VEGETATION MAPPING IN THE KIVALLIQ USING DIGITAL LANDSAT TM 5/7 DATA

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INTERIM REPORT
TO THE NUNAVUT WILDLIFE MANAGEMENT BOARD
(Project # 5110-04-1)

Prepared by: The Department of Environment
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Title: Vegetation mapping in the Kivalliq using digital Landsat TM 5/7 data.

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Project Summary:

The Kivalliq Habitat Mapping project began as a pilot study in July/August 2000. The pilot study was successful initiating the projects expansion to cover the entire Kivalliq Region. From August 8-14th 2000, approximately 200 plant communities in the Banks Lake study area were visited and plant type and percent cover recorded. During August 2001 160 sites were visited and plants and their percent cover values recorded in the Tehak Lake area. During August 2002 240 plant communities were examined in the Beverly lake area and 65 sites in the Lyon Inlet area, again in August 2003 240 sites in the Lyon Inlet area were sampled, in 2004 600 sites were sampled in the Baker Lake, Rankin Inlet and Snowbank River areas, while in 2005 presently 450 plant communities were sampled in the Princess Mary Lake and Brown Lake areas. Currently 550 sites were sampled August 2006 in the Henik, Edehon, Nulitin, Maguse and Hicks Lake areas south to the Manitoba border. (Figure 1).

A final classification of habitat types in the Banks Lake area, based on information recorded in the field, resulted in the identification of 27 distinctive habitats to a precision of 95%, far above the minimum accepted precision of 75-80% set prior to the initiation of this study (Figure 2). All additional sense up to the 2006 field season (not including the Henik, Edehon, Nulitin, Maguse and Hicks Lake scenes) have been completed with associated habitat maps.

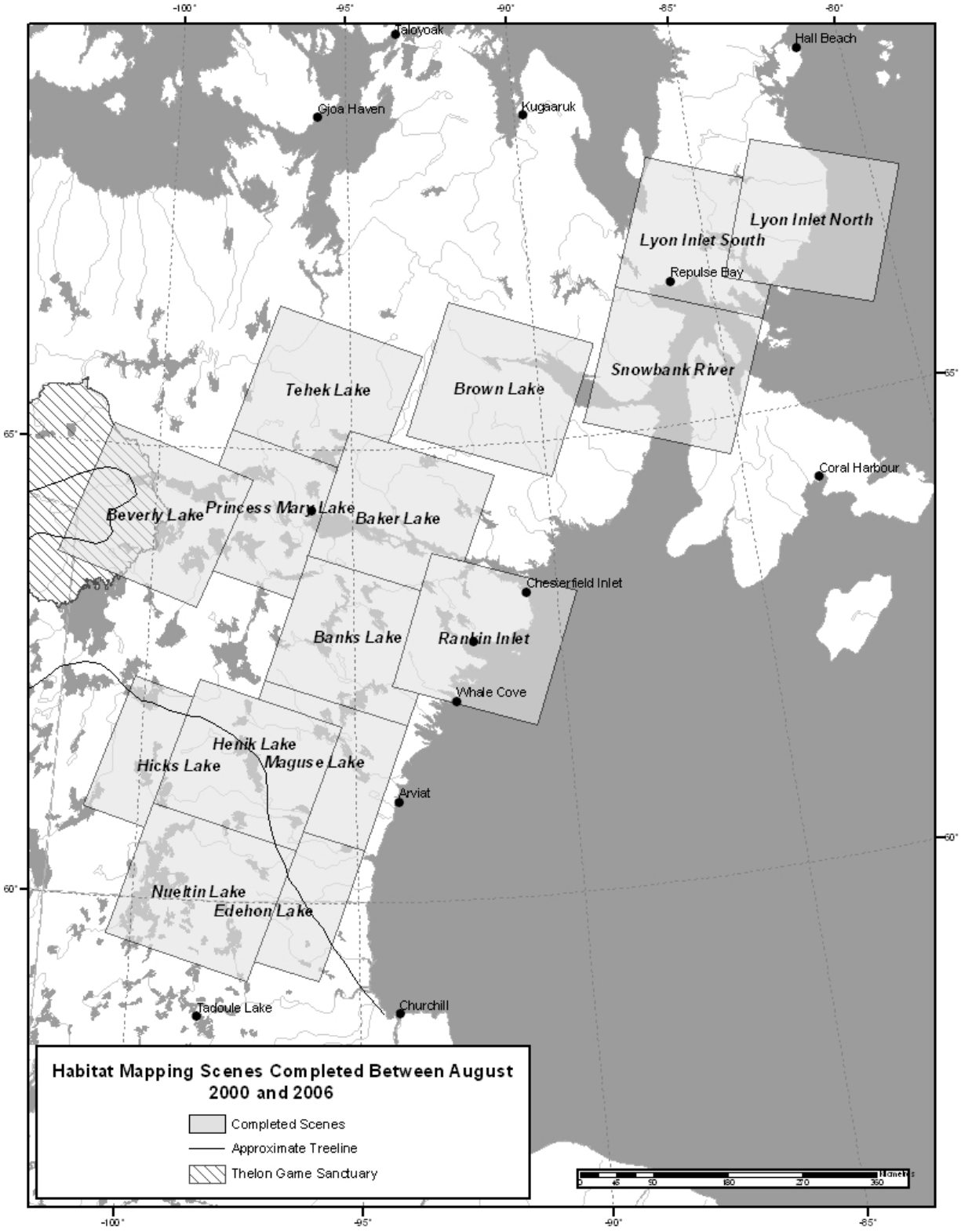

Figure 1 Landsat 7 and Landsat TM scenes sampled as of August 2006.

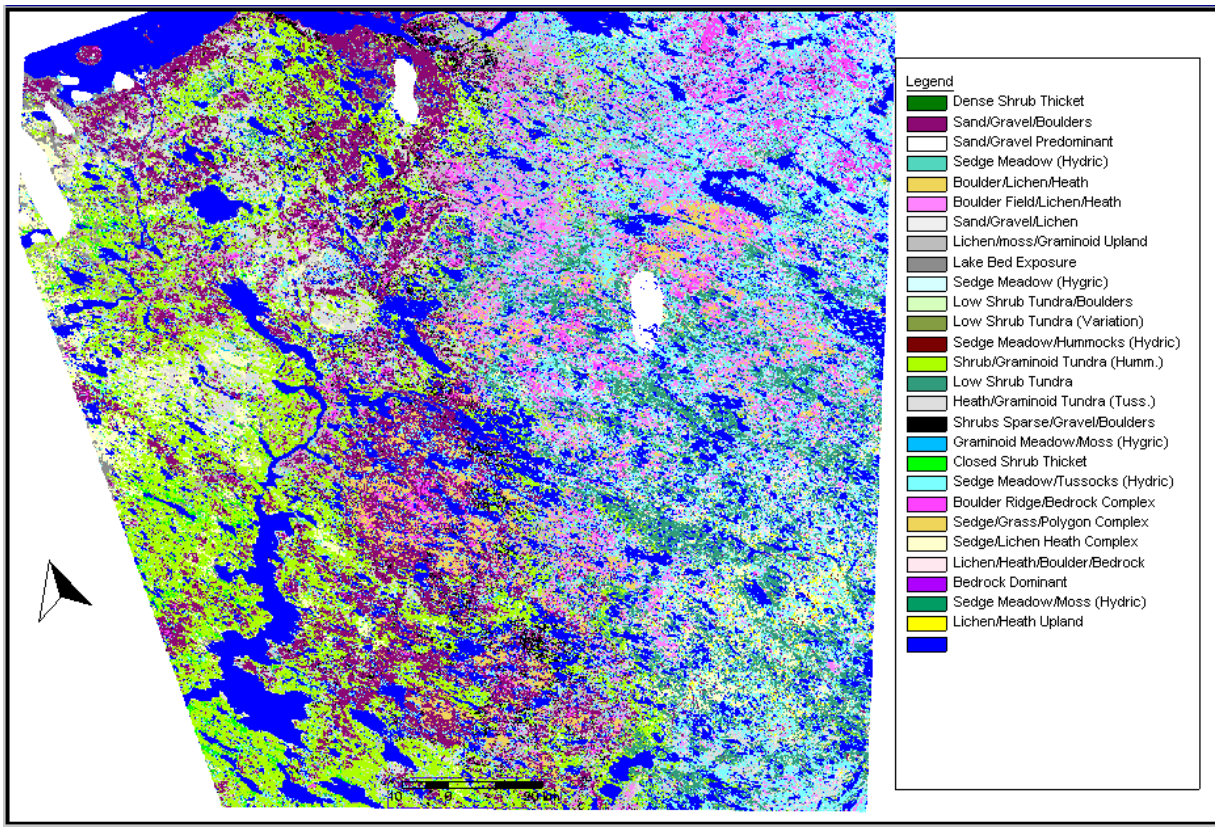

Figure 2 A classified habitat map of the northwestern portion of the Banks Lake scene. Baker Lake is in the upper left corner of the image. The Qamanirjuaq calving grounds lie roughly in the center of the image.

The Kivalliq Region is presently not in a position to respond proactively or cost effectively to wildlife crisis pertaining to ecosystem health, or the potential impacts of water and land use applications on the present and future status of wildlife habitat. As various demands on wildlife habitat heighten, we can predict with confidence that more and more information will be necessary to evaluate and mitigate the impacts. The maintenance of viable wildlife populations with high sustainable yields will require escalation in our attempts to understand, quantify and protect wildlife habitat. The identification of vegetation classes important to wildlife coupled with a map displaying the size and location of these vegetation classes will assist wildlife managers in their assessment of the potential impacts of land use on wildlife through the modification and/or destruction of their habitat. Strip and/or open pit mines, water development projects, urban expansion, pipelines, road constriction, chemical contamination, noise pollution etc. are on the increase across Nunavut a trend that will only intensify with time. We need to provide managers with more sophisticated ecological tools to deal with the increased pressures placed on wildlife habitat if wildlife and their habitats are to be conserved for future generations to enjoy. The proposed research for the 2007/08 field season will analyze plant type and percent cover for 2 digital satellite images in the Dubawnt, Tulemalu and North Henik Lake scenes areas known to be used by both the

Qamanirjuaq and Beverly Herds of barren ground caribou. These areas are also thought to provide habitat to barren ground grizzly bears wolverine and muskox.

Background:

The use of digital landsat imagery to map arctic vegetation is a familiar idea that has only recently moved from the realm of experimental trials to a reliable cost effective tool. This technique has proven its ability to distinguish broad vegetation classes on the basis of their differing spectral characteristics (Thompson et al, 1980: Wakelyn, 1990; Mosbech and Hansen, 1994: Joria and Jorgenson, 1996; Robinove, 1981; Pearce, 1991; Markon and Derksen, 1994). The importance of vegetative communities to wildlife populations is clear. Despite this clarity, increased demands for renewable and non-renewable resources have and will continue to conflict with the conservation of wildlife habitat. These conflicts are in-turn amplified by wildlife management practices that lack the tools necessary to resolve issues pertaining to the identification and protection of important wildlife habitat, the foundations of which are composed of plant communities (Gray and Donihee, 1983; Scotter, 1980; Thompson et al, 1980).

Successful vegetation classifications have been carried out using a variety of remote sensing techniques including high resolution aerial photography and the lower resolution multi spectral satellite imagery of SPOT (using a HVR system – high resolution visible sensor system), Landsat 5 and 7 (Thermatic Mapper) and Landsat MSS (Multi spectral scanner). The choice of method depends primarily on desired resolution. Landsat 5 and 7 utilizes up to 7 spectral bands (4 more then SPOT images) and as a result has a greater capacity to separate vegetative classes on the basis of their spectral signature (Wakelyn, 1990: Pearce, 1991; Mosbech and Hansen, 1994; Joria and Jorgenson, 1996; Thiesenhausen and Veitch, 1998; Robinove, 1981). It is for these reasons the proposed study is recommending the use of Landsat 5 and 7 data as the medium for the stratification of broad vegetation classes across the Kivalliq Region.

A wildlife location database developed from aerial surveys, sighting data, classification data and satellite telemetry data, when used in combination with a digital vegetation database and spatial analysis software, will provide insight into habitats important to caribou, muskox, barren ground grizzly, wolverine as well as other species of wildlife. This information in-turn can be used to steer land use activities in an informed, conservation minded direction. The establishment of protected areas will also rely on this type of integrated knowledge base.

Objectives:

The objectives of the project are to utilize digital Landsat 5 and 7 imagery to stratify and map terrestrial habitats of the Kivalliq Region into approximately 20-30 classes (15-20 vegetation classes and 5-10 abiotic (non-living) classes such as boulder fields, water

etc.). The digital database (vegetation map) resulting from the proposed analysis will be used in association with GIS (Geographical Information System) software to:

1) Locate and Quantify Important wildlife habitats: *Biological rationale:* Habitat quality, quantity and availability largely govern the distribution and abundance of many ecologically and economically important species of wildlife. It is increasingly clear that migratory caribou populations are regulated by the abundance of high quality forage on their calving grounds. An understanding of the locations and size of distinct vegetation classes containing high quality forage and how these classes relate to wildlife will be critical to a manager's assessment and prediction of a population's status.

2) Provide Inter-jurisdictional and Jurisdictional Management Boards and Wildlife Biologists with a tool to make informed decisions concerning land use impacts on wildlife habitat: *Biological Rationale:* The identification of vegetation classes important to wildlife coupled with a map displaying the size and location of these vegetation classes will assist wildlife managers in their assessment of the potential impacts of land use on wildlife through the modification of their habitat. Strip mines, water development projects, urban expansion, pipelines, road constriction, chemical contamination, noise pollution etc. are on the increase across Nunavut a trend that will only intensify with time. We need to provide managers with more sophisticated ecological tools to deal with the increased pressures placed on wildlife habitat if wildlife and their habitats are to be conserved for future generations to enjoy.

3) Be better prepared to respond to the root of wildlife crisis through an initial analysis of habitat condition and availability in a logistically efficient and cost-effective manner: *Biological Rationale:* Presently habitat analysis in the Kivalliq is logistically difficult and financially restrictive. Stratifying terrestrial habitats into broad vegetation classes will ease logistic and financial constraints by providing biologists with the ability to sub-sample representative strata rather then face the daunting task of randomly sampling an entire study area, which in the case of the Qamanirjuaq caribou range, is some 300,000 Km^2. Having this kind of information at the ready will also shorten response time to a perceived crisis and allow for greater focus. Successful planning for wildlife and habitat management is contingent upon an adequate database, and a process to utilize that database.

Application of Results:

The habitat map produced following the completion of the proposed research will be used to associate specific habitat types with the many species of wildlife found in the Kivillaq. This will be achieved using location data from past and present wildlife surveys, observations from hunters and research staff and satellite collar location data. The product of this association will be an index of habitat importance based on past and present observations of various species of wildlife within each of the assigned vegetation classes. This index of importance can then be used to assess land use issues based on the type, size and importance of the habitats being affected. Making

this information available at the community level remains a key component of the goals of this research. This will allow the communities of the Kivalliq to have the necessary information at hand to make informed decisions on the potential implications of resource developments and climate change within their traditional hunting areas.

Study Area:

To date fieldwork has been concentrated within or adjacent to known caribou calving areas including Banks Lake area, Tehek Lake area, Beverly Lake vicinity and the Lyon Inlet area, Rankin Inlet, Snowbank River, Baker Lake, Brown Lake and Princess Mary Lake areas, as well as known migratory corridors, rutting areas and post-calving areas (Figure 1). Proposed research will continue until the entire Kivalliq has been mapped on or about August 2008.

Project Design:

Digital Landsat 5 and 7 images will be used to classify between 15 and 20 vegetation classes and 5 to 10 abiotic (non-living) classes such as rocky outcrops, boulder associations, water, gravel ridges etc. The Kivalliq images (scenes) will be chosen based on the following specifications: The images must have been taken between June 20th and August 15th to capture vegetation in full leaf, cloud cover within the scene should not exceed 5% and only the most recent images should be used. Images meeting this criterion will then be geo-corrected using 1:250,000 scale NTS base maps. Bands 5(mid-infrared), 4(near-infrared), 2(green) and 3(Red) will be used to determine spectral differences between vegetative classes. Vegetation classes will then be allocated using the following methodology: *A* – *Establish training sites*: Training sites (sites chosen on the imagery to be investigated on the ground using a Bell 206B rotary wing aircraft to access sites) will be selected from a color composite of the Landsat 5/7 scene and plotted on a 1:250,000 geo-corrected satellite image; *B* – *Ground Truthing*: A minimum of 150 training sites per scene, systematically chosen based on their homogenous spectral attributes, will be analyzed as to plant type and cover value (%) using a Bell 206B helicopter (Thiesenhausen and Veitch, 1998); *C* – *Supervised Classification*: Information collected during the ground truthing phase will be used to assign vegetation attributes to spectral classes (i.e. groups of pixels with similar reflective values) using image analysis software. This process will continue until a minimum accuracy of 80% is achieved (Thompson et al, 1980; Mosbech and Hansen, 1994; Wakelyn, 1990*); D* – *Enter digital Database into GIS software for access and analysis:* Digital vegetation maps will be used as a layer amongst other layers (e.g. a point layer of satellite collar locations, topography etc.) in order to analyze the vegetation classes as wildlife habitat.

Results:

Habitat Mapping 2000 to 2005

During August 8-14th 2000, approximately 200 pre-classified sites in the Banks Lake study area were ground-truthed. Supervised classification of the Banks lake scene (based on the results of the ground-truthing) resulted in the identification of 27 biotic and abiotic habitat types to a precision of 95% far above the minimum accepted precision of 80% (Figure 2). Amalgamation of the classification data with caribou satellite collar data, hydrological data, and weather data into a user-friendly format within a GIS software package is ongoing.

As of June 1st, 2001 satellite imagery of the Tehek Lake area had been purchased and geo-corrected. A total of 160 vegetative sites were ground-truthed in the Tehak Lake area in August 2001. Initial analysis of the Tehek Lake data sheets suggests that habitat classification accuracy will be similar to that of the Banks Lake study area (Figure 3).

Over the 2002 growing season a late spring delayed both calving caribou, green-up and flowering across the region. Vegetation mapping was on hold until late July when warm temperatures and sunshine allowed plant growth to make up for lost time. By August 1st plant communities were at full flowering allowing the mapping program to proceed. Over 200 plant communities were analyzed throughout the Beverly Lake scene between August 3rd and 8th/2002 (Figure 4). The second scene planned for 2002 was the Lyon Inlet scene. Though late in the season an attempt was made to ground-truth the entire scene August 17th/2002. Unfortunately an early frost coupled with the short growing season made ground-truthing difficult and, following the analysis of 61 plant communities the decision was made to complete the scene in July and August 2003. In addition to completing the Lyon Inlet scene two additional scenes are planned for areas north and south of Wager Bay in 2003. These areas encompass the calving grounds of the Lorillard and calving areas of the Wager caribou populations.

Observed differences between the Lyon Inlet scene and other scenes sampled thus far include a dramatic decrease in dwarf birch (*Betula glandulosa*) cover values and a dramatic increase in arctic heather (*Cassiope tetragona*) cover values (Figure 5). This general vegetative change begins on the north shore of Wager Bay and becomes more obvious as you proceed north to Repulse Bay.

The Lyon Inlet scene was completed in early August 2003 (Figure 6). The growing season was normal in 2003 and flowering was at its peak early August when the ground truthing took place. A total of 240 sites were ground truthed making the total for the Lyon Inlet scenes of approximately 300. Due to a malfunction of the forward motion compensator on landsat 7 images no other images were available for the area and as a result the Lyon Inlet scenes were the only ones completed in 2003/2004. The malfunction on the satellite was not rectified and Landsat 5 images of the same configuration minus a high resolution black and white band were used during the selection process.

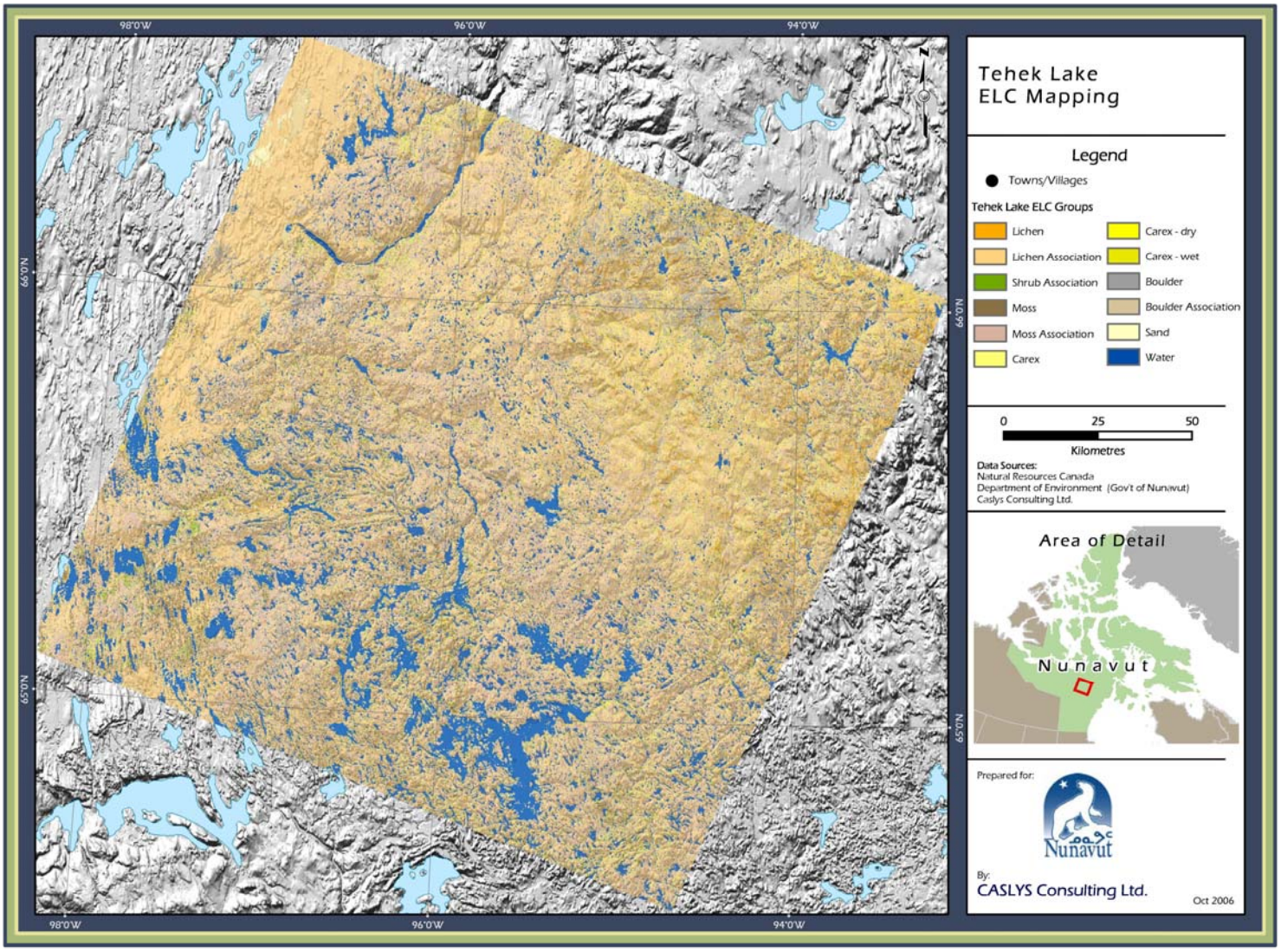

Figure 3 A first draft of the Tehek Lake habitat map.

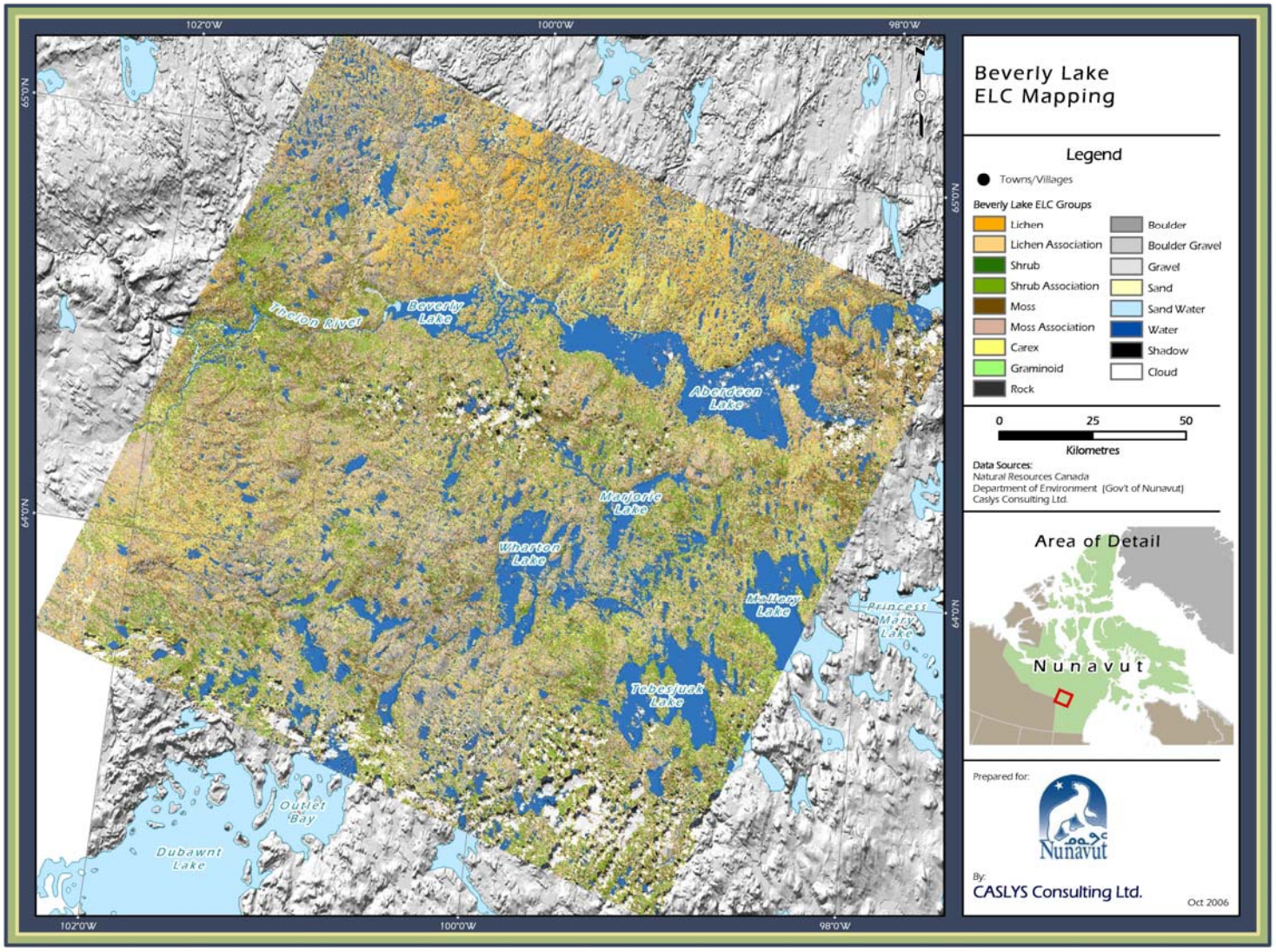

Figure 4 A first draft of the Beverly Lake habitat map.

A

B

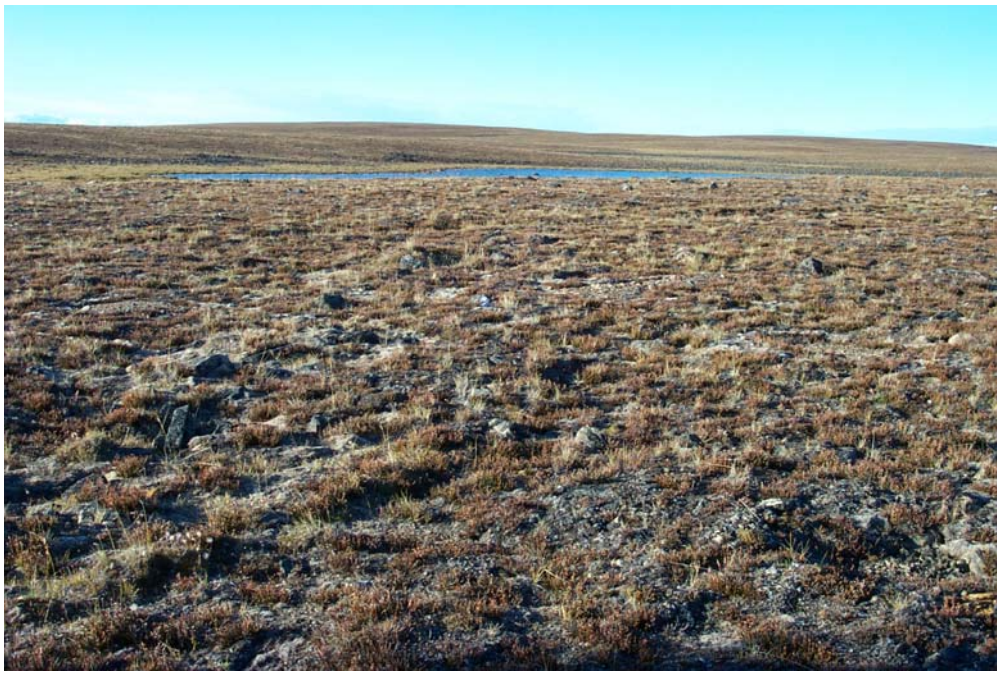

Figure 5 Dwarf birch (A) cover values decline and Arctic heather (B) becomes the dominant shrub north of Wager Bay.

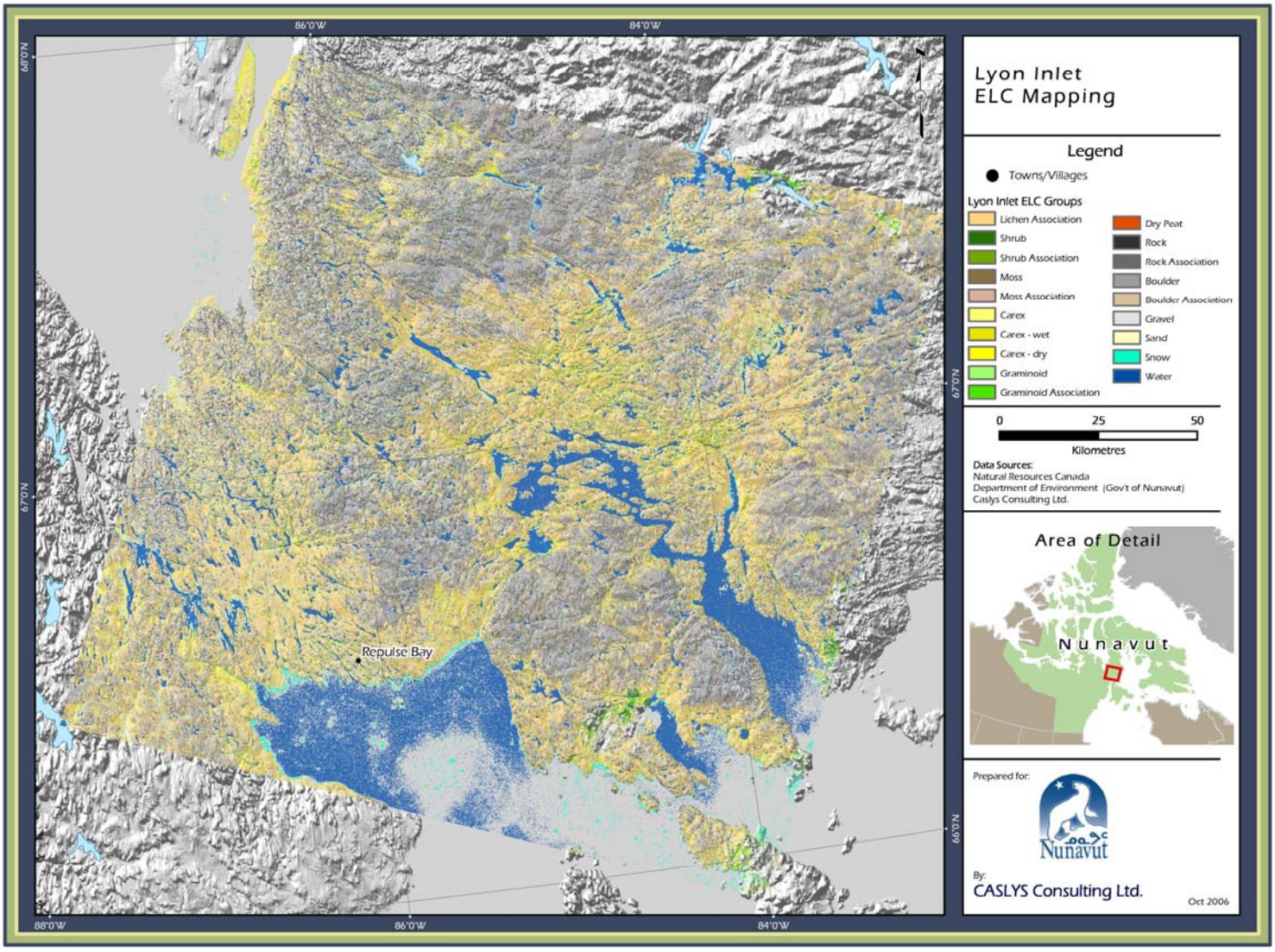

Figure 6 A first draft of the Lyon Inlet habitat map.

In July and August 2004 a total of 640 sites representing three Landsat 7 scenes were sampled in the Baker Lake Area, Wager Bay area and the Rankin Inlet area (Figures 7, 8 & 9). Though the growing season was short all three scenes starting with Baker Lake followed by Rankin Inlet then Snowbank River area (Wager Bay) were completed before the end of the growing season. Green up in the Snowbank River area was not ideal but as graminoide (grasses and sedges) seed heads were visible in over ninety percent of the communities, we preceded and managed to successfully complete the scene following a three-day wait. The completed Tehek Lake, Beverly Lake and Lyon Inlet habitat maps were used in preliminary buffer analysis using Arc View GIS software to determine seasonally preferred habitats during calving and post-calving. Though results are preliminary initial findings suggest that calving caribou tend to prefer rocky sites in association with shrub communities while during post-calving wetter habitats associated with wet graminoid meadows are preferred. A poster revealing a small component of this analysis was produced and distributed amongst all Kivalliq co-managers. The buffer analysis is on-going with an expected completion date for spring 2008.

In July and August 2005 a total of 270 sites representing two Landsat 7 scenes were sampled in the Brown Lake and Princess Mary Lake Areas (Figure 10). The conditions were wetter then in past years and as a result the growing season was delayed somewhat, however conditions for sampling the sites were well within set limits allowing the successful completion of both sites. The caribou point data analysis continues and integrates all newly completed habitat maps as well as new satellite collar location data into the analysis scheduled for completion spring 2008.A presentation of the information bases power to aid wildlife Management and monitor climate warming has been completed and the initial formate for conservation education materials developed. At present all sampled scenes with the exception of the 2006 field seasons have been developed into habitat maps though following the completion of the Snowbank River, Banks Lake, and Brown Lake scene maps target precisions, though meeting the 80% precision levels initially set, it was apparent that a cross over analysis (using sampling sites in the areas of overlap between scenes to enhance precision) would improve precision. As a result finalization of these maps has been delayed to allow for the additional analysis.

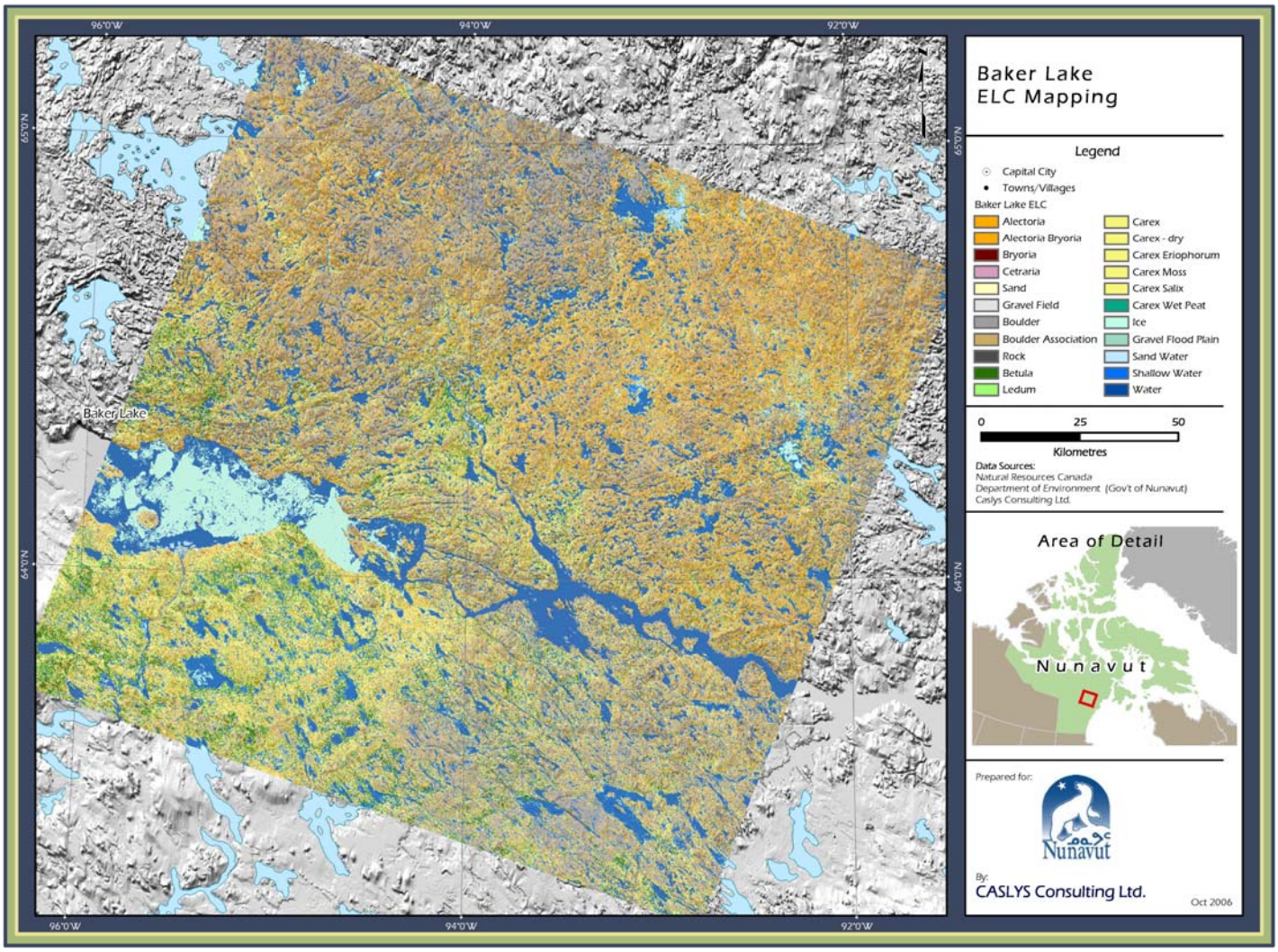

Figure 7 A first draft of the Baker Lake Habitat Map.

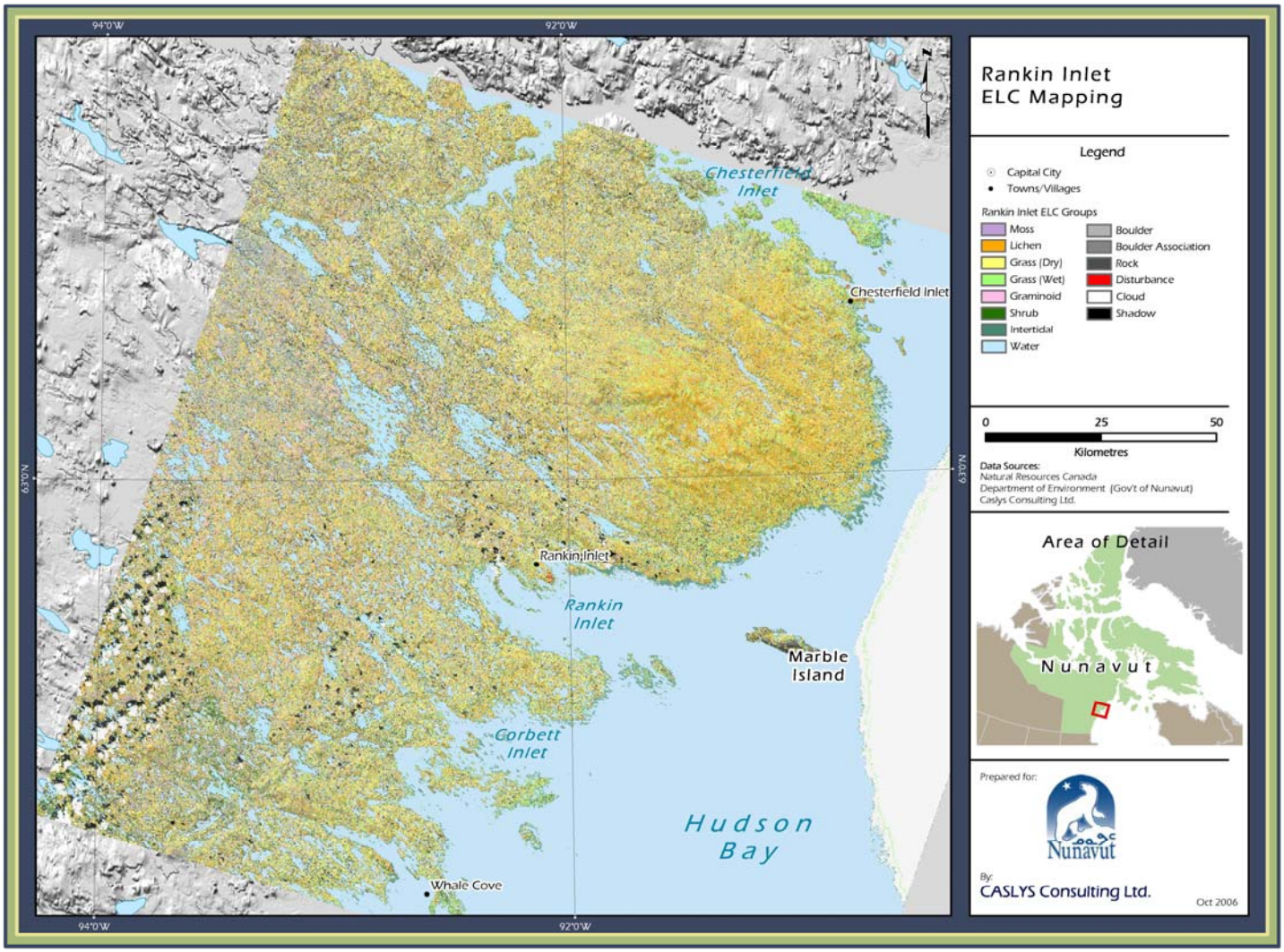

Figure 8 A first draft of the Rankin Inlet Habitat Map.

Figure 9 A first draft of the Snow bank River Habitat Map.

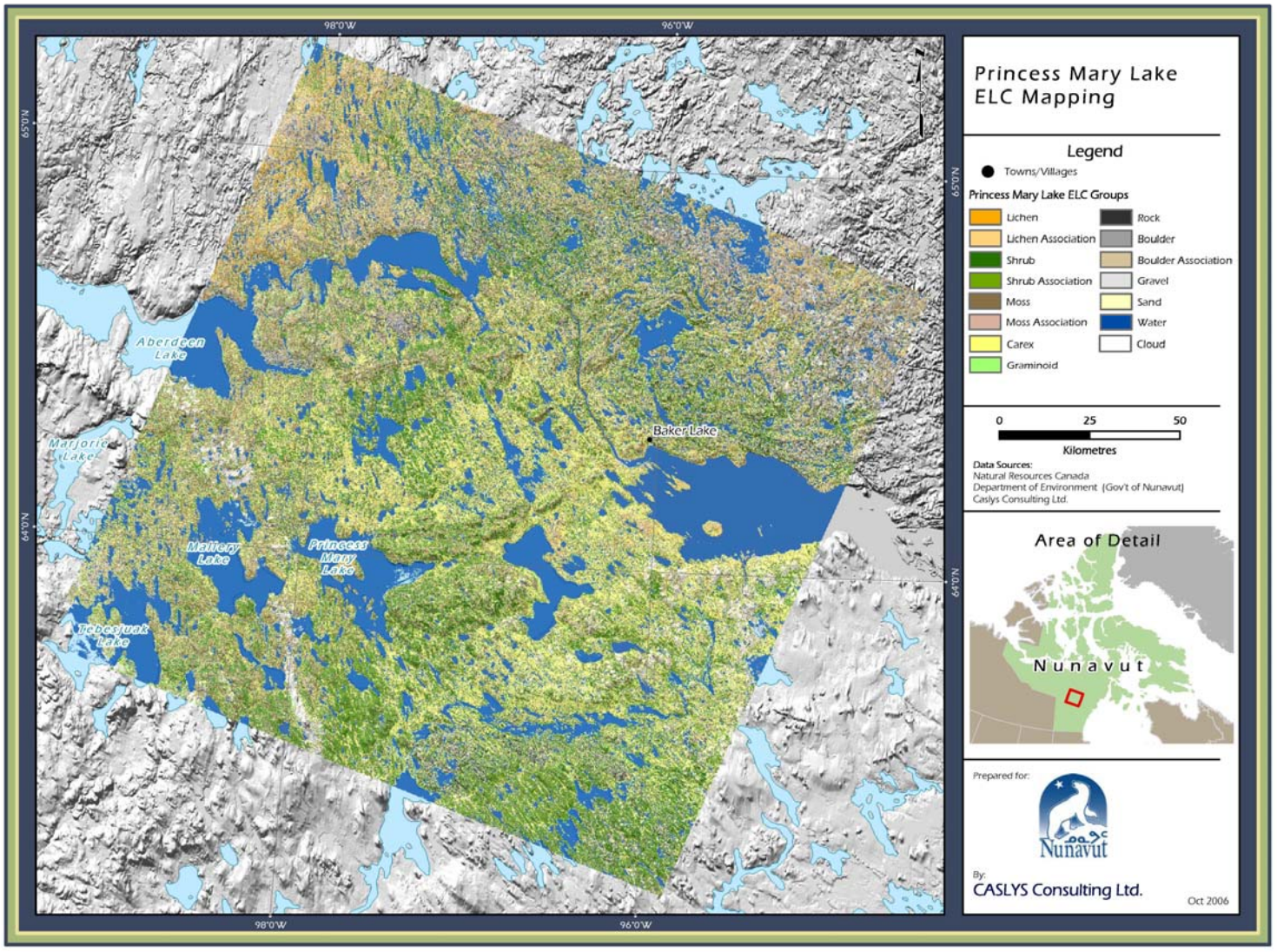

Figure 10 A first draft of the Princess Mary Lake Habitat Map.

Habitat Mapping 2006/07

The 2006 winter was one of the milder recorded within the last decade resulting in an early spring melt and prolonged growing season. Graminoides were in full flower by mid July and in seed by the end of July. Plant communities were considerably dryer then in previous years, an observation Likely due to the early spring melt, higher mid-summer temperatures and below average amounts of precipitation. The net effect particularly within the moister graminoide communities was a noticeable reduction in biomass though good identifiable cover values were realized. Also apparent was the general lack of forbs within drier sites though cover values of forbs within these habitat types typically vary from year to year a factor largely dependant on moisture but also the life history strategy of the plant species itself. A total of 550 sites were ground truthed within the Henik Lake, Maguse Lake, Hicks Lake, Nueltin Lake and Edehon Lake scenes (Figure 1). Data entry for these scenes is currently on going and expected completion date for the completed habitat maps will be early March 2007. In association with the Habitat Mapping project was the development of the Journey of The Caribou compact disk which in part analyzes important caribou range by using all available satellite collar location data. In addition animations are added to fulfill an early phase of the con-ed component of this and other Kivalliq research initiatives. Initial analysis using the digital habitat maps produced will be added to the disk in version 1.2 to be released September 2007. A more sophisticated analysis is ongoing with an expected completion date of spring 2008 and will be presented with all other pertinent data in the form of a DoE file report.

Management Implications:

The goals and objectives of this study are to create a database that includes vegetation type as its foundation but also includes, wildlife location data, hydrological records, weather records, geology, and topography, hunters observations. Through the use of GIS software this database will then be used to identify the biotic and abiotic characteristics of any geographic location and/or area within the Kivalliq Region and identify the components of these characteristics important to various species of wildlife. This procedure is on going with an expected completion date of spring 2008. This integrated database will then be used by Regional Wildlife Organizations and biologists to assess proposed land use activities in a manner that could predict, and as a result restrict or mitigate, negative impacts on wildlife and habitat important to wildlife, before they occur. Also, the information collected at numerous sites across the region over a range of many habitat types can be re-visited at some future date to document the effects of climate change and what these effects may mean to Nunavut's wildlife distributions and numbers.

Community Consultation and Reporting:

The communities of Baker Lake, Chesterfield Inlet, Repulse Bay, Coral Harbour, Arviat, Whale Cove and Rankin Inlet, through meetings with the Kivalliq Wildlife Board, have supported this project and have been provided status reports and a newsletter concerning project initiation and results, expected deliverables and completion dates. A copy of the study proposal has been circulated to all regional HTOs and The Kivalliq Wildlife Board for critical comment on the study design and objectives. Copies of the compact disk "Journey of The Caribou" have been provided to all Kivalliq HTOs, the KWB, the NWMB and all other co-managers and environmental impact assessors. Additional copies are being prepared to provide to all Kivalliq schools to integrate current Nunavut based wildlife research into their curriculum. Following the analysis each community will be revisited in order to explain the results and products of the vegetation analysis. All display material and verbal communication will be transcribed and/or translated to insure understanding and inspire informed debate. A presentation was given to the Kivalliq Wildlife Board in October 2003 and 2004 and members voted unanimously in support of the continuation of this research. The status of the project was discussed in September 2005 with individual board members indicating their support. Issues concerning wildlife habitat are considered a top priority by Kivillaq regional wildlife organizations as evidenced by the 2004 Nunavut Wildlife Management Boards research priorities setting meeting.

Schedule:

The program began with a pilot study in August 2000. The successful completion of the pilot project initiated the start of the project itself, which will run over an approx. 7-year period winding up the field component in August 2008. The completion of the Kivalliq composite habitat map will be expected approximately a year following the completion of the field component.

Anticipated Outputs:

1) DoE file report following the completion of all phases of the project. This report (including a completed vegetation map of the Kivalliq Region) will be provided to all Wildlife Management Boards, Regional Wildlife Organizations and HTO's.
2) A DoE conservation education compact disk and accompanying report to be provided to all co-managers and Kivalliq schools.
3) Annual progress/interim reports to supporting agencies.
4) The vegetation map produced will be related to important wildlife habitats, the effects of climate warming and will be used as a tool to determine the potential and real impacts of proposed land use activities. The product of this

research will be designed to empower Kivillaq communities with the information base necessary to make informed decisions regarding these issues.

5) Community meetings and/or radio shows explaining the results of the study and training as to how to use the vegetation map to better assess land use issues.

6) A Kivalliq Regional habitat map mosaic displaying up to 15 - 20 vegetation classes including a key relating seasonally important wildlife habitats to delineated vegetation classes.

Personnel:

Mitch Campbell, Regional Wildlife Biologist, DoE, Arviat, NU.
- project design and implementation, unsupervised classifications, supervising botanist.

Jonathon Pameolik, Regional Wildlife Technician, DoE, Arviat, NU.
- coordinator of project logistics, Botanical Technician.

Mike Setterington, Ecosystem Monitoring Biologist, DoE, Arviat, NU.
- Botanical Technician, project advisor.

Jason Shaw, GIS Analyst & ELC Specialist, CASLYS Environmental Consulting Limited, Victoria, BC.
- Training and final site classification.

Partners:

The Department of Environment Kivalliq Region is partnered with the Nunavut Wildlife Management Board, the Canadian Wildlife Service, Parks Canada and Kivalliq HTOs. A partnership has also been developed with the Beverly-Qamanirjuaq Caribou Management Board whose management plan incorporates Ecological Land Classification, is in strong support of the research. This project is also strongly supported by the Kivalliq Wildlife Board.

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Vegetation Mapping (2006-2007)

ITEM	TOTAL BUDGET	VENDOR	STATUS	EXPENDED	COMMITTED	STATUS
Aircraft Charters	**80000**	Northern Networks	Done	$71,088.70		
		Sila Lodge	Done	$2,327.92		
subtotal				$73,416.62	$0.00	$0.00
Contracts/Contributions	**37500**	Caslys Consulting	PO'd		$74,930.00	
		Caslys Consulting	PO'd		$3,567.30	
subtotal				$0.00	$78,497.30	$0.00
Fuel Purchase/Shipping/Cacheing	**25400**	Unaalik Aviation	Done	$0.00	$21,816.91	
subtotal				$0.00	$21,816.91	$0.00
Scientific/Field Equipt. disposable		Northern Stores	Items Received	$674.29		
subtotal				$674.29	$0.00	$0.00
Scientific/Field Equipt. Non-disposable	**2200**					
subtotal				$0.00	$0.00	$0.00
Travel & Accomadations	**10500**					
subtotal				$0.00	$0.00	$0.00
PROJECT TOTALS	**156600**			**$74,090.91**	**$100,314.21**	**-$17,805.12**