involved a mapping section and discussion about participants' connection to the land
 Credit: J. Lankshear

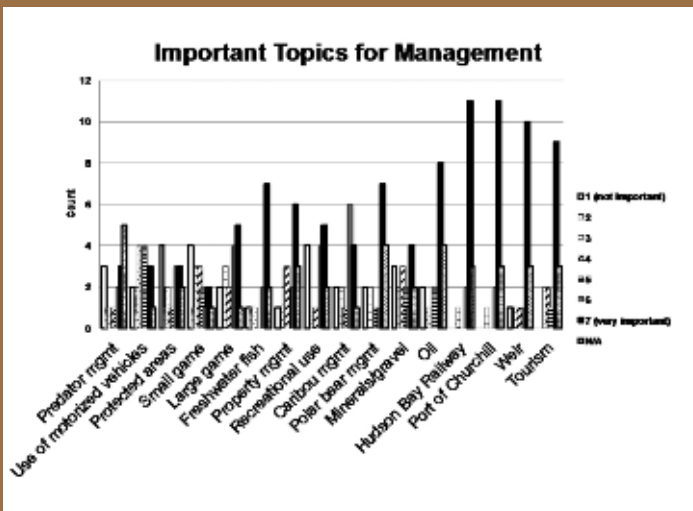


Figure 1. Participants ranked a range of management topics from 1 (not important) to 7 (extremely important). Those who chose not to answer were coded as N/A.

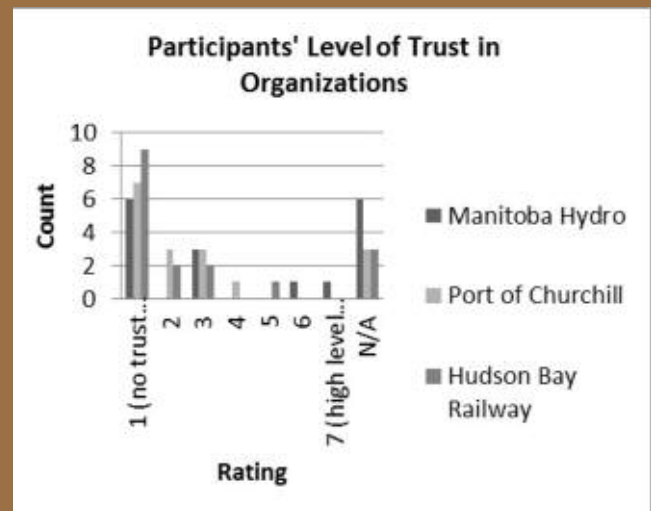


Figure 2. Participants rated their level of trust in Manitoba Hydro, the Port of Churchill and Hudson Bay Railway from 1 (no trust at all) to 7 (high level of trust). Those who chose not to answer were coded as N/A.

The ecology, population dynamics, and status of polar bears in relation to environmental change

Rationale:

As a keystone species, polar bears provide insight into overall health of biodiversity within the Arctic marine ecosystem. Over the past several decades, studies have documented significant reductions in sea-ice cover in parts of the Arctic, thinning of multiyear ice in the polar basin and seasonal ice in Hudson Bay, and changes in sea ice chronology that are a consequence of climate warming. Previous results from Environment and Climate Change Canada (ECCC) studies of polar bears in western Hudson Bay include declines in body condition, natality, and in survival rates of dependent young, juveniles, and old bears related to changes in timing of sea ice breakup, which have resulted in a decline in abundance.

ECCC initiated a long-term study of polar bears in western Hudson Bay in 1981 that has resulted in an ongoing, consistent record from which to examine past, present, and future trends and impacts. The research increases scientific knowledge of population dynamics, furthers understanding of barriers to potential recovery, and aids development and implementation of effective conservation actions.

Objectives:

- Continue ongoing, long-term research on the ecology, population dynamics, health, and status of polar bears in western Hudson Bay in relation to environmental change.
- Obtain information on habitat use, migration timing, population delineation, and regional sea ice projection modelling through the application of telemetry.
- Assess shifts in polar bear foraging ecology in relation to environmental change.

Methods:

- Polar bears are located and captured from a helicopter using standard immobilization techniques.
- Polar bears are handled in locations that are safe for their overall well-being. During handling procedures, vital signs and responses are monitored.
- Standard measurements are taken from each animal; those captured for the first time are permanently identified by unique numbers applied as both tattoos and ear tags.
- GPS, satellite-linked telemetry collars are fitted to a sample of adult females.
- Blood, hair, claw, fat, and skin samples are collected.
- A temporary mark is applied to ensure that individuals are only handled once in the season.

Years of data collection:

Ongoing Project since 1981

Partners:

- Churchill Northern Studies Centre
- Environment and Climate Change Canada
- Isdell Family Foundation
- Manitoba Conservation and Water Stewardship
- Natural Sciences and Engineering Research Council (Northern Supplement)
- Parks Canada
- University of Alberta
- Wildlife Media Inc.

Results:

- Sea ice breakup (50% ice cover) in western Hudson Bay occurred on 18 May, which is the earliest in the 1979-2015 time series; although breakup occurred very early, ice still persisted elsewhere in the Bay well into summer.
- 73 bears of all age- and sex-classes were handled in September 2015.
- There is correlation between date of sea-ice breakup and overall condition of polar bears when they come ashore; earlier breakup results in polar bears coming ashore with less fat resources.
- On a 5-point scale of fatness, most bears (n=35) were scored as thin (Fat 2), followed by average (Fat 3, n=27), and fat (Fat 4, n=11). No bears were scored as skinny (Fat 1) or obese (Fat 5).
- 9 GPS satellite collars were deployed on females with cubs; 3 collars were recovered that were previously deployed.

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Adult male polar bears, Wapusk National Park
Credit: David McGeachy



Family group along coast, Wapusk National Park
Credit: David McGeachy



Polar bear tracks in mud, Wapusk National Park
Credit: David McGeachy



Sunrise, Churchill, Manitoba
Credit: David McGeachy

Effects of Lesser Snow Geese on carbon cycling of a coastal tundra pond, Wapusk National Park

Rationale:

During the past ~40 years, coastal regions of Wapusk National Park (WNP) have witnessed rapid increases in the population density and nesting area range of Lesser Snow Geese (LSG). This has raised concerns and uncertainty about environmental effects of their activities on the abundant shallow tundra ponds. These ponds can be particularly responsive to environmental stressors due to their high surface area to volume ratio. In this study, we use a combination of contemporary limnological measurements and water and carbon isotope tracers to compare seasonal patterns of hydrolimnological and biogeochemical conditions between 15 low disturbance coastal fen ponds (LDCF) with one pond disturbed by LSG activities (WAP 20). We further disentangled the roles of hydroclimatic conditions and waterfowl disturbance by comparing the paleolimnological record from WAP 20 with another LSG disturbed pond (WAP 21) and with the record from an undisturbed pond (WAP 12).

Objectives:

- Determine the range of variability of biogeochemical conditions for ponds unaffected by the LSG population expansion.
- Compare seasonal changes and patterns of hydrolimnological and biogeochemical conditions between the LDCF ponds and WAP 20 to assess the influences of LSG activities on carbon cycling and trophic status.
- Use analyses of pond sediment cores to reconstruct past changes in hydrolimnological and biogeochemical conditions to assess the roles of multiple stressors (e.g., climate change, LSG population expansion).

Methods:

- Water samples were collected from 15 LDCF ponds and WAP 20 at three different times (June, July and September) during 2010 for analysis of water isotope composition and water chemistry (e.g., TP, TKN, DOC, chlorophyll a, pH, DIC).
- Samples were collected at the same time from these ponds for the carbon isotopic composition of dissolved inorganic carbon and particulate organic matter to provide information on carbon balance.
- Sediment cores were retrieved from two LSG disturbed ponds and one LDCF pond in 2010 and 2011, respectively.
- Chronologies were established using radiometric dating and sediment cores were analyzed for a suite of physical, geochemical and biological variables.

Years of Data Collection:

2010-2012

Partners:

- Parks Canada
- Natural Sciences and Engineering Research Council of Canada
- Natural Resources Canada Polar Continental Shelf Program
- Aboriginal Affairs and Northern Development Canada Northern Scientific Training Program
- Churchill Northern Studies Centre Northern Research Fund

Results:

- Lake water balances did not differ substantially between WAP 20 and the LDCF ponds.
- Water-chemistry variables at WAP 20 were generally within the range of values observed for the LDCF ponds, but marked differences in carbon balance were evident throughout the ice-free season. Unique behaviour of WAP 20 was evident in the carbon isotope signature of dissolved inorganic carbon, likely as a consequence of intense benthic algal carbon demand in the presence of high pH (process termed ‘chemically-enhanced CO₂ invasion’), driven by increased nutrient loading from the LSG.
- Sediment core analyses identify two distinct hydrolimnological and biogeochemical changes that have comparable timing in the two ponds disturbed by the LSG population. The first shift occurred in the early 1900s and corresponds with post-Little Ice Age warming. The second shift occurs ~1970 and corresponds with the exponential increase in the LSG population. Analyses of a sediment core from a LDCF pond only displayed the early 20th century shift.
- The broad range of measurements multiple times throughout the ice-free season including the measurement of carbon isotopes, as well as the paleolimnological records were key in determining that high levels of waterfowl disturbance have the potential to alter biogeochemical cycles in subarctic ponds.

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Ponds from the coastal fen ecotype of Wapusk National Park
Credit: Lauren MacDonald

Dr. Jon Sweetman with a sediment core taken from a coastal pond with high disturbance from the Lesser Snow Goose population
Credit: Celia Symons

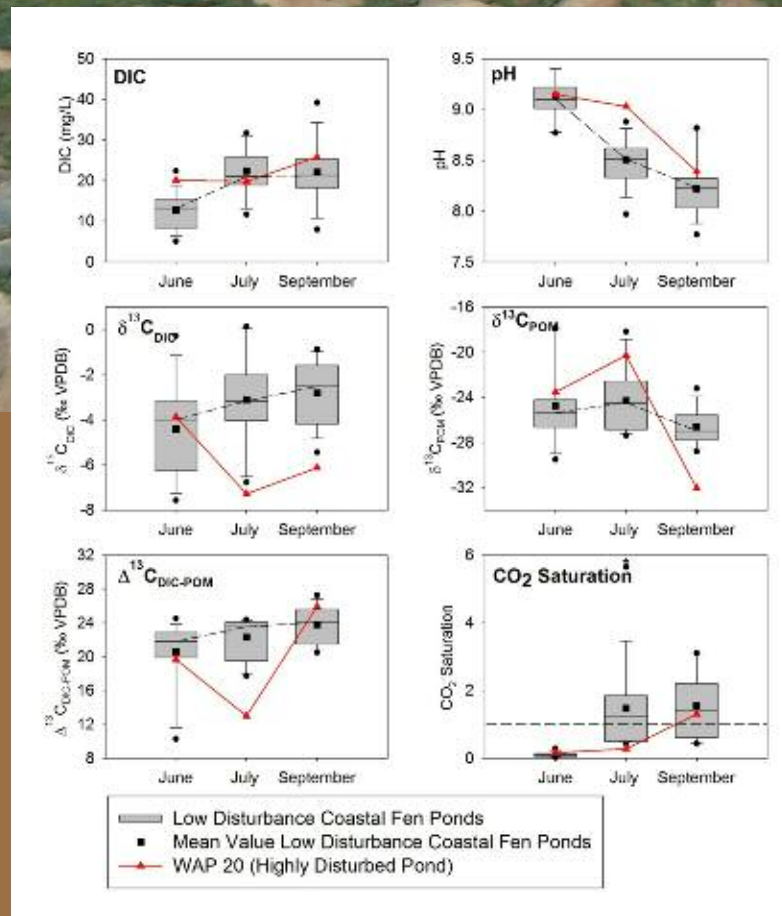


Figure 1. Boxplots depicting seasonal changes in $\delta^{13}C_{DIC}$ and $\delta^{13}C_{POM}$. The boxes identify the 25th percentile, median value and 75th percentiles for the low disturbance coastal fen (LDCF) ponds. The whisker bars represent the 10th and 90th percentile and the solid black circles represent the maximum and minimum values observed for the LDCF ponds. Black squares represent the mean seasonal value for the LDCF ponds. Red triangles joined by the solid red line represent the values for WAP 20.



Examples of ponds from the coastal fen ecotype of Wapusk National Park with low disturbance from the Lesser Snow Goose population
Credit: Lauren MacDonald



Photos from WAP 20, which has evidence of high disturbance from the LSG population
Credit: Lauren MacDonald

Microclimate, snowpack, treeline dynamics, and permafrost degradation in Wapusk National Park, Manitoba

Rationale:

Collection of tree foliage and analysis of water retention can yield insights into the effects of summer warmth versus winter stressors on health of extant trees. Permanent microclimate stations will monitor a number of weather parameters year-round and wildlife cameras mounted on the stations will be used to assess snowpack development and vegetation phenology. Station measurements of snow characteristics will be supplemented by mid-winter snowpack ground surveys.

Objectives:

- Establish and maintain microclimate monitoring stations.
- Collect data from established snowpack monitoring sites.
- Develop a proxy climate record using annual growth rings of trees and shrubs.
- Evaluate conifer tree foliage water retention in relation to wind exposure.

Methods:

- Treeline (5 sites): Current year branch tips were collected from trees across an exposure gradient and analyzed for resistance to water loss and frost hardiness from 2013 to 2015.
- Microclimate (2 sites): Monitoring stations were established at Mary (2004) and Roberge (2005) Lakes with the aim to become long-term reporting sites. Sensors measure snow depth, rain, wind speed and direction, air temperature, air relative humidity, near surface soil and permafrost temperature. Wildlife cameras were installed on the stations in 2014 and oriented towards snow stakes with a 1 cm graticule resolution. Cameras were programmed to take one photograph at midday during peak lighting. Photos were analyzed for snowpack development during winter and vegetation phenology during the snow-free season.
- Mid-winter snowpack (11 sites, sampled during February 2006-2016): Using snow pits, Adirondack snow cores, and RAM penetrometer measurements, we measure snowpack depth, density, snow water equivalent, insulation, and hardness.

Years of data collection:

Ongoing Project since 2004

Partners:

- Churchill Northern Studies Centre
- Parks Canada
- University of Saskatchewan

Funding:

- Current: Earthwatch International, University of Saskatchewan, Wapusk National Park.
- Past: Garfield-Weston Foundation, Northern Scientific Training Program, S.M. Blair Family Foundation, Canadian Museum of Nature, CNSC Northern Research Fund, IPY core project PPS Arctic as part of IPY 2007–2008, sponsored by the International Council for Science and the World Meteorological Organization.

Results:

- Treeline: Cool temperatures during the year of needle formation resulted in short, immature white spruce needles by the end of the growing season. Annual temperatures during 2013 (-6.4 °C) were cooler than 2012 (-4.6 °C) and 2014 (-6.0 °C). Needle water loss and mortality in mid-winter 2014 more than tripled relative to winter 2013.
- Microclimate: During June 2015, we replaced some of the instruments on the Roberge Lake station and completely replaced the Mary Lake station. No trends are evident in either record, though annual temperatures across the park in 2015 were 1 °C warmer relative to the 2006–2015 mean.
- Snowpack: Most ecosystems that receive snow accumulation from wind redistribution (e.g., forest, tree island, shrub, and sedge fen) had 6–54% shallower snow in 2016 relative to the 2006–2016 mean.

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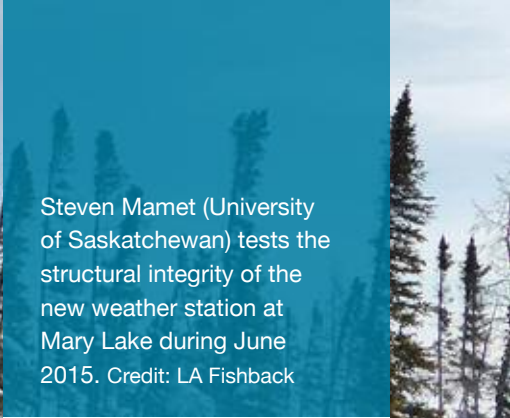
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LeeAnn Fishback (CNSC) and Jessica Lankshear (Parks Canada) collect snow cores from a tree island near Roberge Lake during February 2014. Credit: S.D. Mamet



Steven Mamet (University of Saskatchewan) tests the structural integrity of the new weather station at Mary Lake during June 2015. Credit: LA Fishback



Microclimate stations at Roberge (upper panels) and Mary (lower panels) Lakes during winter and snow-free seasons. The red circles indicate the location of the weather stations. Photo dates (clockwise from upper left): September 2015, February 2016, February 2013, and August 2005. Credit: S.D. Mamet



Peter Kershaw (University of Alberta) and Natalie Asselin (Parks Canada) collect current-year branch tips from white spruce near Broad River during February 2013. Credit: S.D. Mamet

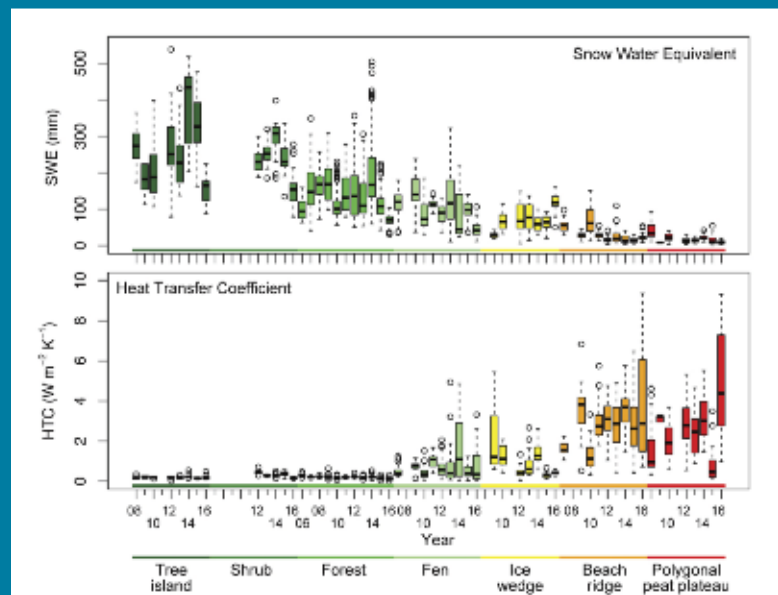


Figure 1. Snow water equivalent (SWE) and snow heat transfer coefficient (HTC) among ecosystems with tall, woody plants (green) and low-stature vegetation (yellow–orange). HTC is the potential heat loss through the snowpack. Higher values occur with thin, dense snow on beach ridges and polygonal peat plateaus, while the deeper, less dense treed and shrub snowpack insulates the ground.

Hydroecology of ponds in Wapusk National Park – transferring knowledge from research to sustainable long-term ecological integrity monitoring

Rationale:

Wapusk National Park (WNP) protects landscapes and ecosystems of the Hudson Bay Lowlands, which are susceptible to disturbances due to climate change and an exponential increase in Lesser Snow Geese population. Monitoring changes in ecosystem diversity and dynamics is essential but a challenge when working in remote areas with limited resources and high staff turnover. Reliable and sustainable long-term monitoring of the ecological integrity of WNP depends on the development and application of user-friendly monitoring protocols. Through collaboration with research partners, knowledge and methods can be adapted to support park ecological integrity monitoring that non-specialists can perform reliably. This project will facilitate knowledge transfer from hydroecology research methods to assess pond water dynamics (impacts of climate change) and goose aquatic impacts in WNP. These user-friendly protocols could also promote opportunities for public involvement and citizen science.

Objectives:

- Transfer knowledge and methodology from research to long-term ecological integrity monitoring between Parks Canada and hydroecology researcher partners.
- Develop training material and train Parks Canada staff.
- Maintain collaboration in pond field sampling and in laboratory analyses with research partners.
- Build and apply detailed user-friendly monitoring protocols for pond water dynamics and goose aquatic impacts.

Methods:

- Research method to monitoring protocol: using a template adapted from the US National Parks, acquire, organize and review documents, photos and partners' knowledge; integrate goals and logistical requirements from Parks Canada.
- Training: presentations, schematics, hands-on activities, field sampling.
- Pond water dynamics: collect field water samples at three different times (June, July and September) and send to research partners for laboratory analysis of stable isotope composition. Monitor an evaporation pan in Churchill to provide partners with data to constrain isotope-mass balance modelling of lake water isotope compositions.
- Goose aquatic impacts: collect pond water samples in July; filter and divide for different analyses; send samples to research partners for laboratory analysis of water isotope composition and water chemistry.
- Other measurements: At each pond, measure pH, water temperature and conductivity using a hand-held multi-sensor instrument, and note environmental conditions.

Years of data collection:

Pond water dynamics (hydrology): on-going project since 2010.

Goose aquatic impacts: new sampling design started 2015 (previous design: 2013 to 2015).

Partners:

- Parks Canada Agency
- Wilfrid Laurier University and University of Waterloo
- Natural Resources Canada - Polar Continental Shelf Program
- Churchill Northern Studies Centre
- Natural Sciences and Engineering Research Council of Canada

Results:

- Development of protocols for the monitoring of pond water dynamics and goose aquatic impacts are in progress through on-going collaboration.
- Training material and community presentation material were produced and presented by research partners and used by park staff in communications with managers, the Wapusk Management Board and other staff. Seven park employees from different functions were trained and five sampled ponds in the park.
- The sampling design for goose aquatic impacts was re-assessed and modified from a total of 15 ponds (five ponds from three areas) sampled at three different times (June, July, September) to a grid of 30 ponds distributed between Nester One and Broad River and sampled a single time (July). This provides a larger spatial monitoring area with better ability to detect long-term changes over time and space.

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Wapusk National Park: the challenges of ecosystem monitoring increase in a vast remote landscape half land, half water. Credit: Parks Canada

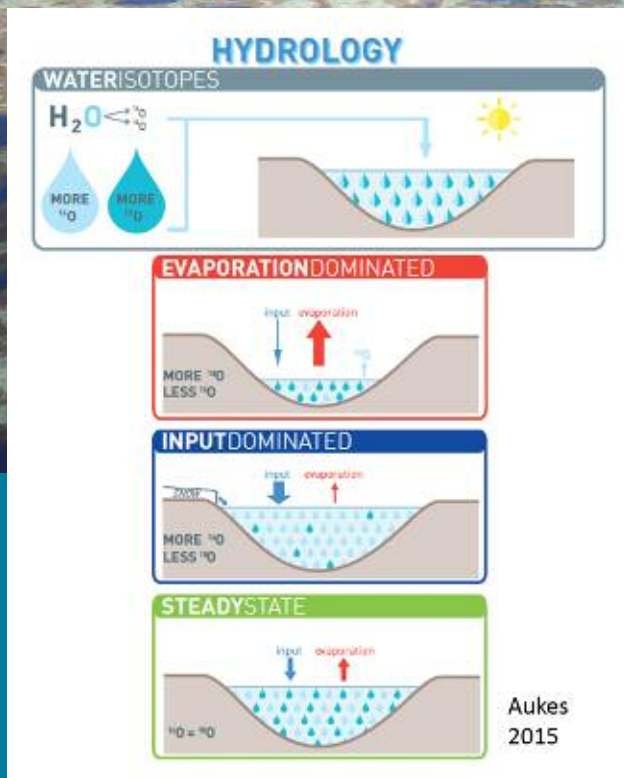


Figure 1. Example of the training material developed and presented by research partners to park staff. It shows the possible water dynamics (hydrological regimes) of ponds in Wapusk National Park based on the balance between common and heavier oxygen isotopes (160 and 180) in water dynamics, such as the drying of ponds through evaporation. Park staff also uses this material in communications with managers, the Wapusk management board and other staff. Credit: Hilary White, Wilfrid Laurier University



Pond desiccation, or the drying of ponds across Wapusk National Park; a main reason to assess pond water dynamics in response to climate change. Credit: Hilary White, Wilfrid Laurier University



Training: Hands-on knowledge transfer between research partners, Hilary White (in black) and Stephanie Roy (in blue), and Parks Canada staff (Mallory Light, Andrea Dillon, Brian Wasylkoski, Marc-André Belcourt) Credit: Parks Canada



Impacts of lesser snow goose on Wapusk ecosystems: reduced vegetation diversity and quantity, increased soil salinity, dead shrubs, high water conductivity (i.e., containing high loads of sediments and nutrients). Credit: Parks Canada

Nested expertise monitoring approach: a graded approach to expertise development and long-term monitoring

Rationale:

In a context of limited or variable resources (ex.: expertise, funding, human resources, time), nested expertise monitoring methods provide a planned and flexible approach to build long-term monitoring programs integrating the skills and knowledge of experts and non-specialists. Park ecologists need to ensure monitoring reliability and sustainability when experts are not available and require non-specialist methods that can be done by park staff and Aboriginal partners and visitors. The selected methods need to be simple enough to be done by non-specialists, explained clearly in a user-friendly, detailed monitoring protocol, and complemented once in a while by expert monitoring. The combination of methodologies over the same sampling sites represents nested expertise monitoring. This approach can provide challenges of increasing interest to citizen observers, facilitating long-term engagement of volunteers, greater sustainability of monitoring projects, and deeper understanding of ecosystem functioning and of the scientific process.

Objectives:

- Develop the concept of nested expertise monitoring approach.
- Combine three field tundra vegetation monitoring into a nested expertise approach.
- Test their applications in the field with botanists applying the expert methods and non-specialists (park staff, youth) applying the coarser methods, all on the same sampling quadrats.

Methods:

- Three sampling methods nested within the same field sampling square: 1) International Tundra Experiment (ITEX) vegetation point frame protocol was applied as expert method by botanists; 2) in-field vegetation percent cover by functional groups (lichen, moss, herb, grass, shrub, rock, bare soil, water) was assessed by non-specialists (park staff, youth); 3) standardized photos of quadrats were taken by non-specialists and analyzed on the computer in the laboratory by botanists.
- The mean and precision of the estimate were compared between levels of expertise and between types of tundra vegetation.

Years of data collection:

2010, 2011

Partners:

- Labrador Highlands Research Group, Memorial University of Newfoundland and Labrador
- kANGIDLUASUK youth camp
- Torngat Mountain National Park
- Western and Northern Service Centre, Parks Canada, Winnipeg

Results:

- Expert sampling took longer than non-specialist sampling.
- In simple vegetation structure, the precision of the expert method (point framing) in the field is greater than for photo analysis. In complex vegetation, both the mean and the precision are different between methods.
- Further testing of nested expertise methods are needed to assess reliability and sustainability.

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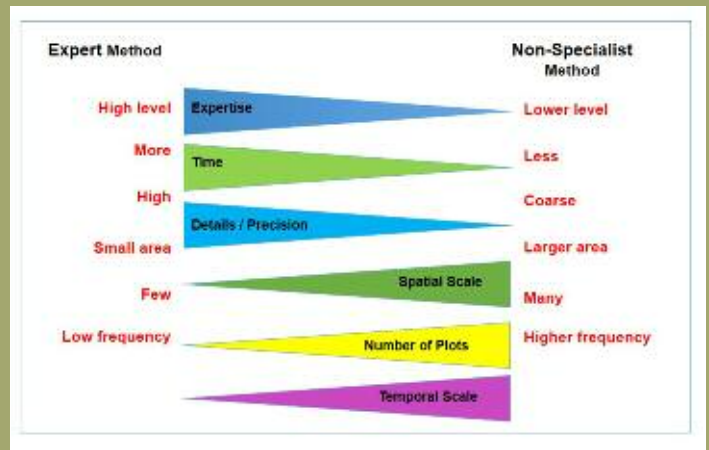


The ITEX (International Tundra Experiment) expert field method in action. Identification of plants to species level and 100 points samples within the 1m² frame
 Credit: Parks Canada, Chantal Ouimet



Three nested vegetation sampling methods:
 1) expert ITEX point frame (grey frame with green threads) for detailed but time-consuming sampling;
 2) non-specialist percent (%) cover in the field using a small brown frame without threads for faster, less detailed assessment; and 3) taking photos of the frame using a tripod and camera: very quick but captures only the top layer of vegetation.
 Credit: Parks Canada, Chantal Ouimet

Figure 1. Comparison of characteristics between expert and non-specialist methods.
 Credit: Parks Canada, Chantal Ouimet



Ecology and impact of Lesser Snow Geese

Rationale:

Traditional knowledge indicates Lesser Snow Geese have nested at La Pérouse Bay since at least 1933. We began studying the colony of 2,500 pairs in 1969 and have seen it increase numerically to >75,000 pairs and geographically from 4 km² to more than 300 km², extending now to Rupert Creek. The goals of this long-term study are to examine the interplay of this keystone herbivore and its habitat, especially in response to increases in goose numbers and climate change.

Objectives:

- Monitor the size and nesting density of snow geese.
- Determine the impact of snow geese on vegetation and other animal species.
- Ascertain the recovery potential of degraded salt and fresh water habitat.
- Examine whether reproductive success changes over time and space and relate this to habitat quality.
- Estimate survival of adult snow geese and determine its dependency on habitat quality.
- Evaluate phenology changes in forage and non-forage plant species.

Methods:

- Conduct aerial surveys of nesting colony boundaries.
- Monitor permanent nesting plots.
- Deploy game cameras to detect predators and determine predation rates.
- Score 21 recovery exclosures and associated control plots.
- Collect aerial photography of brood flocks.
- Conduct standard banding and recapture operations.
- Photograph samples of target plant species every 3 days.

Years of data collection:

Ongoing Project since 1969

Partners:

- American Museum of Natural History
- Arctic Goose Joint Venture
- Central and Mississippi Flyway Councils
- Canadian Wildlife Service
- US Fish and Wildlife Service
- Wapusk National Park

Results:

- The hatch date in 2015 was 6 days earlier than the 46 year mean.
- Nesting density was returned to historic levels.
- After 10 years, there is substantial recovery in enclosed, degraded freshwater habitat.
- During our annual aerial brood survey and banding operations we found that productivity has dropped to half the historic level.
- Polar bears, grizzly bears, arctic foxes, sandhill cranes and herring gulls predated snow goose nests.
- Publication of scientific papers:
 - Koons, DN, M Gamelon, J-M Gaillard, LM Aubry, RF Rockwell, F Klein, R Choquet and O Gimenez. 2014. Methods for studying cause-specific senescence in the wild. *Methods in Ecology and Evolution* (on-line early) doi: 10.1111/2041-210X.12239.
 - Peterson, SL, RF Rockwell, CR Witte, and DN Koons. 2014. Legacy effects of habitat degradation by lesser snow geese on nesting savannah sparrows. *The Condor: Ornithological Applications* (in press).
 - Koons, DN, RF Rockwell, and LM Aubry. 2013. Effects of exploitation on an overabundant species: the lesser snow goose predicament. *Journal of Animal Ecology* 83:365-374.
 - Peterson, SL, RF Rockwell, CR Witte and DN Koons. 2013. The legacy of destructive snow goose foraging on supratidal marsh habitat in the Hudson Bay Lowlands. *Arctic, Antarctic, and Alpine Research* 45:575-583.
 - Aubry, L.M., R.F. Rockwell, E.G. Cooch, R.W. Brook, C.P. Mulder, and D.N. Koons. 2013. Climate, phenology, and habitat degradation: drivers of gosling body condition and juvenile survival in lesser snow geese. *Global Change Biology* 19:149-160.

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A gaggle of geese
Credit: E. Wampole



A gosling at rest
Credit: E. Wampole



A brood of snow geese
Credit: E. Wampole



Gosling eating willow leaves
Credit: E. Wampole



Oddly plumaged gosling
Credit: E. Wampole

The ecology and population dynamics of Common Eiders at La Pérouse Bay

Rationale:

- Common eiders at La Pérouse Bay have been monitored for nearly 40 years. Typical of the species, they display a boom or bust pattern of reproductive success with years of high success punctuated by years of complete failure. Among the predators responsible are polar bears and arctic foxes with flooding being the primary non-biological cause of failure. Both polar bear arrival (and predation) and spring flooding will be increasingly affected by global climate change. Part of this project aims to monitor success of the colony closely.
- The second part of this project is to develop projection models that examine the effects of such boom and bust reproductive success on the population's dynamics. Among the specific questions to be addressed are what frequency and pattern of catastrophic failures can the population sustain without declining or being extirpated.

Objectives:

- Monitor local population size of common eiders for nesting density, reproductive success and both juvenile and adult survival.
- Determine the pattern and frequency of depredation events by predator.
- Develop a population model incorporating catastrophic events.

Methods:

- Visit and map nests in the Mast and Wawao River systems near the La Pérouse Bay Research Station.
- Use egg candling to determine the nesting phenology.
- Monitor the nests regularly and estimate daily failure rates.
- Capture females on their nests and band them or record band numbers of those previously marked.
- Generate population projection models using MATLAB.
- Use game cameras deployed at nests to determine predators and predation rates.

Years of data collection:

Year 27 of an ongoing project

Partners:

- American Museum of Natural History (AMNH)
- Utah State University
- University of North Dakota

Results:

- We found and mapped a total of 164 nests.
- The average date of nest initiation was 7 June 2014.
- Nesting success was 9.7%, a reduction due primarily from predation by arctic foxes and sandhill cranes.
- Our remote camera array caught a substantial portion of the predation.
- Publication of scientific papers:
 - Iles, D.T., R.F. Rockwell, P. Matulonis, G.J. Robertson, K.F. Abraham, C. Davies, and D.N. Koons. 2013. The effects of predators, alternative prey, and climate on common eider nesting success. *Journal of Animal Ecology* 82:683-693.

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Common eider pair
Credit: R.F. Rockwell



Setting video camera on eider nest
Credit: E. Wampole



Sandhill crane predation
Credit: D.T. Iles



Common eider eggs
Credit: R.F. Rockwell



Fox predation
Credit: A. Barnas

Expansion of Lesser Snow Goose nesting in Wapusk National Park

Rationale:

As the numbers of Lesser Snow Geese in Wapusk National Park have increased, their destructive foraging has degraded local habitat. Since their continued success depends on the quality of the habitat, one might expect their survival and reproductive success to decline. This should limit the population's growth and control the population's size through density-dependent regulation. For that to happen, however, the geese must remain in the degraded areas. Our long-term research at La Pérouse Bay indicates this is not likely.

Objectives:

- Establish a route and annually monitor the entire coast of Wapusk National Park and the inland interface of the tundra and boreal forest for nesting Lesser Snow Geese.
- Perform a preliminary ground inventory of any location that has more than 1 nest per hectare.

Methods:

- Surveys are flown in a Bell 206B Jet Ranger at 250 to 300m altitude.
- GPS locations of any nesting Lesser Snow Geese are recorded.
- Any area with an apparent density of >1 nest/hectare is circled and may be examined from the ground.
- Areas recorded as having been used are specifically checked.

Years of data collection:

Ongoing Project since 2005

Partners:

- American Museum of Natural History
- Arctic Goose Joint Venture
- Central and Mississippi Flyway Councils
- Canadian Wildlife Service
- US Fish and Wildlife Service
- Wapusk National Park

Results:

- The Thompson Point Lesser Snow Goose colony now extends from just south of the White Whale River to just north of the Broad River.
- The highest nesting density at two points – one north and one south of Thompson Point.
- Snow goose nesting now extends at low density from 10km south of the Broad River to Rupert Creek.
- Nesting density has returned to historic levels.
- Nesting has extended 5-10km inland from the White Whale to the Broad River.
- Destructive foraging is occurring up to 25km inland.
- Publication of scientific papers:
 - Koons, DN, M Gamelon, J-M Gaillard, LM Aubry, RF Rockwell, F Klein, R Choquet and O Gimenez. 2014. Methods for studying cause-specific senescence in the wild. *Methods in Ecology and Evolution* (on-line early) doi: 10.1111/2041-210X.12239.
 - Peterson, SL, RF Rockwell, CR Witte, and DN Koons. 2014. Legacy effects of habitat degradation by lesser snow geese on nesting savannah sparrows. *The Condor: Ornithological Applications* 116:527-537.
 - Koons, DN, RF Rockwell, and LM Aubry. 2013. Effects of exploitation on an overabundant species: the lesser snow goose predicament. *Journal of Animal Ecology* 83:365-374.
 - Peterson, SL, RF Rockwell, CR Witte and DN Koons. 2013. The legacy of destructive snow goose foraging on supratidal marsh habitat in the Hudson Bay Lowlands. *Arctic, Antarctic, and Alpine Research* 45:575-583.
 - Aubry, L.M., R.F. Rockwell, E.G. Cooch, R.W. Brook, C.P. Mulder, and D.N. Koons. 2013. Climate, phenology, and habitat degradation: drivers of gosling body condition and juvenile survival in lesser snow geese. *Global Change Biology* 19:149-160.

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Degraded habitat
Credit: S. Hervey



Degraded habitat
Credit: R.F. Rockwell



Degraded habitat
Credit: R.F. Rockwell



Degraded habitat
Credit: R.F. Rockwell



Degraded habitat
Credit: R.F. Rockwell

Habitat assessment in the Thompson Point region

Rationale:

Millions of Lesser Snow Geese use the east coast of Wapusk National Park for spring staging. In 2001, a large number stayed and nested near Thompson Point. Their offspring consider this “home” and they began a new nesting colony. The destructive foraging of both spring migrants and residents has led to rapid degradation of both coastal and inland freshwater habitat in the area. We have established a monitoring system for the area and are investigating processes underlying degradation in the freshwater habitat.

Objectives:

- Establish a habitat classification system integrating effects of foraging
- Establish and monitor vegetation transects using that system
- Establish and monitor nesting density of snow geese
- Determine recovery potential

Methods:

- Score the habitat along 5km transects perpendicular to the coast
- Score nesting density at two sets of transect plots
- Erect recovery exclosures and mark adjacent control plots
- Deploy remote cameras to monitor predation

Years of data collection:

Year12 of an ongoing project

Partners:

- American Museum of Natural History
- Arctic Goose Joint Venture
- Central and Mississippi Flyway Councils
- Canadian Wildlife Service
- Great White Bear Tours
- US Fish and Wildlife Service
- Wapusk National Park

Results:

- Less than 30% of the vegetation in the region is intact
- Nesting colony has expanded inland by 5-10km
- Nesting density has returned to more normal historical levels
- Recovery has begun in 8-year-old exclosures
- Exclosures were erected in an area converted from graminoid cover to a peat barren have begun to show signs of recovery
- Publication of scientific papers:
 - Koons, DN, M Gamelon, J-M Gaillard, LM Aubry, RF Rockwell, F Klein, R Choquet and O Gimenez. 2014. Methods for studying cause-specific senescence in the wild. *Methods in Ecology and Evolution* (on-line early) doi: 10.1111/2041-210X.12239.
 - Peterson, SL, RF Rockwell, CR Witte, and DN Koons. 2014. Legacy effects of habitat degradation by lesser snow geese on nesting savannah sparrows. *The Condor: Ornithological Applications* (in press).
 - Koons, DN, RF Rockwell, and LM Aubry. 2013. Effects of exploitation on an overabundant species: the lesser snow goose predicament. *Journal of Animal Ecology* 83:365-374.
 - Peterson, SL, RF Rockwell, CR Witte and DN Koons. 2013. The legacy of destructive snow goose foraging on supratidal marsh habitat in the Hudson Bay Lowlands. *Arctic, Antarctic, and Alpine Research* 45:575-583.
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Habitat damage from grizzly bear
Credit: R.F. Rockwell



Habitat damage from grizzly bear
Credit: R.F. Rockwell



Habitat damage from grizzly bear
Credit: R.F. Rockwell



Snow goose degraded habitat
Credit: S. McWilliams



Recovery exclosures at Thompson Point
Credit: R.F. Rockwell

Non-invasive polar bear monitoring in Western Hudson Bay

Rationale:

Polar bears in Western Hudson Bay are already being affected by changing ice and climate conditions and need to be monitored to track population changes over time. When the ice melts, polar bears are forced ashore in large numbers, where they leave behind scat (feces) and hair (in beds) as they move across the tundra. Using molecular analyses of scat and hair we employed an innovative way to estimate abundance, survival, and other population parameters of polar bears so that no animals needed to be handled or marked. Data are then analyzed using the same mathematics as traditional capture-mark-recapture approaches allowing for direct comparison of results.

With longer ice-free seasons, polar bears will likely seek alternative foods while on land. By documenting items in scat piles, we can identify past and future shifts in diet, especially in response to changing food supplies.

Objectives:

- Monitor local population size of polar bears within the sampling area
- Determine individual and sex-specific movement patterns of polar bears along the coast of Western Hudson Bay
- Examine relatedness of polar bears that gather in large groups along the coast or that den in clusters
- Establish baseline data on polar bear diet during the ice-free season to document past and future shifts in response to climate change

Methods:

- Molecular analyses of hair (from beds and dens) and scat (collected using a trained dog) to generate DNA profiles for individual polar bears
- Use traditional mark-recapture and rarefaction analytic approaches to estimate abundance and survival of polar bears using DNA from samples
- Use spatial coordinates, DNA and sex-specific markers to track movement patterns of bears while on land
- Use nuclear and mitochondrial DNA to examine relatedness of bears from hair collected from clusters of beds or dens to infer genetic structuring across the landscape
- Identify and quantify vegetation and animal items in polar bear scat piles; compare data with previous studies to document foraging shifts that may have occurred in the last 40 years

Years of data collection:

Year 10 of an ongoing project

Partners:

- American Museum of Natural History (AMNH)
- Arctic Institute of North America
- Manitoba Conservation - Sustainable Development Innovations Fund

Results:

- We collected a total of 262 hair samples from coastal day beds between the Ontario Manitoba border and Churchill.
- We surveyed the coastline of Wapusk National Park five times
- Publication of scientific papers:
 - Gormezano, LJ and RF Rockwell. 2015. The Energetic Value of Land-Based Foods in Western Hudson Bay and Their Potential to Alleviate Energy Deficits of Starving Adult Male Polar Bears. PLOS ONE DOI:10.1371/journal.pone.0128520.
 - Gormezano, LJ and RF Rockwell. 2013. Dietary composition and spatial patterns of polar bear foraging on land in western Hudson Bay. BMC Ecology 13:51-64. doi:10.1186/1472-6785-13-51.
 - Gormezano, LJ and RF Rockwell. 2013. What to eat now? Shifts in terrestrial diet in western Hudson Bay. Ecology and Evolution 3:3509–3523. doi:10.1002/ece3.740.
 - Iles, DT, SL Peterson, LJ Gormezano, DN Koons and RF Rockwell. 2013. Terrestrial predation by polar bears: not just a wild goose chase. Polar Biology 36:1373-1379.

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Grizzly bear near White Whale River
Credit: R.F. Rockwell



Andrew Barnas collects polar bear hair
Credit: S. Hervey



Polar bear scat
Credit: S. Hervey



Grizzly bear near Kiosk Island
Credit: R.F. Rockwell

Collection of polar bears on Cape Churchill
Credit: S. Hervey



Arctic fox food web interactions and impacts through ecosystem engineering

Rationale:

Top predators can strongly influence prey populations and also can provide fundamental ecosystem services such as nutrient cycling. Their impact on nutrient dynamics can be even greater in environments with low nutrients and productivity, such as Arctic tundra. Arctic foxes depend on well-established dens for breeding, and suitable den sites are limited to elevated topographical features like relict beach ridges. With large litters, averaging 8-10 pups in Canada, active den sites receive high amounts of nutrients from urine and fecal deposits as well as nutrient release from decaying prey items. These concentrated nutrient additions could affect soil nutrient dynamics on den sites, with effects on vegetation biomass and plant community composition that also may attract herbivores to these hotspots of nutrient-rich plant productivity.

Thus by modifying their physical environment, Arctic foxes may act as ecosystem engineers, with impacts on other species through denning.

Objectives:

- Estimate the effect of Arctic fox denning activities on local nutrient dynamics by analysing soil inorganic nitrogen (N) and extractable phosphorous (P) and seasonal changes in these nutrients.
- Compare vegetation biomass on fox dens and paired control sites.
- Examine plant community composition on and off fox dens.

Methods:

- We collected soil samples from 20 fox dens on elevated beach ridges near Nester One in Wapusk National Park in June and again in August. We also collected soil samples from paired control sites 50 m from each den (5 samples per den and control site).
- Total inorganic N and extractable P concentrations were measured in each sample.
- To estimate productivity we collected vegetation biomass samples in August from 0.25 m² quadrats (5 per den and control site) and measured the dry mass.
- Vegetation surveys were conducted on den and control sites using 1 m² quadrats centred on each soil sampling site.

Years of data collection:

Ongoing Project since 2010

Partners:

- Parks Canada
- Manitoba Conservation
- Churchill Northern Studies Centre
- Natural Sciences and Engineering Research Council of Canada
- University of Manitoba Field Work Support Program

Results:

- Soils from fox dens contained much higher nutrient levels in both June and August than adjacent control sites.
- Inorganic N levels decreased from June to August on both dens and controls, whereas extractable P increased.
- Vegetation biomass in August was 2.8 times greater on fox dens.
- Plant species richness on den and control plots did not differ, but the species composition within den or control quadrats differed significantly. Control sites were dominated by prostrate shrubs and contained more lichens, mosses, and sedges than dens, which were dominated by grass or erect shrubs of *Salix* spp. and contained more forb species.
- By concentrating nutrients on dens Arctic foxes enhance nutrient cycling as an ecosystem service and thus engineer Arctic ecosystems on local scales.

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Tazarve Gharajehdaghpour inspecting Arctic fox den
Credit: Jim Roth



Arctic fox bringing prey to pups on den
Credit: Jim Roth



Aerial photo of Arctic fox den
Credit: Tazarve Gharajehdaghpour



Paul Fafard sampling vegetation
Credit: Jim Roth

Stress and parasites related to diet in arctic fox

Rationale:

Challenges such as low food availability, or increased parasite load can provoke a stress response in an organism that, over time can inhibit reproduction and immunity and increase mortality. Arctic fox populations can experience dramatic variation in food availability that strongly affect their population dynamics, which may be reflected in their physiological response to changing environmental conditions.

Objectives:

- To examine the relationship between stress, parasites, and diet in arctic foxes near the southern edge of their distribution in Canada.

Methods:

- We collected shed hair samples noninvasively from fox dens in around Wapusk National Park, as well as hair samples from arctic foxes harvested by local fur trappers.
- We also identified and enumerated internal parasites from fox carcasses collected from trappers, and estimated body condition.
- We measured cortisol concentrations in hair samples using radioimmunoassay, and measured their stable isotope ratios as a reflection of diet. These values reflect stress and diet in the fall, when this hair was grown.
- We compared cortisol concentration in foxes to lemming abundance estimated using mark-recapture at several sites in and around the park, and examined the relationship of stress and condition to parasite loads.

Years of data collection:

2010-2012

Partners:

- Parks Canada
- Manitoba Conservation
- Churchill Northern Studies Centre
- Natural Sciences and Engineering Research Council of Canada
- University of Manitoba Field Work Support Program

Results:

- Cortisol concentrations tended to be higher in animals with lower body condition, but cortisol and condition were unrelated to sex or age.
- Stable carbon isotope ratios were positively related to cortisol concentration and negatively related to condition, suggesting foxes may benefit from consuming rodents over alternative prey.
- We found a high prevalence and abundance of both cestodes and nematodes (parasitic worms), but neither cortisol concentration nor body condition were related to parasite abundance.
- These results suggest that high parasite burdens may have little effect on arctic fox populations and illustrate the physiological mechanisms relating the population response to changing prey availability.

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Molting arctic fox on den
Credit: Ryan McDonald



Collecting samples on fox den
Credit: Jim Roth



Fox necropsy
Credit: Olwyn Friesen



Tapeworm scolex
Credit: Olwyn Friesen

Characterizing the influence of hydrological processes and climate change on shallow lakes in Wapusk National Park, western Hudson Bay Lowlands, Manitoba

Rationale:

Over the past ~50 years, the western Hudson Bay Lowlands (HBL) has experienced some of the greatest warming in the circumpolar North and is considered one of the most sensitive regions to permafrost thaw, in northern Canada. Wapusk National Park (WNP), located within the HBL, contains over 10,000 shallow, mainly thermokarst lakes and ponds that provide important wildlife habitat. This pond-rich landscape has the potential to be greatly influenced by increased evaporation due to longer ice-free seasons, alteration in seasonal precipitation, accelerated permafrost thaw, and more frequent lake drainage events. This research examines past and present hydrological conditions of ponds in WNP to determine how the landscape has responded in the past and continues to respond to climate warming.

Objectives:

- Investigate the different hydrological and limnological processes that influence modern-day pond water balances.
- Identify limnological and hydrological variability on decadal to centennial scales.
- Determine if pond desiccation has occurred in the past or if it is a recent response to climate warming.

Methods:

- Surface water samples were collected three times a year (June, July, September) from 37 WNP ponds spanning three unique ecotypes (coastal tundra, interior peat plateau-palsa bog, boreal forest).
- Water samples were analyzed for water isotope composition (^{18}O , ^2H) to assess seasonal and inter-annual hydrological variability. Isotope-mass balance models were utilized to quantify the relative influence of hydrological processes (snowmelt, rainfall, evaporation) on pond-water balances.
- Pond surface sediment samples were collected in September 2012 and pond sediment cores were obtained in the summer of 2013.
- Sediment core chronologies were established using radiometric techniques (^{137}Cs , ^{210}Pb) and physical (loss-on-ignition), geochemical (organic carbon and nitrogen elemental and stable isotope composition, aquatic cellulose oxygen isotope composition), and biological (diatoms, pigments) techniques were utilized on all sediment samples to understand sediment composition and limnological variables.

Years of Data Collection:

2010-2013

Partners:

- Parks Canada
- Natural Sciences and Engineering Research Council of Canada
- Natural Resources Canada Polar Continental Shelf Program
- Aboriginal Affairs and Northern Development Canada Northern Scientific Training Program
- Churchill Northern Studies Centre Northern Research Fund

Results:

- Strong seasonal and spatial variability in pond hydrology related to variable meteorological conditions were identified.
- Boreal spruce forest ponds are the most isotopically-depleted, reflecting the effects of snowmelt offsetting evaporation, whereas interior peat plateau-palsa bog and coastal fen ponds are more isotopically-enriched, reflecting a stronger influence of evaporation.
- Strong variability exists in lake surface sediment organic and mineral matter (2-97%). However, ecotype does not seem to directly affect this range.
- Surface sediments possess a wide range of carbon and nitrogen stable isotope ratios. This range includes relatively high values that could represent a mixture of aquatic and terrestrial organic matter sources and the potential for high algal productivity.
- Additionally, over the sampling years (2010-2013), several ponds have partially or completely desiccated during mid-summer (WAP 3, 4, 10, 11, 12, 32).
- A cellulose-inferred oxygen isotope composition record from WAP 12 shows relatively stable hydrological conditions over the past ~200 years. This record does not contain evidence of pond desiccation in the past; therefore, an increase in pond desiccation is likely a recent climate-driven phenomenon.

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Pond desiccation in Wapusk National Park, July 2013
Credit: Hilary White



Sample ponds (WAP 10, 11, & 12), July 2013
Credit: Hilary White

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Photo Credits:

Cover: Tundra ponds, Wapusk National Park Credit: Parks Canada • Back Cover: Standing guard Credit: Parks Canada



Caribou
Credit: Parks Canada





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