

## **Inuit Knowledge and Geospatial Ontologies in Nunatsiavut**

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## Abstract

There is an urgent need to document and share the extensive and valuable knowledge held by Inuit Elders and other Inuit experts with local Arctic decision makers, younger generations, and with members of the scientific community to better to understand pressures on and changes in these systems. In the context of ongoing and impending new development, there is a need to capture and communicate changes in Inuit Knowledge (IK) and use of the land. Geographic Information Systems (GIS) and other spatial data organization and representation technologies have been used for a variety of applications for, with, and by Indigenous groups in recent decades (e.g. land use planning, natural resource management, land claims negotiations, documentation and transmission of IK to younger generations). Processes such as Participatory GIS (PGIS) and the development of geospatial ontologies methods of capturing and representing Indigenous conceptualizations of spatial phenomenon can be empowering and create useful tools to illustrate and communicate IK and concepts of the environments. When focused on current important cases, such as Inuit Knowledge of key species undergoing dramatic change (e.g. caribou), or land use mapping of currently changing, or threatened areas (e.g. lands likely to be impacted by industrial development) efforts of this nature have the potential to create tools that can support local decisions about the environment and its resources, in ways that better reflect local understandings and cultures. This project is conducting a geospatial ontology exercise with expert knowledge holders in the Nunatsiavut Settlement Area. The long term goal is the development of a geospatial ontology application and interface that complements existing GIS for use in land use planning, environment and development decision-making as well as Nunatsiavummiut Knowledge (NK) representation and transmission to a variety of audiences. This project is a partnership between the Nunatsiavut Government (NG), local knowledge holders and University based researchers. The short term results are expected to provide representations of NK on key issues in support of decision making needs

around land and development in the region while the longer term results are expected to provide evidence for a different and potentially more culturally-specific way of accessing and using Inuit Knowledge in decisions about land and landscape in Nunatsiavut and other Inuit regions.

## Key Messages

- This project is developing a Nunatsiavummiut Knowledge (NK)-based ontology and computer interface of aspects of the land and environment
- Based on NK and conceptualizations of the land around one case community (Nain) this ontology will be used to provide GIS representations of Inuit Knowledge and provide decision makers access to documented NK in the region
- Interviews and focus groups with knowledge holders and land experts in the region have documented key Inuit Knowledge needed for regional decisions on land use (in the Voisey's Bay and Strange Lake areas) and caribou management (Torngat Mountains herd), as two examples to be used in the development and illustration of the prototype system
- A prototype ontology has been developed and these two components of the project (recently documented IK and developed ontology and GIS interface) will be linked in the final year of this project (2014-15) to show new representation formats for IK in this region in support of environment related decision processes.

## Objectives

- Document Inuit conceptualizations of land and environment use and features using expert priority cases identified by local knowledge holders in one Nunatsiavut community (Nain)
- Develop a prototype Nunatsiavut ontology of aspects of the environment and land for the

construction of a unique NK based decision support system that includes geographic representation of this information

- Through an interactive participatory GIS (PGIS) process, begin the development process of GIS representation of this land and environment conceptualization for one case Nunatsiavut community (Nain) and one or more specified case examples using this developed ontology
- Communicate findings on Inuit geospatial conceptualizations of land and the environment via workshops with regional decision makers, the research community via publications and conference presentations and regional youth via summer student programs when possible

## Introduction

Geographic Information Systems (GIS) and other spatial data organization and representation technologies have been used for a variety of applications for, with, and by Indigenous groups in recent decades (e.g. land use planning, natural resource management, land claims negotiations, documentation and transmission of Traditional Knowledge to younger generations) (Bocco et al. 2001, Duerden and Kuhn 1996; Laituri 2002; Tobias 2000). It is argued that through processes such as Participatory GIS (PGIS) and geospatial ontology research methods of capturing and representing Indigenous conceptualizations of spatial phenomenon, such initiatives can be empowering and create useful tools to illustrate and communicate Indigenous Knowledge (IK) and concepts of the environments which local people understand so well. Additionally, these efforts have the potential to create tools with which to make local decisions about the environment and resources which better reflect local understandings and cultures (Wellen and Seiber, 2012).

Conceptual ontology research in geography attempts to understand how people think about and organize geographic phenomenon (Agrawal 2005; Smith and

Mark 2003). It is more than simply GIS representation of geographical data or human use of the landscape. A prime goal of geographic ontologies is to make explicit the geographical categories embodied in a geographic information database such as a GIS system. Previous research in this area with Indigenous groups has been conducted predominantly in more southern regions of the globe. It illustrates how people from different cultural and language groups use different categories to make sense of the geographic world, and that these different sets of categories do not map onto each other in a straightforward manner. Most conceptual ontology research has focused on Aborigine groups in northwestern Australia and the Navajo in the United States (Mark and Turk 2003; Stea 2007; Mark et al., 1997) with more recent work being conducted among Cree in James Bay (Wellen, 2008, Wellen and Seiber, 2012) and by Fletcher and others in Labrador with the Ashkui (Innu Cultural Landscape Unit) project (as in Furgal et al., 2006). Associated work in the Inuit context is represented in work by Laidler (2006) in her Inuit representations of sea ice formation and dynamics and linguistically in the Inuktitut terminology workshop held by Nunavut Tungavvik Inc in 2005 to which team member (CFurgal) was an advisor and participant.

In the context of environmental, economic and political change, a fundamental question at the centre of the Nunatsiavut Government dialogue is the issue of land use management and decision-making processes. It is vital that Inuit land use and, more importantly, Inuit Knowledge and values associated with land are at the core of this new way forward. This project, a partnership between the Nunatsiavut Government (NG), Nunatsiavummiut Knowledge (NK) holders and University-based researchers is conducting pilot Inuit geospatial ontology research. The NG is ideally positioned to take immediate advantage of the outcomes of the study and incorporate them into policy and legislation. The Nunatsiavut Government is currently at an early stage in its governance structure and even though this is a pilot study, it has been designed so that the outcomes are directly relevant to the priorities of the young government. The Nunatsiavut Government will consider the outcomes to help guide land use management processes as well

as inform environmental assessment and protection regulation deliberations in the context of climate change and development in the region. This project directly supports and informs future actions under the newly established Nunatsiavut Environmental Protection Legislation and Environmental Assessment Act of the Nunatsiavut Government.

The results of this study will also provide Inuit regions across the Arctic with a template and process to better incorporate and represent IK-based conceptualizations and classifications of land and environmental phenomena and cultural values into land management and development decisions.

Since holding a workshop in the community of Nain in 2012-13, the work under the project this year has focused on preliminary ontology development and documentation of NK on desired topics of interest to partners for use in the project. This project is directly related to the needs of the Nunatsiavut Government and will have an extremely high impact on Nunatsiavut Inuit as well as the Nunatsiavut Government and its relationship with industry. The outcomes will feed directly into the land management process, as outcomes will be directly relevant to how NK is seen, accessed and considered in environmental decision processes.

## Activities

For a detailed description of previous year's activities, please see those reports (Furgal and Sheldon 2011-12, 2012-13). In 2012-13 we conducted a workshop with Nain Knowledge holders that identified three foci for the project related to the development of innovative, useful and practical representations of NK to support decision making. 1) Continued work on the ontology development, 2) Further caribou NK collection and review (as the case example for ontology development) and 3) Initialization of an Inuit land use mapping sub project to gather additional NK specific to the original goals of the project to support land use decision making in Nunatsiavut based on NK concepts and understandings.

Initiatives 1 and 2 flow directly from the recommendations and discussions of a late winter 2012-13 workshop held with Nain Inuit Knowledge holders. Initiative 3 was added to this project in association with a land use mapping project led by the project leads (C Furgal and T Sheldon) in response to the Quest Rare Minerals proposal for mine exploration and development near the Quebec-Labrador border inland of Voisey's Bay, Nunatsiavut. The connection with this initiative is providing access to recently documented NK of contemporary relevance to the Nunatsiavut Government in decision making on Inuit land use for which recent NK was not previously documented. It is enhancing the abilities of this project to be more regionally relevant and applicable, in the contemporary sense through the inclusion of recently documented and needed knowledge, while still addressing its original goals.

### *1) Development of Inuit Ontology*

In the early stages of this project, the focus was on establishing a preliminary model of a selection of knowledge held by the people of Nunatsiavut. To do this, a content analysis of text in *Our Footprints are Everywhere* (Brice-Bennett 1977) was carried out and provided the research team with a foundational understanding of local knowledge of the land, caribou and other key subsistence species up to the 1970s.

In previously reported work (see annual reports from 2012, 2013), several visualization tools were evaluated and tested based on a variety of criteria. The D3.js visualization tool was selected and used to develop the prototype presented (see <https://github.com/mbostock/d3/wiki>).

This year a standards compliant ontology viewer build on D3 was used and customized to develop a production-level prototype. This resolved a major data conversion issue present in previous versions of the system (Pulsifer et al. 2012b). The OFAE knowledge model concept maps previously described were transformed into the Resource Description Framework (RDF) and Web Ontology Language (OWL). RDF/OWL files are used by the visualization sub-system to generate online, interactive concept

maps of OFAE knowledge model subsets. The RDF/OWL files were used to link concepts and specific examples of concepts (e.g. a lake) to an online mapping system developed by the project team. The team then developed a computer-based representation of this model using standard knowledge modelling methods including the Resource Description Framework (RDF, <http://www.w3.org/RDF/>) and the Web Ontology Language (OWL, <http://www.w3.org/OWL/>) (Pulsifer et al. 2012a). Using a subset of this model, a visualization tool supporting the exploration of concepts, relationships and related media was developed (Pulsifer et al. 2012b, [http://heicresearch.com/nunatsiavut\\_onto/](http://heicresearch.com/nunatsiavut_onto/)). This tool was then extended to directly connect to the RDF/OWL knowledge model, and to support the web-based mapping of real world instances of geographic concepts (Pulsifer et al. 2013).

### ***2) Further collection of NK pertaining to caribou in Nunatsiavut***

For initiative 2, HQP K Wilson conducted a review and synthesis of the science and NK (and other IK) available on the George River caribou herd in support of the visual concept map shown previously (Furgal and Sheldon, 2012-13). Further, in cooperation with Parks Canada, Torngat Secretariat, Nunatsiavut Government and the Makivik Corporation some team members have become involved in an Inuit Knowledge documentation study of the Torngat Mountains Caribou herd in preparation for contribution to a COSEWIC report on this herd. This will provide greater access to recently documented NK on caribou for trial presentation in the ontology prototype.

### ***3) Collection of NK of land use to gather additional knowledge specific to the Nain area for use in the ontology prototype and in support of decision making on land, environment and development decisions.***

For initiative 3, Furgal and Sheldon began a contemporary Inuit land use mapping project involving participants in Nain, Hopedale and Makkovik to identify and understand land use and its significance to Inuit in the area inland of Voisey's Bay Nunatsiavut

proposed as a roadway corridor from the proposed Strange Lake rare earth minerals development site to the port at Anaktalak Bay. This sub-project fit directly with the objectives of the geospatial ontology project and leveraged significant in-kind and cash funds and widened the practical scope and short term application of the current initiative. In 2013-14 all individual and focus group interviews were completed in Nain, Hopedale and Makkovik; map conversion and GIS database development took place; qualitative analysis, map creation and validation was conducted with participants in the three communities and a draft report was produced and is currently under review.

Further, additional discussions have been held with representatives inside the Nunatsiavut Government as to the most practical final product to be delivered under this project, in addition to academic reporting and publications. In association with this rich database development that took place under initiative 3 it was decided that using this data to generate representations of this knowledge (land use and knowledge in the Voisey's Bay area south of Nain) the identification of key features and areas for Inuit, and how this has changed over time (via inclusion of other existing GIS databases from other projects) would provide a needed, interesting, and rich example to show the ontology prototype and representation format to NK holders in Nain and decision makers. In this way, it is hoped that the project will deliver an innovative example for the research conducted but also a practical product in support of Nunatsiavut interests and needs relating to access to NK in support of regional and local decisions.

## **Results**

### ***1) Development of Inuit Ontology***

A staging level prototype interactive visualization system was developed (Figure 1a,b,c). A subset of the caribou ontology can be viewed in any standards compliant Web browser. To effectively manage the size and complexity of the model, users can pan and zoom the model. Hyperlinks provide the access to related content ([http://heicresearch.com/nunatsiavut\\_onto/](http://heicresearch.com/nunatsiavut_onto/)).

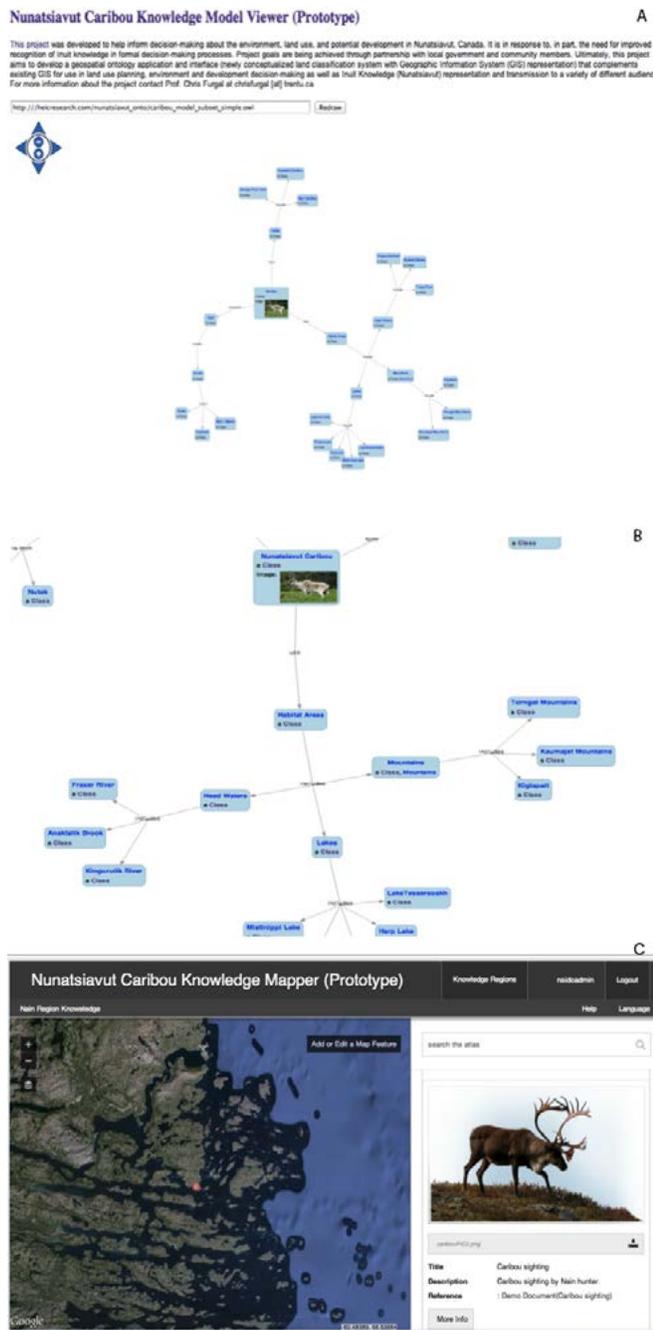


Figure 1 a, b and c. Caribou ontology visualization system prototype.

A primary result of this development iteration is the resolution of issues with labeling and the support of hyperlinking. Additionally, new software was implemented to avoid the need to convert the model to non-standard formats. This greatly enhances interoperability and ultimately knowledge sharing. A prototype map and multimedia viewer was implemented for use with the knowledge model viewer.

The knowledge model viewer allows users to explore and understand concepts and relationships (Figure 1a). When a particular concept of interest is identified and there are data available, an instance or example of that concept can be portrayed on a map along with a wide variety of descriptive media (photos, sounds, movies etc.) (Figure 1b,c).

This significant advancement was presented at the ArcticNet meeting in Halifax and garnered positive feedback from several researchers interested in IK issues and GIS technologies.

## 2) Further collection of NK pertaining to caribou in Nunatsiavut

Following the review of IK and NK on the George River herd and the submission of this report / draft paper to the Nunatsiavut Government the issue of a lack of knowledge of the Torngat Mountains Caribou herd arose and became an important topic of discussion. As a result, team members partnered with representatives from the Torngat Secretariat, Parks Canada, Nunatsiavut Government and Makivik Corporation to design and conduct a study documenting (mapping and narrative) Inuit Knowledge of the Torngat Mountains herd for the purposes of regional documentation and input into a COSEWIC report being written on the status of these animals. This case is another example for the potential application of the prototype ontology and geographic representation in the future. Expertise developed under this project made the other possible.

**3) Collection of NK of land use to gather additional knowledge specific to the Nain area for use in the ontology prototype and in support of decision making on land, environment and development decisions.**

A total of 46 individuals were interviewed in Nain, Hopedale and Makkovik to document current and historical use, knowledge of and connection to the land in the Voisey’s Bay to Strange Lake corridor. A total of 22 maps representing land use and knowledge of the area were created from the GIS database for this project that included nearly 75 hours of recorded interviews and 78 participant-drawn maps. The data gathered represents the uses of the land in all seasons (see Figure 2), the common routes used in each season (see Figure 3) and other activities defining Nunatsiavummiut’s relationship to and use of that land (e.g. char fishing sites, caribou hunting areas, terrestrial mammal sites, etc) in each season. The

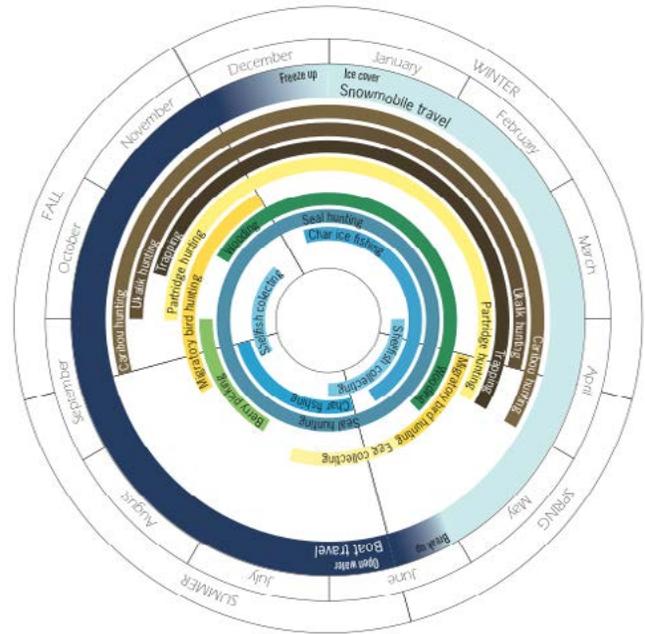


Figure 2. Seasonal land use and key harvesting cycles for Inuit in the area during the last 15 years.

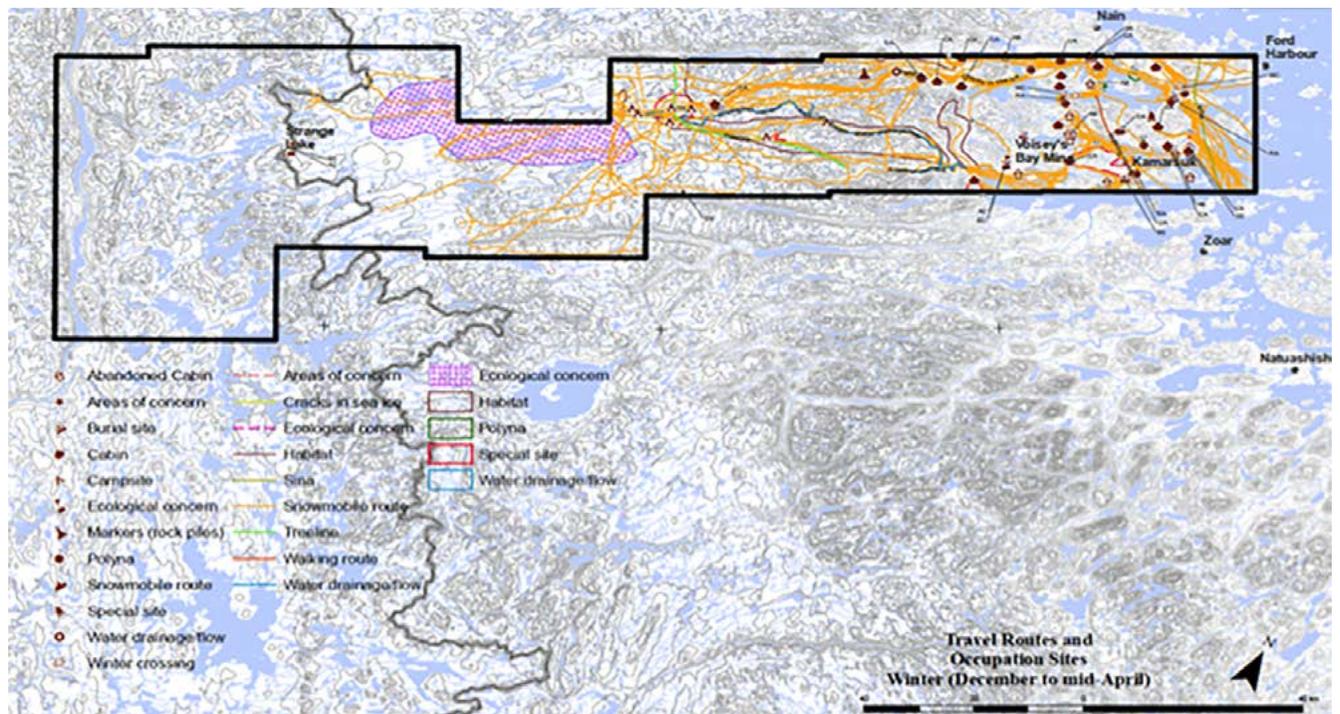


Figure 3. Winter trail routes in the area during the last 15 years

database is representative of an extensive and rich knowledge of and relationship to the land and various features in the area. A final report of this study was produced and is currently under review. The report will be finalized, final copies of maps will be produced, and publications will be prepared from this work in the coming spring/summer.

In discussion with the Nunatsiavut Government, it was determined that the most valuable focus for the last year of this project would be to utilize this extensive NK land use database generated under this cooperative initiative in combination with the prototype ontology and a GIS interface to show examples from this land use study data. As well, through access to existing databases for the same area that have been conducted by other groups at different times, look at changes in land use and representations of these relationships in this work as well if possible.

## Discussion

The importance of mapping land use and land 'formations' is a common discussion in the environmental management literature in regards to land use planning. Several authors identify GIS mapping as the favoured method of many Indigenous communities, industry and governments through which to make land use decisions. Additionally, the map biography method complements GIS by integrating oral history, perceptions of history and geographical knowledge, as well as travel routes and habitation (Usher, 2003). In this way, mapping assisted by the narratives of community members and their observations of the landscape can be critical for making sustainable land use decisions, according to Kendrick and Manseau (2008). They add that GIS cannot be used as a substitute for the narratives and cumulative experience of Indigenous knowledge holders, but rather as a tool to complement and to help represent IK holistically. The authors insist that narratives and commentaries are key to applying spatial data

to management. The current project brings together these two elements in one Inuit region of the Canadian North. It brings together Indigenous knowledge and mapping or map visualizations for geospatial data to support decision making among Inuit communities and regions in the future. As a result it will make a contribution to the literature in the development of new spatial ontologies from an Inuit worldview and knowledge system as well as learning about the process through which this takes place and Inuit knowledge holders become involved. It is using the examples of NK of caribou and knowledge of, use and relationship to land in the Voisey's Bay – Strange Lake area as examples.

Natcher (2001) writes that there are two reasons for mapping – land claims and resource conflicts. Such conflicts may include for example, the free entry system of mineral exploration, which highlights mining as the preferred land use activity (Hipwell et al., 2002). The 'highest valued use' concept of land, which is most often driven by short-term economic interests, is not 'value-free' and is often incompatible with Indigenous community perspectives (Paci et al., 2002). Our approach in this project is to develop an Inuit ontology such that conceptualizations of the land are based in Inuit understandings, views and perspectives of the environment. This is being done through two use cases, one on knowledge and representations of knowledge on caribou and the land and the other on a contemporary case of a proposed development associated with Strange Lake and a road to Anaktalak Bay.

Literature also reveals a trend towards an Indigenous planning approach, as noted by Paci et al. (2002). Indeed, there are social, cultural, economic and ecological aspects of planning the landscape (Stevenson and Webb, 2003) and there is an increasing effort to understand this complexity at a greater level by working to integrate Indigenous concerns in land use planning (Houde, 2007). According to Wolfley,

cultural values and diversity should be reflected in planning (as cited in Paci et al., 2002). For example, Simpson (2008) writes that traditional Nishnaabeg decisions about land use reflected a concern for the next seven generations. In these ways, it is evident that Indigenous models and visualizations of land use planning are founded upon Indigenous knowledge systems and view points and are very challenging to depict in current GIS and mapping languages and processes. Through a temporal extension of the one case we are using to show this prototype ontology, via connection with other land use databases for the region gathered in 1997 and then in 2002, 2006, 2008 and 2010 we will also be able to show this change in land use, knowledge and relationship to environment in one location over time.

We see the ontology as a socio-technical system. It is critical that Indigenous knowledge is represented and communicated in a way that is true to its original cultural and traditional conceptualization and thinking, rather than simply ‘fitting’ knowledge into existing scientific or anthropological frameworks of seeing or understanding. Innovative use of visualization techniques may contribute to more appropriate representations of Inuit knowledge. To realize the benefits of this approach, knowledge holders must be fully engaged in the ontology creation and visualization process. Such engagement will help to prevent the re-colonization possible when Inuit knowledge is transformed to make it more ‘digestible’ by others who are not knowledge holders. The system developed through this research has the ability to visualize concepts as well as maps together, providing a platform for a more holistic representation of Indigenous knowledge.

## Conclusion

- Representatives from the Nunatsiavut Government and residents of Nain that are active land users would like to see practical products

presenting Inuit Knowledge easily and in a logical form to support decisions.

- This project is developing a Nunatsiavut geospatial ontology of aspects of the land and environment in the region
- Previous year’s work focused on the initial draft / prototype of the concept mapping exercise in addition to data gathering on use cases (NK on caribou and land use in the Voisey’s Bay / Strange Lake area)
- A prototype ontology has been developed and will now be used to present an example representation of land use data in the region this coming year
- This project will support current and future decision making processes by the Nunatsiavut Government in enhancing accessibility and presentation of NK
- It is expected that this project will make contributions to a growing Indigenous geospatial ontology literature as well in providing an Inuit example from the rapidly changing Canadian Arctic and information as to the engagement of Inuit knowledge holders and their interests in this process.

## Acknowledgements

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## Publications

*(All ArcticNet refereed publications are available on the ASTIS website (<http://www.aina.ucalgary.ca/arcticnet/>)).*

Durkalec, A., Furgal, C., Skinner, M.W., Sheldon, T., 2014, Investigating Environmental Determinants of Injury and Trauma in the Canadian North., *International Journal of Environmental Research and Public Health*, 11, 1536-1548

Furgal, C., Durkalec, A., Wilkes, J., Winters, K., Pilgrim, A., Webb, R., Dicker, G., Wilson, K., Toll, M., Keresztesi., 2013, *Inuit Knowledge, Land Use and Connection to Place Study*, Nunatsiavut Government, 135

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Wilson, K., Furgal, C., and T. Sheldon., 2013, Review, synthesis and critique of Inuit Traditional Ecological Knowledge and science-generated knowledge regarding the George River caribou herd., Report prepared for the Nunatsiavut Government, 36