DISTRIBUTED GIS SOLUTIONS FOR ABORIGINAL RESOURCE MANAGEMENT: THE CASE OF THE LABRADOR INNU

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Abstract / Résumé

The increasing usefulness of GIS to Aboriginal resource managers has coincided with an apparent paradigm shift within the GIS community itself. Data availability on the Internet has soared; consequently, stand-alone desktop computers with specialist software and hardware have been complemented by distributed GIS systems accessible to generalists and specialists alike, from anywhere in the world. Governmental agencies and other geo-spatial data providers are moving towards this integrated and distributed infrastructure, and it may prove invaluable for Aboriginal communities to do the same. This paper examines GIS work at the Innu Nation (Labrador, Canada) to highlight the potential benefits of distributed GIS for Aboriginal communities.

L'utilité croissante du Système d'information géographique (SIG) pour les gestionnaires de ressources autochtones coïncide avec un changement apparent du paradigme au sein de la collectivité des utilisateurs du SIG. La quantité de données accessibles par Internet a monté en flèche. Par conséquent, les ordinateurs de bureau autonomes des généralistes et des spécialistes du monde entier qui étaient équipés de matériel et de logiciels spécialisés ont été mis à niveau en offrant un accès à des installations de traitement distribué du SIG. Les organismes gouvernementaux et d'autres fournisseurs de données géospatiales adoptent progressivement cette infrastructure intégrée de traitement distribué et il serait très avantageux pour les collectivités autochtones de faire de même. Le présent article présente les travaux en matière de SIG réalisés dans la collectivité des Innu au Labrador (Canada) afin de mettre en évidence les avantages potentiels des installations de traitement distribué du SIG pour les collectivités autochtones.

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> **Who makes the map? The answer will help determine who decides what is important in a community, what routes lie open to the map's users, and, in effect, whose reality counts. (Lydon 26)**

Introduction

In May 2002, the Innu Nation and Newfoundland and Labrador's Forestry Department announced that they had agreed on the amount of wood to be cut in Central Labrador over the next five years. The forest management plan, which ended a seven-year stalemate between the two governing bodies, provides the Innu with a share of harvesting permits for the first time ever, and will presumably increase the amount of forestry activity in the region (Piggot *CBC Morning News*). The Innu Nation's recognized role in the forest management process was as dependent on its Environmental Guardians' data collection, as it was on the use of Geographic Information Systems (GIS). At the Innu Nation Environment Office, GIS were used to estimate the amount of forest in the area and to ensure that buffers were maintained around mapped habitat, such as that of the Red Wine caribou herd. Furthermore, GIS were deployed to map, analyze, and protect areas of Innu cultural value.

Like the Innu Nation, Aboriginal communities across Canada are playing an increasingly active role in the management of their traditional lands. The Delgamuukw decision handed down by the Supreme Court in 1997 acknowledged their input regarding proposed projects in a concrete way. It stipulates that "governments be obliged to consult with Aboriginal groups regarding potential development activities on their traditional lands" (Inkpen 2) and that physical occupation of a territory must be demonstrated to prove Aboriginal title to it (Tobias vi-vii). As such, First Nations leaders have increasingly stressed the importance of developing in-house GIS expertise to reach land claims settlements and manage local resources. In northern British Columbia, for example, the Gitxsan people are integrating Traditional Ecological Knowledge with "modern ecosystem mapping techniques" (Lydon 27). GIS implementation in Aboriginal communities, however, has been as varied as it has been successful.

"Effective resource management," writes Benjamin D. Johnson, "requires the input of disparate data describing social, ecological and environmental phenomena, and the ability to respond flexibly and dynamically to rapidly changing real world conditions, characteristics inherent in GIS" (7). Many First Nations, however, are working hard to build GIS capacity and are taxed by the number of requests to comment on development issues affecting them. Ecotrust Canada has addressed the problem by building an Aboriginal GIS community of practice. In partnership with the Gitxsan and Ahousaht Nations, it has created the Aboriginal Mapping Network to foster information exchanges on Aboriginal-related GIS topics through its website, workshops, conferences, and publications (Hopwood 15; Olive and Carruthers 1).

The increasing usefulness of GIS to Aboriginal resource managers has coincided with an apparent paradigm shift within the GIS community itself. Data availability on the Internet has soared; consequently, stand-alone desktop computers with specialist software and hardware have been complemented by distributed GIS systems accessible to generalists and specialists alike, from anywhere in the world. These systems are based on the adage "Own what you must—minimize what you can" (Wilson).

Governmental agencies and other geo-spatial data providers are moving towards this integrated and distributed infrastructure, and it may prove invaluable for Aboriginal communities to do the same. This paper examines GIS work at the Innu Nation to highlight the potential benefits of distributed GIS for Aboriginal communities. More specifically, it outlines the principles of the "new" GIS, including web services, online mapping applications, and hand-held technologies, and suggests future GIS directions the Innu Nation and other Native communities may take.

Setting the Stage in Labrador

Since the construction of the Goose Bay airstrip in 1941, a variety of other developments and resource-use activities have been introduced in Labrador at a hurried pace. Of particular note, a three hundred-kilometre stretch of road between Goose Bay and Labrador City was built. In 1971, the Churchill Falls hydroelectricity project flooded a 5600 square kilometre area in the upper portion of the Churchill River watershed (Innu Nation, "More Damns Planned" 1). Nine years later, the Department of National Defence began its low-level flying activities over areas of eastern and northern Labrador.

A number of other developments and activities are in the early planning and construction stages or are being proposed. Parks Canada, for example, is conducting a feasibility study into all aspects of a proposed national park in the Mealy Mountains, located 80 km. east of Sheshatshiu. Options for developing the lower Churchill River for hydroelectric power have been discussed recently among interested parties (Walsh 1-2). Meanwhile, Voisey's Bay Nickel Company has begun construction of a $3-billion megaproject 80 km. from Utshimassit (Davis Inlet) (Hasselback and Jack). A 350 km. section of highway between Red Bay and Cartwright has been completed, and a 220 km. stretch from Cartwright to Goose Bay has begun (Transportation and Works, 1-2). Furthermore, forestry activities will likely increase in Labrador, given the fact that Newfoundland's mills are under-capacity (Wall 1-3).[1] The intensifying will of many proponents to "develop" Labrador underscores the value of GIS as a tool in Innu decision-making processes. Of course, GIS capacity is of significant importance to other Aboriginal communities as well.

Innu Nation and GIS

The Innu Nation's GIS work has been intimately tied to its land use and occupancy research. The Innu, like other First Nations in the Canadian north, have carried out various land use and occupancy studies for two primary purposes: to "document the extent of land use and provide the basis for claims to ownership or usufruct property rights to the land by traditional occupants;" and, "to provide an appropriate measure of compensation to Aboriginal peoples for loss of or disruptions to the use of traditional lands and resources" (Armitage 3). These Innu research projects, conducted between 1975 and 1999, employed established land use mapping methodologies to produce hundreds, if not thousands, of map biographies. Peter Armitage, who conducted much of the research, writes:

> Each biography is based on "informant recall" and constitutes, therefore, a record of an individual harvester's land use both as part of community-based and country-based harvesting activities. The biographies record the locations of campsites, travel routes, birth and death locations, harvest areas for various animal species and wild fruit, and other information. (Armitage 2)

Between 1996 and 1998, Armitage digitized the map biographies using MapInfo GIS software. The composite layers have become a key component in concurrent and ongoing Innu land claims and self-government negotiations.[1]

In early 2001, Innu Nation augmented its GIS capacity by hiring a full-time GIS Analyst. A number of software packages were used to build on the earlier mapping work, to establish an inventory of Innu Nation and governmental geospatial data, and to assist in the aforementioned forest management plan. This person also worked with Inn Nation Forest Guardians to incorporate their field data into GIS.

To better manage and make more accessible its land use and occupancy data within its own organization, the Innu Nation, with Environment Canada's support, developed a GIS called "CREATOR." The CREATOR application enables browsers "to query the digitized map biographies according to any combination of variables" (Innu Nation *CREATOR* 1). For example, users can produce maps illustrating travel routes and/ or camp locations for any number of informants over any consecutive period of time. However, the application is limited to those who understand and have access to platforms that support SPANS GIS 7.0 software (Innu Nation *CREATOR* 1). This application is not far from the traditional GIS model that consists of a single software package and data on a stand-alone desktop computer.

Given the number of proposed developments in Labrador, the Innu Nation's GIS Analyst will likely receive a growing number of information requests. Furthermore, their work is usually only accessible on computers with specialized software and hardware.

Principles of the New GIS

Today many GIS projects are "multi-agency, multi-disciplinary, and multi-software" and "require not only maps, but also many forms of multimedia output (e.g. documents)" (Green and Bossomaier 23). To properly assess the impacts of a proposed highway in Labrador, for example, the Innu Nation might use a proposed highway layer from the Department of Transportation, vegetation cover and wildlife habitat layers from the Department of Forest Resources, and its own land use and occupancy layers, Such an assessment would require the most up-to-date data to generate authoritative GIS models and reports. For these reasons, GIS users are seeing the benefits of displaying and accessing data online.

The rise of the Internet has caused a paradigm shift in the GIS community. GIS technicians, once accustomed to solely working on standalone desktops and managing all of their datasets (whether their own or not), are now able to share and access data on scales that were once impossible. Online GIS has the advantages of providing worldwide data access to web browsers without costly expert equipment. In this model, generalists and specialists alike can process information at its source—where the data providers are responsible for its maintenance (Green and Bossomaier 13).

In order to be truly "distributed" and "seamless," an online GIS must be organized in such a way that it provides information quickly and easily, its data sources remain stable, and the form and content of its information is standardized (Green and Bossomaier 8). Although the Innu Nation has not yet built such an infrastructure, the *Labrador Atlas Project* has been the first attempt at bringing Innu land use and occupancy data online.

Labrador Atlas Project

In April 2002, Environment Canada partnered with the Innu Nation and began incorporating data within CREATOR into an online mapping application called the *Labrador Atlas Project*, better known as LAP. Funded by Environment Canada's Northern Ecosystem Initiative, the application incorporated Innu Ecological Knowledge (IEK) and Western science-based waterfowl data into a cumulative effects atlas of Labrador. LAP attempts to strengthen the environmental assessment process by presenting IEK in a GIS recognizable to a cross-cultural audience. It is being designed with ongoing Innu input and will assist in identifying impacts of potential developments on resources the Innu have laid claim to in ongoing land rights negotiations. While the online-mapping application is being developed with Innu Nation resource managers and environmental assessment specialists in mind, a transparency-based atlas is also being produced for the Innu communities of Utshimassit and Sheshatshiu.[2] The traditional atlas with overlaid transparencies will: provide the Innu with information on existing and proposed developments in a visual manner, thereby reducing misinformation; and, make IEK and scientific data accessible to all Innu.

To build the LAP application, the Innu Nation's land use and occupancy MapInfo files were first formatted in Microsoft Access tables and in Autodesk MapGuide Author. Like other Internet GIS products, MapGuide's emphasis is on map display and query use. In addition to showing both vector and raster maps, it allows browsers to navigate in the map window, redline (draw on maps), edit geographic objects, generate reports and print (Longley et al. 174). HTML and Java Script were used to build the client application, while MapGuide Server and ODBC links were used, respectively, to manage data and queries. LAP browsers have the ability to see where scientific and Innu waterfowl data overlap, agree and differ, and to generate various types of IEK reports. To bring sensitive Innu data online, LAP required data-protection measures. Mapping window access is based on standard password profiles. Innu Nation users, for example, have access to all Innu-related layers, whereas non-affiliated browsers are limited access to public layers.

LAP is the first step in bringing Innu data into the new GIS infrastructure. Users can now go online and display Innu land use data over other layers, such as Environment Canada waterfowl habitat, the Department of National Defence low-level fly zone, and the proposed phase III of the Trans-Labrador Highway. Due to financial and temporal restraints, however, LAP does have its limitations.

The LAP application can be used to generate maps and reports, but it cannot be downloaded and used in various platforms by the user. Its map window is generated using Autodesk MapGuide software that provides an array of querying capabilities, but it can be slow and requires the browser to download a plug-in. All data are copies of the originals and do not reside on their proprietors' servers; therefore, they will need to be updated regularly. In a resource management environment where efficient and effective decision-making is dependent on easily-accessible and current environmental data, this is problematic. In the long term, however, these issues can be easily resolved. LAP could be made to access datum from its proprietor's server, where it is maintained, and display it in any user platform. It could also employ two mapping software packages—MapGuide for specialists requiring "thick" analytical tools, and the "thinner" University of Minnesota MapServer client for users intent on accessing fast and more general information. Distributed GIS provide all of these solutions.

Although it involves a considerable investment in in-house software, hardware and expertise, as well as tremendous coordination between affiliated data providers, a growing number of organizations believe adopting the new GIS paradigm is essential to fulfilling their mandates. With this in mind, the Open GIS Consortium (OGC), an international melange of companies and public agencies, has created "publicly available geoprocessing specifications" that standardize data to support interoperable web-based GIS solutions. Its vision is a "world in which everyone benefits from geographic information and services made available across any network, application, or platform."[3] In Canada, a few federal departments have also been involved. The Department of Natural Resources, for example, has committed $60 million dollars over six years to build its "Geoconnections" infrastructure. The initiative will:

> ...increase the amount of geospatial data, information and services online; ease data integration issues and data standardization; expand the use and application of geo-information by working with user communities of practice; promote the development of innovative technology; and, simplify the conditions for geo-information use and resale (Wilson).

Similarly, Environment Canada has established the Canadian Information System on the Environment (CISE) to provide a strategic approach to the dissemination of environmental information. Its vision is to "enable timely access to and effective application of relevant, credible, integrated environmental data and information in support of decision-making by all Canadian" (Frappier). CISE's online GIS infrastructure will be fully distributed and interoperable.

Whereas traditional GIS were essentially programs that access data, the new paradigm consists of "programs that support web services that access data" (Kralidis and Doyon). A web service is not tied to any one operating system or programming language. It is any software that makes itself available over the Internet and uses standard Extensible Markup Language (XML). Unlike unstructured HTML, XML is "self-describing, structured, human readable, portable, non-proprietary, and interoperable" (Kralidis and Doyon). Because of its transparent nature, XML enables online GIS to access data from numerous sites and present them in any OGC-compliant program (Green and Bossomaier 71).

In the Atlantic Region, Environment Canada's Environmental Information and Reporting Group (EIRG) is responsible for overseeing LAP's GIS development. Recently, the group adopted Microsoft .NET as its standard platform for developing and reusing web services. In implementing .NET's "building block approach," the group's programmers can develop reusable and self-contained software and build larger software systems gradually. The group is also developing both "thick" and "thin" mapping services; thick applications have a range of analytical capabilities, whereas "thin" applications have limited querying tools, but are faster to deploy. EIRG is also developing software that will deploy web services on hand-held GIS. This technology will enable its users to create maps with data obtained from distributed sources and to post data to a central database. Such tools could be valuable to Aboriginal groups conducting a variety of fieldwork, whether it is forest regeneration surveys or the collection of Traditional Ecological Knowledge (TEK).

In its executive summary and recommendations, CISE highlighted the value of TEK and the "unique decision-making processes in Aboriginal communities." It elaborated:

> It [CISE] must reflect how Aboriginal peoples wish to safeguard their knowledge, which mechanisms are most appropriate to them, and how they might wish to link modern technologies with their traditional systems. We believe that inclusion of Aboriginal peoples and an ongoing dialogue that reflects respect for, and recognition of, the value of traditional knowledge and the rights of the holders of knowledge are an important next step in the development and implementation of CISE (Final Report on the Task Force on a Canadian Information System for the Environment 10).

CISE values TEK and its incorporation in the new GIS infrastructure. However, the financing and data-security will likely be key concerns for Aboriginal groups wishing to take this route. In addition to the financial strain of "going distributed," many Aboriginal groups across the country are wary of disclosing their ecological knowledge to outsiders. There is a justifiable concern that it may be appropriated to access valuable local resources or misused to satisfy environmental assessment regulations. During the Voisey's Bay Nickel Company environmental assessment, for example, concerns were expressed that the company was attempting to gather Innu Ecological Knowledge from Elders without their explicit consent. This only heightened the already existing tensions between the two parties (Inkpen 108). As mentioned, LAP has addressed online data-protection concerns by employing user profile logins and by bundling Innu TEK data into more generalized map layers.

Suggestions for the Future of Aboriginal GIS

Environment Canada has a record of collecting and analyzing TEK of Aboriginal peoples. Over the last six years, it has developed, for example, a working relationship with the Innu Nation. In 1997, the two partnered with other governmental agencies and established the *Ashkui Project* – an endeavour investigation "innovative ways of linking western science and Innu knowledge together in order to gain better insight into the ecological make-up of Labrador." Since that time, Environment Canada and the Innu Nation have worked with other funders to establish an Innu Co-Researcher and an Innu Environmental Guardians Program in Sheshatshiu. Given Environment Canada's CISE initiative and its working relationship with the Labrador Innu, a concerted attempt at developing a distributed Innu Nation GIS infrastructure could be invaluable. If the Innu Nation or other Aboriginal communities decide to invest in a distributed GIS infrastructure, the route suggested below might be of some use.

Database Management

Aboriginal communities could manage all of their existing and future geospatial data in server-based database software. Built on Web standards, this software is able to store and retrieve data in XML format, conduct full-test searches on documents stored in the database, run queries over the Internet with natural language, and expedite and translate data from any source. Furthermore, it can be used with any Microsoft Visual Studio tool to design and code database applications.

Online Application Development

Microsoft .NET Enterprise Servers could be used to develop Aboriginal Web applications that access data. In addition to its relative ease of use, .NET enables software integration using XML. Web services. As mentioned, these Web services provide "reusable components built on industry standards that invoke capabilities from other applications independent of the way the applications were built, their operating system or platform or the devices used to access them" (Green and Bossomaier). .Net Enterprise Server's ASP.NET application service is especially useful to informal software developers with limited programming ability.

Thick and Thin Mapping Applications

LAP deploys Autodesk Mapguide to generate its online maps. MapGuide is a "thick" application in the sense that it offers extensive analytical capabilities—indispensable to resource management specialist acquiring and querying data online. However, this mapping application is slow to deploy and requires a downloaded plug-in. MapGuide software could be used in conjunction with "thin" University of Minnesota MapServer applications. Faster to deploy and "plug-in free," MapServer's core functionality would meet most non-specialists' needs.[4]

Remote Data Entry Using Hand-Held Technology

In the instructive example of the Innu Nation, Environmental Guardians are currently using traditional methodologies to collect and store their field data. They employ paper maps and field tally sheets to plot their location and inscribe their findings. The tally cards are then brought back to the Environment Office, the information they contain are entered by hand into Excel spreadsheets, and then, time permitting, imported into stand-alone desktop GIS software like MapInfo or ArcView. The use of hand-held technologies in conjunction with server-based database and Microsoft .NET development would produce a powerful distributed GIS.

In this scenario, Environmental Guardians or Aboriginal resource managers would enter the field with a hand-held device outfitted with a GPS and wireless technology. They would have the power to download relevant maps "on-the-fly" from a data warehouse with the features of their choosing. For example, the Innu might download a 1:12 500 partial map of the lower Churchill River in Labrador along with the following features: contours, waterbodies, vegetation cover, Innu and provincial forestry surveyed-sites, and Innu archaeological sites. Guardians would then conduct their fieldwork and enter their findings using a data-entry form accessed on the hand-held. Data would be instantly submitted to the data warehouse and stored in the appropriate database. All OGC-compliant applications, whether they are simple database querying tools or thick and thin mapping services, could instantaneously present this most up-to-date data.

Aboriginal groups could also benefit from the technologies being developed through Environment Canada's industry-tied partnerships. They include the creation of: hand-held data-entry forms to be used by staff and volunteers on Environment Canada's oiled-bird monitoring system (AG Research Associates): and, data warehouse management and environmental OGC hand-held tools (Cube Werx). Scripting produced for these projects could be tailored for use by any particular group.

Knowledge Sharing and Capacity-Building

The success of the Innu Nation's transition from stand-alone to distributed GIS is largely dependent on the future GIS-Capacity of its staff – in particular, its GIS Analyst and Environmental Guardians. This also holds true for other Aboriginal groups. Relatedly, Environment Canada, in partnership with others, is supporting the development of an ongoing environmental training program for Innu Environmental Guardians. Class instruction will be provided on a variety of subjects, from word-processing to field data collection. The development of GIS training modules within this and other Aboriginal training programs would broaden Aboriginal GIS capacity.

Conclusion

GIS is not new to the Innu Nation. Its active participation in the forest management agreement amply demonstrates its ability to use GIS and incorporate its extensive TEK holdings into its resource-management decision-making. *Distributed GIS*, however, would be a new approach to data storage, retrieval, and analysis for the Innu. Given that there is an increasing interest in developing Labrador, and that the Innu may have self-governing responsibilities over large tracts of it, the need of a structured, coherent, and easily accessible GIS is crucial. The Innu Nation has an opportunity to be a proactive developer of a new GIS infrastructure, possibly in partnership with Environment Canada and its CISE initiative. In so doing, the Labrador Innu would become leading developers of distributed GIS among Aboriginal communities in Canada.

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Notes

1. "Transportation and Works, 2005. 'News Release: Minister announces awarding of contract for continued work on Phase III of the Trans Labrador Highway.' September 9."
2. For more information on the *Labrador Atlas Project*, visit http://map.ns.ec.gc.ca/lap . If the website is password-protected, contact the author at jake.whalen@ ec.gc.ca
3. Visit the Open GIS Consortium website at www.opengis.org.
4. Visit the University of Minnesota Mapserver website at http://mapserver.gis.umn.edu/

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