Joint Polar Knowledge Canada/ NASA Arctic Boreal Vulnerability Experiment/Government of Northwest Territories Workshop Report

May 10-12, 2016
Yellowknife,
Northwest Territories,
Canada

Polar Knowledge Canada
Savoir Polaire Canada

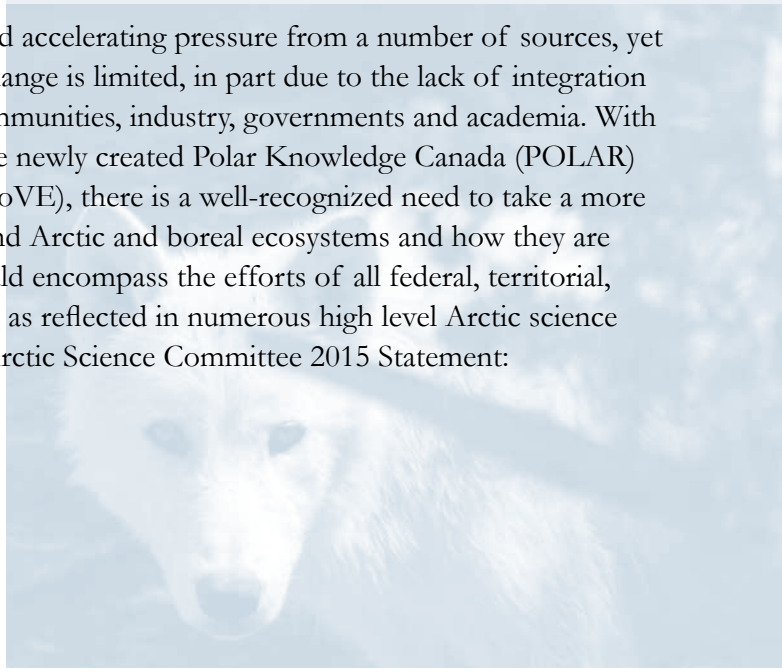
NASA

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

TABLE OF CONTENTS

BACKGROUND

Arctic communities and ecosystems are under increasing and accelerating pressure from a number of sources, yet our ability to detect trends and understand the drivers of change is limited, in part due to the lack of integration between existing research and monitoring efforts led by communities, industry, governments and academia. With this in mind, and considering opportunities presented by the newly created Polar Knowledge Canada (POLAR) and the NASA Arctic-Boreal Vulnerability Experiment (ABoVE), there is a well-recognized need to take a more coordinated research and monitoring approach to understand Arctic and boreal ecosystems and how they are responding to cumulative pressures. This coordination should encompass the efforts of all federal, territorial, Aboriginal and non-government agencies and organizations as reflected in numerous high level Arctic science statements including the following from the International Arctic Science Committee 2015 Statement:



> *"It is critical to anticipate changes in the Arctic rather than respond to them, but to do this requires sustained observations and improved understanding of local, regional, and global processes. These research challenges must be addressed in a coordinated and timely manner to ensure sustainable development and resilient Arctic communities and ecosystems."*

There is also a need to rescue and aggregate existing long-term datasets and an opportunity to employ new technologies (e.g. paleo-ecological studies, new remote sensors, drones, eDNA, etc.) to increase our understanding of a changing north.

The Canadian north has a strong history of research and monitoring, and northerners in particular are playing an ever-increasing lead role in research and monitoring that addresses their needs. Canada, in particular, stands out as a leader in research and monitoring led by Inuit, First Nation and Métis organizations applying, respectively, Inuit Qaujimajatuqangit (IQ) and Traditional Ecological Knowledge (TEK) as a means to identify, interpret and understand change. Canada—through its co-management agencies established through land claims processes, is also a leader in collaborative research and monitoring that respects and utilizes local and Traditional Ecological Knowledge as well as scientific approaches.

POLAR has recently partnered with ABoVE to more closely study changes in the western Canadian Arctic. POLAR's overall mission is to support knowledge generation, through partnerships that foster economic opportunities, environmental stewardship and quality of life across the Arctic. POLAR has two science priorities that this partnership promises to advance:

- Baseline information to prepare for northern sustainability; and,
- Predicting the impacts of changing ice, permafrost, and snow on shipping, infrastructure and communities.

In order to achieve its mandate, POLAR needs to work with regional partners and focus on value-added, strategic investments, targeting priority northern issues. In a similar manner, through ABoVE, NASA aims to support the scientific research needed to better understand aspects of vulnerability and resilience of regional Arctic and boreal ecosystems and their social-ecological implications. ABoVE research combines field-based, process-level studies with remotely sensed data and modeling studies to improve understanding and predictability of complex ecosystem responses and their societal implications. The POLAR and ABoVE mandates are easily aligned, providing an opportunity for a productive and symbiotic partnership.

Figure 1. Map of the Slave Geological Province, comprising both POLAR and ABoVE's research domains.

The POLAR-ABoVE collaboration focuses on the western Canadian Arctic including the Slave Geological Province, an area overlapped by research domains of both agencies (Fig. 1). This area is considered a hotspot of climate and ecological change due to its steep climatic gradient, predicted high species turnover, and high mining development potential. It is also geographically connected to POLAR's Canadian High Arctic Research Station (Government of Canada 2015), providing unique opportunities as a hub for science and technology development in the region for coordinating long-term ecologically representative and relevant monitoring programs.

Partnering with the Government of Northwest Territories (GNWT), a joint workshop was held by POLAR and ABoVE from May 10th to 12th, 2016 in Yellowknife. These activities were funded by POLAR and GNWT with support also from NASA. Below we report on key themes, research and monitoring needs, and potential project directions that arose from the meeting.

POLAR-NASA ABoVE WORKSHOP OBJECTIVES AND OVERVIEW

The POLAR-ABoVE-GNWT workshop was held to achieve several key objectives:

- identify key management/research needs and questions;
- exchange information on ongoing and planned research and monitoring;
- solicit feedback on the POLAR Integrated Research and Monitoring Plan and planned ABoVE activities;
- review and discuss best practices for engaging and including communities and Indigenous Knowledge holders in research/monitoring activities; and,
- explore collaboration opportunities in the context of ongoing monitoring and research and management/research questions

There were over 70 participants comprising academic (university) and government researchers, partner organizations associated with both POLAR and/or ABoVE, Indigenous community representatives (e.g., Aboriginal government and regional wildlife co-management board members), and industry. The workshop began with presentations exchanging information on ongoing monitoring and research across the area of interest (Appendix 1). Introductory overview presentations reviewed POLAR's integrated research and monitoring plan, ABoVE's implementation plan and planned activities, and GNWT's ongoing research, monitoring and management needs and activities. These presentations were followed by more specific presentations of ongoing academic research in boreal, tundra, and taiga domains, industry perspectives, and community-based research monitoring, management, and networking needs. The presentations can be viewed and downloaded at: http://above.nasa.gov/consultations_2016/yellowknife.html. Presentations were followed by plenary discussions on research opportunities and challenges. NASA researchers and staff also presented on ABoVE's Airborne and Science Cloud (ABoVE Airborne Science Working Group 2016) campaigns, allowing for participants to identify key opportunities for research, collaboration, and data applications. The NASA ABoVE Science Implementation Plan can be found at: http://above.nasa.gov/implementation_plan.html?. A detailed, interactive map showing the notional ABoVE Airborne Campaign flight lines can be found at: https://www.arcgis.com/home/webmap/viewer.html?webmap=5a086f754788493abc52a089505c5854&extent=-180,45.5969,-84.4693,76.7851. Following each presentation, participants were provided with an opportunity to ask questions and discuss relevant concerns and potential research areas of focus. Subsequent self-organized break out sessions took place around maps of key research and management areas, which were followed by open-ended, plenary discussions among all participants.

The workshop presentations can be found at: http://above.nasa.gov/consultations_2016/yellowknife.html

WORKSHOP DISCUSSION OUTCOMES AND CONCLUSIONS

Summary of Day 1 Presentations on Key Research and Management Needs and Questions

There is a need to direct future funding for not only ecosystem resilience and adaptation activities but also specific funding to support partnerships linking POLAR, ABoVE, GNWT, academic and Indigenous community interests. From the perspectives of Aboriginal governments, co-management bodies, territorial governments (NWT and Nunavut), industry and academia, there was a general emphasis on the following research and monitoring priorities under the auspices of climate change, and their effects on human health and natural and heritage resources:

- general abiotic responses (e.g., geomorphology, slope stability, permafrost thaw, ground subsidence, surface and subsurface energy balances, fire behaviour and dynamics)
- hydrological changes (e.g., runoff and storage processes, river flow rates and timing)
- greenhouse gas flux and potential changes in air quality
- terrestrial ecosystem changes (e.g, forest cover, shrubification)
- effects on fish and wildlife and harvest-dependent communities

Photo: Polar Knowledge Canada

The GNWT already has several initiatives in place to monitor these changes (e.g., GNWT's Cumulative Impact Monitoring Program, forest management strategies, etc.). The Northwest Territories Centre for Geomatics is also linked to NASA's data cloud, allowing for (near) real time access to a wealth of data.

Within the context of research and monitoring, there is still a need to appropriately scale local and regional data, as there is wide variation in ecosystem responses to natural disturbances. Canada's northern ecosystems are defined by unique legacies (e.g., permafrost, old sea ice, peat, etc.) and understanding these legacies is necessary to predict change and provide baselines across time and space. Accordingly, modeling needs to reflect current and updated fieldwork data to avoid poor assumptions. For linkages with industry partners, the Diavik mine (owned by Rio Tinto and Dominion Diamonds) has provided unique opportunities for research and monitoring projects relevant to wildlife, hydrology, and aquatic effects. These include wildlife sampling and monitoring wind and/or diesel systems on site. However, regional data relevant to mine-related effects is lacking and needs to be incorporated into climate-related impact models.

Recognizing the need to evolve from a species- to ecosystem-level approach which is more consistent with the holistic views of Aboriginal communities, collaborative monitoring and management activities that utilize both science and traditional knowledge are needed. For example, both the Government of Nunavut (Kivalliq region) and Sahtú Renewable Resources Board are leading projects that map land use by elders and youth. These maps are based on habitat selection modeling and can inform subsequent monitoring efforts (e.g., wildlife surveys, sampling to track diseases). Both the Gwich'in and Sahtú Renewable Resource Boards also focus on wildlife research that is informed by the needs of local communities, particularly in regard to ensuring sustainable harvest. In most cases, local harvesters play a key role in research and monitoring utilizing both scientific and Traditional Knowledge techniques. This information is widely used to inform regional and community-based management plans for environmental resources.

Identifying key management and research needs

Several recurring management and research needs and questions arose both during the plenary talks and the breakout discussions. These discussions were reported back across the workshop and several of them could be addressed through ongoing and potential collaborative opportunities (see below).

Encouraging data rescue, archiving, analysis and exchange

There is a need to create a culture of organized data sharing, so that environmental data are easily and routinely compiled, organized, stored, and disseminated. For example, academic, industry, and government and other groups in the Northwest Territories have collected year-round ground temperature data for a range of purposes (e.g., development of roads and buildings, academic theses, mining exploration, etc.) but these potentially valuable data are not easily (publicly) accessible, largely due to no central or interoperable data management structures. This lack of accessibility limits our ability to establish historical baselines and monitor trends. In some cases, existing data or data collection initiatives are simply unknown, limiting our ability to develop landscape level assessments, and make informed and timely management decisions that advance our collective understanding of how northern ecosystems are changing.

To address this issue, participants at the workshop were interested in instituting a program of guidance on how to record and report year-round ground temperature information using a standardized approach. This would require working closely with multiple groups (e.g., the Geological Survey of Canada, academics, regulators, etc.) and buy-in from different government partners to develop protocols for metadata and data storage. Strategies for leveraging data (research licensing, procurement and regulatory processes) that incorporate existing protocols would also need to be developed. As a start, existing historical information or data sources could be revisited to back cast and establish historical baselines. Students and post-docs could be employed to examine historical archives and locate data records that are relevant for the territory to rescue, archive, and establish historical baselines for foundational products or projects. These efforts would be beneficial as research and management partners work together to develop value-added (data) products and analysis. Beyond directly underpinning research needs, data could be made available for decision-making (e.g. for infrastructure design and location), project planning, and cumulative effects and climate change assessments.

Engaging and including Traditional Knowledge holders in research and monitoring

Good research needs to be pragmatic from a funding perspective and collaborations with local communities and their interests are required for meaningful and effective research. Developing strong practices for engaging and including IQ and TEK holders in research and monitoring will require ongoing effort and discussions beyond this workshop (e.g., as POLAR's research and monitoring programs mature and over the 8 to 10 years of the ABoVe program). Community-based research planning with a practical focus (e.g. determining where and what projects could take place on the ground and how they could be led or supported by local communities) could be beneficial both to ABoVE's airborne campaign and additional future activities, and to the communities themselves.

However, when interfacing with local communities, incorporating the concept of "ecosystem services" in GNWT decision-making is a challenge when communities (Aboriginal groups) have not yet defined or conceptualized ecosystem services themselves. At smaller scales, an ecosystem services working group is already in place for projects that have been funded by ABoVE, and this could provide a starting point for a larger, "meta" working group across the north. Webinars and/or conferences will be useful platforms in initiating discussions.

Communicating useful and relevant information back to communities and focusing on major trends (versus quantities) can encourage knowledge transfer. For example, in the context of monitoring fish and water, communicating how many fish and of what sizes are healthy to eat versus maximum mercury intake per day is a more effective strategy. Youth-elder transfers are particularly useful when local schools are engaged. Schools can act as a gateway to community interests in research, through awareness in research initiated through local curriculums. In this manner, linking research to local educational systems can support capacity and understanding in research that is being conducted and its applications.

Exploring collaborative opportunities across a range of research and policy groups

ABoVE's upcoming Airborne campaign and Science Cloud (supercomputing resource) were presented in detail to explore their potential applications in the western Canadian Arctic. ABoVE is seeking proposals that maximize the utility of the airborne campaign to address a range of science questions. Foundational and baseline measurements from fixed-wing aircraft using a range of state-of-the-art sensors will be made across seasons with the majority of flights in 2017 and 2019 (with some bridging activities in 2018). Canadian collaborators can both contribute to the provision of high-resolution, ground data over key sites and transects needed for calibration and validation of the airborne data and benefit from the ABoVE Airborne Campaign via access to spatially explicit data products. The data obtained via this campaign provides a unique and significant opportunity to fill key knowledge gaps and allow for observations to be scaled, through modeling, across large spatial and temporal scales. In consideration of the planned Airborne campaign, a number of potential project ideas were generated that would both benefit from and support this campaign:

1. Snow, caribou ecology, and Sahtú

Enhanced and greater snow and snow-water-equivalent (SWE) seasonal measurements can inform existing and potential hydro-electricity generation projects in the vicinity of Yellowknife and these activities could be paired with caribou monitoring initiatives where improved snow data is also required. Snow surveys conducted by GNWT in March and April for hydro basins near Yellowknife and Fort Resolution could also be used to ground-truth satellite data. Comparisons with available historic records could develop better models for SWE that informs power generation potential.

Photo: Polar Knowledge Canada

The Porcupine caribou herd and most Alaskan barren-ground caribou herds are stable or increasing while all others, largely to the east, are in decline. Investigating a number of theories including the differential impacts of drought, changes to winter and calving areas (e.g. food quality) and the impacts of changing snow conditions are of high interest, considering the cultural and dietary importance of this species in northern communities. As well, understanding the key drivers that influence migration patterns could be facilitated through a coordinated effort involving community observers within the range of various herds.

The proposed Mackenzie Valley Highway could also facilitate more data collection (e.g., lake bathymetry, color, etc.) within the watershed including the Mackenzie Delta, however, this proposed project is unlikely to move forward for a number of years. In advance of its initiation, terrestrial baseline data could include snow cover, depth, freeze/thaw characteristics and their impacts on caribou migration. There are also opportunities to link these data to vegetation data, as GNWT national forest inventory (e.g., data on species, heights, etc.) and tree plots are also available for this region. This includes productive forest plots for Fort Liard, which is of high interest, as well as Fort Resolution and the Slave Delta. Hyperspectral dense coverage of the Mackenzie Delta is needed due to budworm infestation, especially between 15 to 30 July where peak defoliation occurs.

Sahtu communities have been making measurements focused on lake ecology in these regions, and especially around Great Bear Lake and UNESCO's approved Tsá Tué Biosphere Reserve (a 9.3 Mha portion of the Great Bear Lake watershed within the Délįnę District) with an online database for all spatial data and maps for their regions. Great Bear Lake is an area of interest as it was described as the largest remaining pristine lake on the planet. This region serves as a late summering ground (at Caribou Point) for the Blue Nose East herd. Prism thermal and infrared imaging tools currently capture lake surface temperatures and multi year ice thawing inferences for this area. GNWT's Slave Province Surficial Materials and Permafrost study—collecting geochemical data and ground temperatures—also acquires remote sensing for this region. Further, baseline information to inform development decisions regarding the shale oil play in the region is needed. Documenting field locations in these areas for research led by the GNWT could be used to warrant adjustments to ABoVE's airborne transects to include this area.

2. Tundra Ecosystem Research Station (Daring Lake)

Daring Lake supports a wide range of research and monitoring activities and is in an excellent position to provide ground support to the ABoVE airborne campaign. At Daring Lake, there is a focus on experimental monitoring, with an interest in mapping ecosystems at appropriate scales relevant to wildlife home ranges to allow for applications in managing wide-ranging wildlife species. For example, ecosystem mapping using vegetation characteristics (e.g., cover) of caribou calving and expanding to other home ranges could be identified and

extended toward larger ranges. Pathogens affecting wildlife are also affected by environmental conditions (e.g., wind speeds, temperature, soil moisture). These abiotic variables could be measured using ABoVE's remote sensing tools. Some of the tools available from the ABoVE Airborne Campaign (e.g.,UV-3719 Gigahertz-Optik (SWE)) would provide key data to inform wetland mapping and hydrologic function, and these data could be validated by ground observations centred on Daring Lake. LiDAR technology would be particularly useful in mapping shrub heights for these applications if also supported by ground validation and potentially higher scales provided by unmanned aerial vehicles. Airplane-based carbon flux could also be measured but it is unclear if these tools are currently available.

There is an ongoing need for funding support and technical expertise to synthesize and deal with remotely sensed spatial data, as well as model environment and wildlife linkages. As a solution, workshop participants proposed Daring Lake as a model pilot site for long-term ecosystem experiments, fostering data synthesis and integration. This research initiative would bring together over 20 years of research and monitoring information by government, academic, and industry groups. POLAR could potentially support current and forthcoming monitoring to fill in knowledge and research gaps.

3. Wetland mapping

As discussed for Daring Lake, sensors to be used for the ABoVE Airborne Campaign are very useful for wetland mapping and hydrologic characterization. Linking to satellite data, the airborne data provide the opportunity to map and characterize wetland typology and distributions over broad areas of the Slave Geological Province and Northwest Territories. A tentative partnership has evolved between the GNWT, POLAR, Ducks Unlimited and the Canadian Wildlife Service to address this opportunity in wetland areas. There are opportunities to support waterfowl habitat change studies based on U.S. Fish and Wildlife Service and Canadian Wildlife Service high arctic surveys (around Cambridge Bay, extending from Gjoa Haven to Taloyoak, and including Government of Nunavut field data at Kugluktuk). Great Slave Lake in particular serves as a candidate location for a more intense peat inventory (Bourgeau-Chavez 2015) and candidate Forest Management Area sites in partnership with the GNWT could be added. The Edéhzhíe study area—sponsored as a candidate National Wildlife Area by the Canadian Wildlife Service— is also in this region where vegetation mapping and complete documentation of the area's ecological, cultural, and economic value takes place (Edéhzhíe Candidate Protected Area Working Group 2009). Ongoing research is also occurring in the region led by Wilfred Laurier University and GNWT to investigate areas for future hydro generation potential.

Airborne remote-sensing data could be used to leverage and pool existing mapping efforts to produce wetland mapping and data on methane (and potentially hydrogen) sequestration, storage, and exchange. Airborne flight line positions (e.g., dual camera and video GPS at 1000 feet) could also be maximized to link fire and vegetation build-up (under lines) impacts on water-flow based hydrology, hydrogeology, and changing snow conditions to effects on permafrost changes and wetland function. This would require integrating multiple resources to create a single base layer map that incorporates the different pieces (e.g., methane exchange, carbon sequestration, etc.), which might be a challenge. However, once in place, this base layer could open up the potential for wide-ranging research and management applications.

4. Manitoba to Nunavut Hydro Transmission Line

Improved data that could be supplied by the ABoVE Airborne Campaign are needed along a proposed hydro electricity transmission corridor between Churchill, Rankin Inlet and Baker Lake. Current projects include the collection of information on geochemistry, permafrost, soils, and linkages to community-based IQ and TEK studies run by hunters and trappers organizations to understand and predict changes in wildlife habitat, availability, and impacts on food access and security. An integrated approach to improving baseline data on

modeling water hydrology, caribou distributions, infrastructure impacts from permafrost degradation would inform engineering infrastructure for road and hydro line development and improve ongoing (and forthcoming) management plans. Benefits to NASA-sponsored researchers for the ABoVE Airborne Campaign would be the collection of field data required for calibration and validation of remote sensing data products. In addition, collection of soil data would have value for modeling studies of soil biogeochemistry.

There are also opportunities through partnerships to assemble strong baseline data in advance of proposed mine development. Known active and proposed mines and a hydro electricity transmission corridor from Churchill to Rankin Inlet to Baker Lake suggest an airborne line transect along the west side of Hudson Bay would be useful in collecting these baseline data.

5. Snow and monitoring sites

The Snow Survey Monitoring Network run by the GNWT Water Resources Division measures snow volume (later converted to snow-water equivalent) at the end of season (April) at 10 sites across the Northwest Territories to allow for annual comparisons, but data are very limited. It is unknown why these sites were selected, though some sites were selected based on forestry sites and hydroelectric facilities that are in place. There is a need to further support and build this network. In addition, data are currently not publicly available, hampering research and management applications. There is a need to develop strategies to leverage data (e.g., procurement process, licensing, incorporating existing protocols, etc.) so that it could be made available for decision-making and management. A collaboration with NASA's ABoVE Airborne campaign and POLAR could provide an opportunity to augment existing efforts.

Feedback on POLAR and ABoVE's planned activities

During the workshop, specific feedback was given regarding both POLAR and ABoVE's research and monitoring plans. Key points are summarized as:

- There is a need for funding to be available for the Canadian academic community to fully participate and leverage the NASA ABoVE campaign;
- There was support for, and desire to emphasize, not only research and monitoring of functional components of ecosystems but the historical baselines needed to provide greater context and understanding of the pace of change relative over time.
- The projects should also emphasize focus on temporal nonlinear dynamics, by incorporating temporal legacies in the context of spatial, non-linear cascades. Dynamics could be coupled across space and time on multiple projects.
- There needs to be more focus on examining the vulnerability of northern communities in the face of change to help inform effective adaptation strategies.

NEXT STEPS

This workshop addressed all of its objectives and was successful in initiating direct engagement with many potential northern partners, communities, academia and industry towards establishing some targeted, collaborative projects that leverage existing and planned research and monitoring in the region (including from both POLAR and NASA). In this context, ABoVE's planned activities could certainly provide data with broad applications in research and monitoring. As a first step, methods of standardizing data and making data publicly accessible will be necessary for collaborative work; these efforts will bring awareness to and encourage support for further collaborative research projects. ABoVE and POLAR, with its partners, will encourage researchers to work closely with local communities to address their interests. This includes exploring changes in funding criteria

and the definition of 'high-qualified person' to be broader in its scope, reflecting the high qualifications of many Traditional Knowledge holders. Strong collaborative networks will be invaluable in informing and more closely monitoring changes in the boreal region of the arctic in support of more sustainable management.

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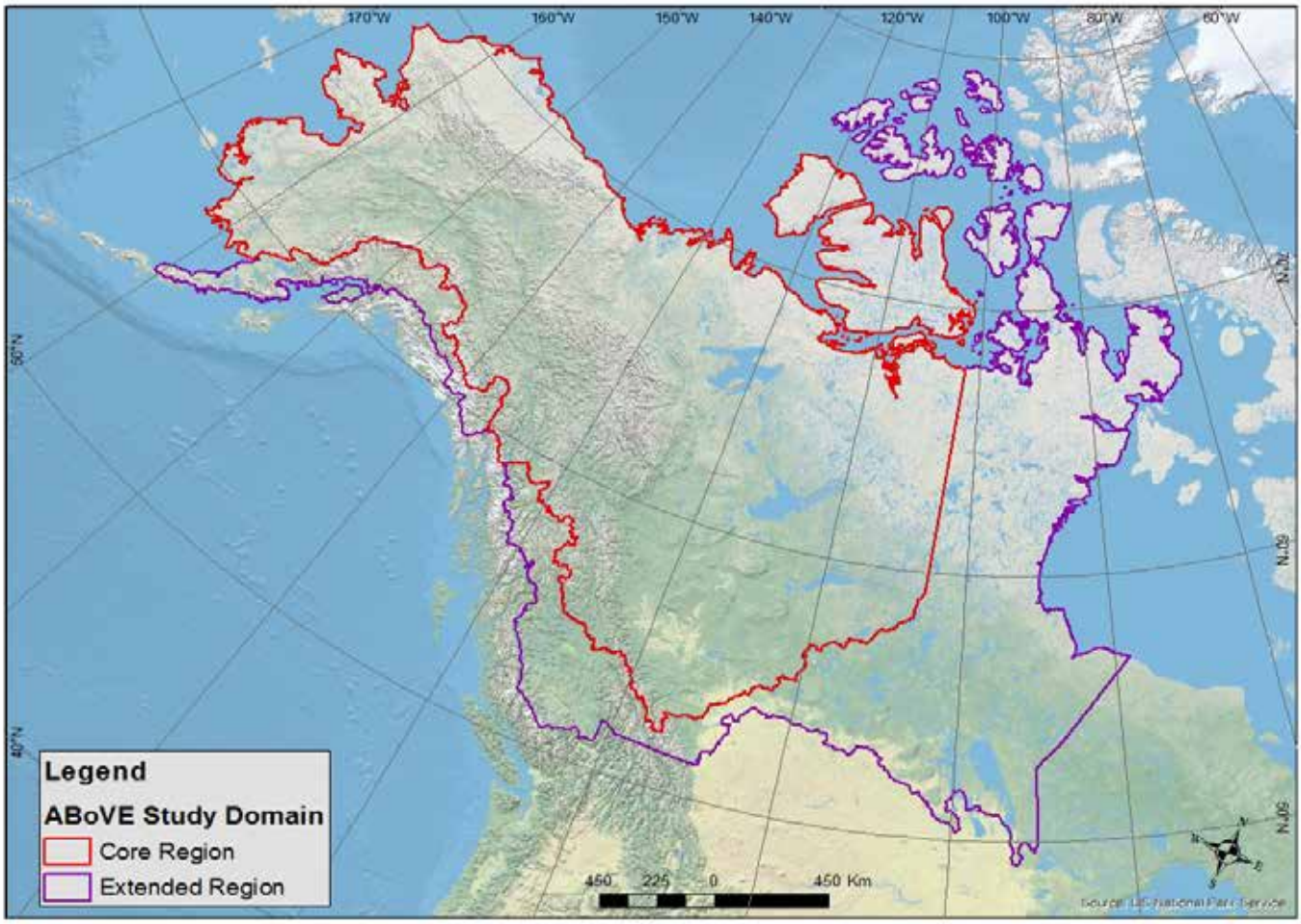
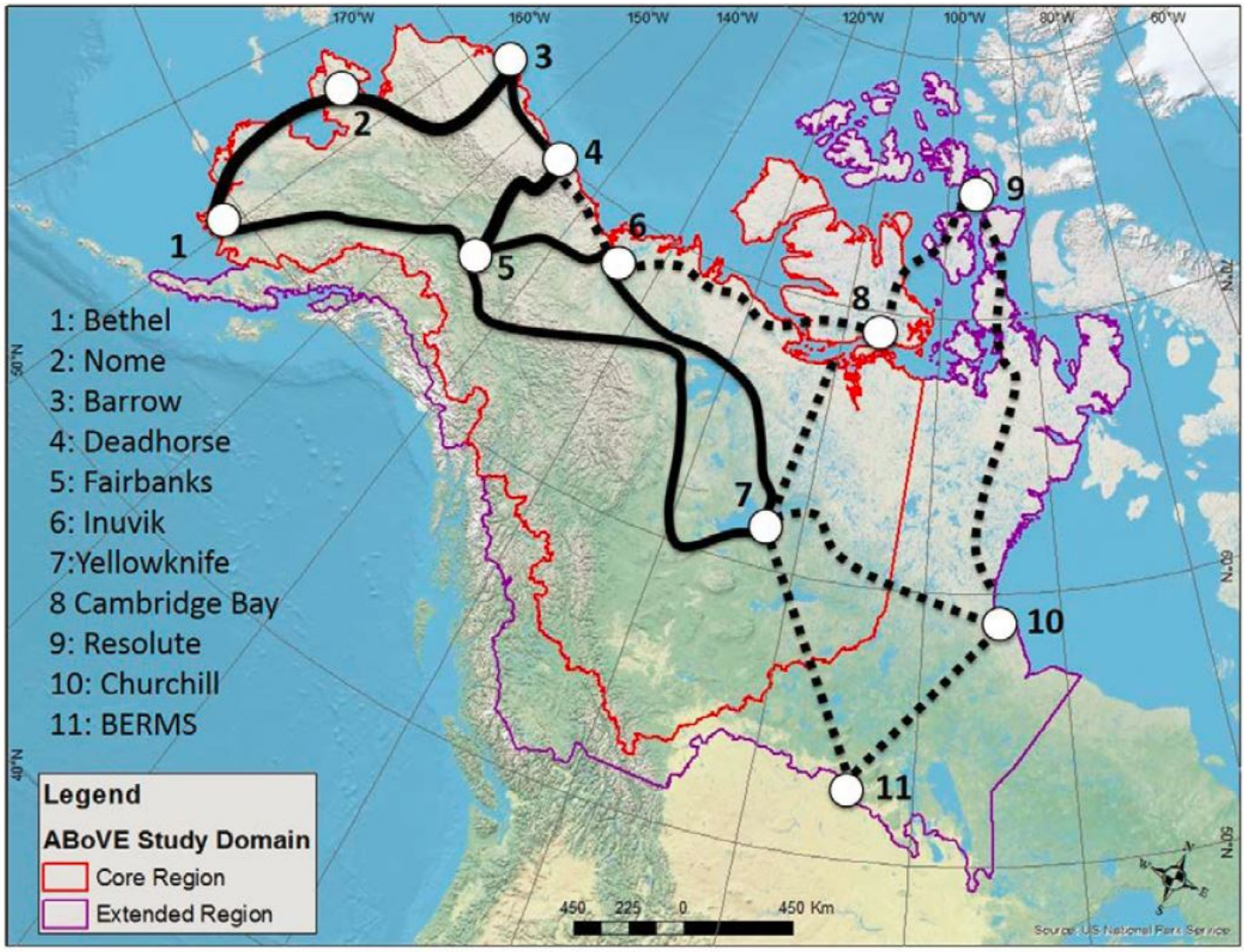
Appendix 1: The ABoVE Study Domain



Appendix 2: Map of Proposed Foundational and Supplemental Flight Lines for the ABoVE Airborne Campaign



Appendix 3. Agenda for Joint Polar Knowledge Canada/NASA Arctic-Boreal Vulnerability Experiment/ Government of Northwest Territories Workshop

The Explorer Hotel, Yellowknife, NWT, May 10th to 12th, 2016
(Katimavik B for May 10-11 and then next door in Katimavik C for May 12)

Workshop Objectives:

- identify key management/research needs and questions
- exchange information on ongoing and planned research and monitoring
- solicit feedback on the POLAR Integrated Research and Monitoring Plan and planned ABoVE activities
- identify best practices for engaging and including communities and Indigenous Knowledge holders in research/monitoring activities
- explore collaboration opportunities in the context of ongoing monitoring and research and management/ research questions

TUESDAY MAY 10:

Identifying Research, Monitoring and Management Needs and Activities

8:00 to 9:00	Registration (at the Explorer Hotel)
9:00 to 9:30	Welcome and Opening Address (Chief Ernest Betsina, Chief of N'dilo, Yellowknives Dene First Nation and Ernie Campbell, Deputy Minister for Environment and Natural Resources)
9:30 to 9:45	Introductions; Review of Workshop Objectives; Day 1 Objectives
9:45 to 10:15	Overview of POLAR's Integrated Research and Monitoring Plan (Donald McLennan and Mike Gill, Polar Knowledge Canada)
10:15 to 10:45	Overview of ABoVE's Implementation Plan and Planned Activities (Eric Kassichke, NASA)
10:45 to 11:15	**Coffee Break**
11:15 to 11:45	GNWT - Research, Monitoring and Management Needs and Activities (Andrew Applejohn, GNWT)
11:45 to 12:15	GNU – Research, Monitoring and Management Needs and Activities for Nunavut's West Kitkmeot and Slave Geological Province (Lisa-Marie Leclerc, GNU)
12:15 to 13:15	**Lunch**
13:15 to 13:45	Aboriginal Perspectives - Research, Monitoring and Management Needs and Activities (Amy Amos, Gwich'in Renewable Resource Board; Deborah Simmons and Leon Andrew, Sahtú Renewable Resource Board)
13:45 to 14:15	Government of Canada – Boreal Research, Monitoring and Management Needs and Activities (Catherine Ste-Marie, Canadian Forest Service)
14:15 to 14:45	Industry - Research, Monitoring and Management Needs and Activities (David Wells, Rio Tinto)
14:45 to 15:15	Taiga Research Opportunities Linked to ABoVE: Opportunities and Challenges in the Academic Sector (Merritt Turetsky, University of Guelph)
15:15 to 15:45	**Coffee Break**
15:45 to 16:15	Tundra and Taiga Academic Research – Research and Networking Needs (Phil Marsh, Wilfred Laurier University)
16:15 to 16:30	Plenary Wrap-Up and Overview of Day 2
17:00 to 19:00	**No host bar – continue networking**

WEDNESDAY MAY 11

9:00 to 9:15 Overview of Day 2 Objectives

9:15 to 11:30 Discussion Map Stations based on Key Research Themes (**including Coffee Break**)

11:30 to 12:00 Report Back from Map Stations and Declare Interest Groups for Breakout Sessions

12:00 to 13:15 **Lunch**

13:15 to 13:30 Breakout Group Instructions

13:30 to 16:00 Breakout Group Discussions (**including Coffee Break**)

16:00 to 17:00 Report Back from Breakouts

THURSDAY MAY 12

9:00 to 9:30 ABoVE Science Cloud (Peter Griffiths, NASA)

9:30 to 10:00 ABoVE Airborne Campaign (Chip Miller, NASA Jet Propulsion Lab)

10:00 to 10:30 **Coffee**

10:30 to 11:30 Plenary Discussion on Next Steps for Developing Specific Collaborations

11:30 to 12:00 Next Steps and Closing

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