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GEOMATICA

THE JOURNAL OF GEOSPATIAL INFORMATION SCIENCE, TECHNOLOGY AND PRACTICE
LA REVUE DES SCIENCES DE L'INFORMATION GÉOSPATIALE, DE LA TECHNOLOGIE ET DE LA PRATIQUE

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LA CARTOGRAPHIE AU CANADA DE 2011–2015

CANADIAN NATIONAL REPORT TO THE INTERNATIONAL CARTOGRAPHIC ASSOCIATION / RAPPORT NATIONAL CANADIEN À L'ASSOCIATION CARTOGRAPHIQUE INTERNATIONALE

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Roger Wheate
Guest Editor / Rédacteur invité

Excerpt / Extrait

CANADIAN NATIONAL REPORT TO THE INTERNATIONAL CARTOGRAPHIC ASSOCIATION /
RAPPORT NATIONAL CANADIEN À L'ASSOCIATION CARTOGRAPHIQUE INTERNATIONALE

COVER / COUVERTURE

Map of Eastern Labrador, showing Grand Lake and the courses of the Nascaupee and George rivers as surveyed and mapped, June 27 to August 27, 1905 by Mrs. Leonidas Mina Hubbard—in *Cabot* [1908]—see article by Dr. Will van den Hoonaard in this issue.

Map image credit: Memorial University of Newfoundland. Libraries. Centre for Newfoundland Studies. Collection: Centre for Newfoundland Studies. Digitized Maps, located in CNS RARE under call no. FF 1041 E47 1908 c.2. Used with permission.

Image sur la page couverture : Carte de l'est du Labrador montrant le lac Grand et le cours des rivières Nascaupee et George tels qu'arpentés et cartographiés entre le 27 juin et le 27 août 1905 par Mme Mina Hubbard—dans *Cabot* [1908]—voir l'article de M. Will van den Hoonaard, ph.D., dans ce numéro.

Crédit image de la carte : *Memorial University of Newfoundland*, bibliothèque : Centre des études de Terre-Neuve. Cartes numérisées trouvées dans CNS RARE sous le no d'appel FF 1041 E47 1908 c.2. Utilisées avec autorisation.

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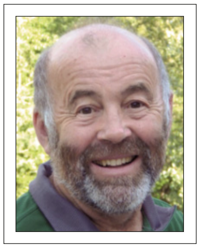

Roger Wheate

CANADIAN NATIONAL REPORT TO THE INTERNATIONAL CARTOGRAPHIC ASSOCIATION

Sixteenth General Assembly, Rio de Janeiro, Brazil, August 23–28, 2015

Guest Editor:
Roger Wheate, Chair of the Canadian National Committee to the ICA

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It is a pleasure to present Canada's national report to the ICA, on behalf of the Canadian Institute of Geomatics (CIG), and to the delegates of the sixteenth General Assembly. This is in accordance with Article 5 of the ICA statutes, on the occasion of the XXVII International Cartographic Conference in Rio de Janeiro. Entitled *Cartography in Canada: 2011–2015*, this comprehensive report is published as a special issue of the Canadian quarterly journal, *Geomatica*, and is distributed to all members of the Canadian Institute of Geomatics. It contains contributions from geomatics specialists across Canada with a focus on cartography and reflects some of the breadth of activity in this sector in Canadian government, industry and education.

The single most significant milestone of this period was the completion of the National Topographic Series at 1:50 000 in 2012. The designated last sheet was NTS 059H12: Pyramid Peak, Axel Heiberg Island; this island was also host to the magnetic north pole for most of the twentieth century. All 13 377 map sheets are available for download from the 'geogratis' website, as raster scanned maps, complete vector layers and elevation data digitized from the contours. In accordance with government agency policy to create spatial data for industry as much as finished map products, one Canadian company (*gotrekkers.com*) has added shaded relief to every map sheet in the National Topographic Data-Base (NTDB).

Canada's national report is also a compendium of peer-reviewed feature articles and activity reports from organizations with a geomatics mandate, which together highlight Canada's cartographic achievements over the past five years. The articles in this report were obtained in response to a call for papers, and underwent the journal's usual peer review process. The featured articles illustrate the breadth of the field of geomatics, in this case encompassing web mapping, remote sensing, and online atlas creation.

The paper by Emmanuel Stefanakis presents the content of courses on web mapping, as he shares the challenges and experiences of this new millennium expansion in the field of cartography. Lanying Wang and her co-authors apply the Landsat 40 year image archive to examine urban expansion in Toronto, Canada's most populous metropolitan area. The use of satellite imagery is critical in a country as large as Canada and is especially advantageous where freely downloadable multi-temporal image data can help monitor our changing environment. The third paper, by Stephanie Pyne and Fraser Taylor, highlights the use of the Residential Schools component within the Cybercartographic Atlas Framework as a tool for transitional justice concerning this traumatic issue in recent Canadian history.

This journal also contains a professional report by Will van den Hoonaard, on the extraordinary mapping exploits of Mina Hubbard during the early 1900s in remote Labrador. These early endeavours in Canada helped build the basis for our modern technologically enhanced mapping.

Also included in this issue are summary reports of cartographic initiatives carried out by provincial and territorial government agencies, national societies and associations and educational institutions in Canada. These reports illustrate the importance and scope of cartography and geomatics in Canada, and showcase the breadth of geomatics science that is part of the work of many Canadians. They also show how difficult it is today to imagine a nation and a world without the high level of integrated maps and data that we currently use and experience daily.

Thanks to everyone who contributed their time and energy in the preparation of this report. This includes both authors who submitted material and their unnamed reviewers. Special thanks go to Laura Duke, Production Manager of *Geomatica*, for her patience and advice throughout the compilation process. We look forward to participating in the XXVII International Cartographic Conference 'Maps Connecting the World,' in August 2015, in Rio de Janeiro, Brazil. ❑

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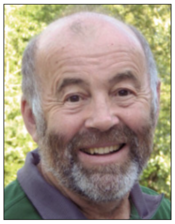

Roger Wheate

RAPPORT NATIONAL CANADIEN À L'ASSOCIATION CARTOGRAPHIQUE INTERNATIONALE

Seizième assemblée générale, Rio de Janeiro, Brésil, 23-28 août 2015

Rédacteur invité :
Roger Wheate, Président du Comité national canadien à l'ACI

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Je suis heureux de présenter le rapport national du Canada à l'ACI et aux délégués de la seizième assemblée générale au nom de l'Association canadienne des sciences géomatiques (ACSG). Nous le faisons conformément à l'article 5 des statuts de l'ACI à l'occasion de la XXVIIe Conférence cartographique internationale à Rio de Janeiro. Intitulé *La cartographie au Canada : 2011–2015*, ce rapport détaillé est publié en tant que numéro spécial de la revue trimestrielle canadienne, *Geomatica*, et sera distribué à tous les membres de l'Association canadienne des sciences géomatiques. Ce numéro contient des contributions des spécialistes de la géomatique de partout au Canada et met l'accent sur la cartographie, en reflétant l'étendue des activités du gouvernement canadien, de l'industrie et des établissements d'enseignement dans le domaine.

Le plus important jalon pendant cette période a été l'achèvement de la série nationale de référence cartographique à une échelle de 1/50 000 en 2012. La carte désignée comme la dernière a été la SNRC 059H12 : Pyramid Peak, Île Axel Heiberg; cette île a aussi été l'hôte du pôle nord magnétique pendant la majeure partie du vingtième siècle. Les 13 377 cartes de la série sont disponibles pour téléchargement sur le site Web « geogratis » sous forme de cartes matricielles numérisées, de couches vectorielles complètes et de données d'élévation numérisées à partir des courbes de niveau. Conformément à la politique de l'agence gouvernementale voulant créer des données spatiales pour l'industrie comme étant des produits cartographiques les plus complets possibles, une entreprise canadienne, (*gotrekkers.com*), a ajouté du relief ombré à chacune des cartes de la Base nationale de données topographiques (BNDT).

Le rapport national du Canada est aussi un recueil d'articles spécialisés revus par des pairs et de rapports d'activités d'organismes dont le mandat est lié à la géomatique. Tous ces apports mettent en lumière les accomplissements du Canada en matière de géomatique au cours des cinq dernières années. Les articles contenus dans ce rapport ont été obtenus par l'entremise d'un appel à contributions et ont fait l'objet du processus habituel d'examen par des pairs de *Geomatica*. Les articles parus illustrent l'étendue du domaine de la géomatique et cernent, dans ce cas-ci, la cartographie en ligne, la télédétection et la création d'atlas en ligne.

L'article d'Emmanuel Stefanakis présente le contenu de cours sur la cartographie en ligne et partage les défis et les expériences de cette expansion dans le milieu de la cartographie qui a eu lieu dans le nouveau millénaire. Lanying Wang et ses co-auteurs examinent la croissance urbaine de Toronto, la région métropolitaine la plus habitée au Canada, grâce aux archives d'images Landsat des 40 dernières années. L'utilisation de l'imagerie par satellite est d'une importance capitale dans un pays aussi vaste que le Canada et présente un avantage, notamment lorsque des données multitemporelles librement téléchargeables peuvent nous aider à observer notre environnement changeant. Le troisième article, rédigé par Stephanie Pyne et Fraser Taylor, met en lumière l'utilisation de la composante des pensionnats indiens et du cadre de l'atlas cybercartographique en tant qu'outil pour la justice transitionnelle liée à ces événements traumatisants de l'histoire récente du Canada.

Ce numéro contient aussi un rapport professionnel rédigé par Will van den Hoonaard sur les exploits extraordinaires de Mina Hubbard en matière de cartographie au début des années 1900 dans les régions éloignées du Labrador. Ces premiers efforts ont contribué à jeter les bases de la cartographie améliorée par la technologie au Canada.

Ce numéro comprend également des rapports sommaires d'initiatives cartographiques entreprises par des agences gouvernementales provinciales et territoriales, des sociétés et associations nationales et des établissements d'enseignement canadiens. Ces rapports illustrent l'importance et l'étendue de la cartographie et de la géomatique au Canada et démontrent l'envergure des sciences géomatiques qui sont partie prenante du travail de nombreux Canadiens. Ils démontrent aussi à quel point il est difficile d'imaginer une nation et un monde aujourd'hui sans le niveau élevé de cartes et de données intégrées dont nous nous servons quotidiennement.

Merci à toutes les personnes qui ont contribué temps et énergie à la préparation de ce rapport. Ceci inclut les auteurs qui ont soumis du matériel ainsi que leurs réviseurs, qui ne sont pas nommés. Merci notamment à Laura Duke, gestionnaire de la production de *Geomatica*, pour sa patience et ses conseils tout au long du processus de compilation. Nous avons bien hâte de participer à la XXVIIe Conférence cartographique internationale, « Les cartes pour relier le monde », en août 2015, à Rio de Janeiro au Brésil. ❑

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Education and training on Web mapping and the geospatial Web

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This paper presents the content of two courses on Web mapping and the geospatial Web for geographers and geoscientists, formulated after a continuous development and delivery in several European and Canadian institutes since 2007. The author wishes to share the challenges and opportunities as well as the experiences and perspectives with educators around the globe who either consider the introduction of a relevant course to their institute curriculum or offer relevant courses and seek ideas for revision of content and teaching practices.

Cet article présente le contenu de deux cours sur la cartographie en ligne et les services géospatiaux en ligne pour les géographes et les géoscientifiques, rédigés suite à un développement et une mise en application continuels dans plusieurs institutions européennes et canadiennes depuis 2007. L'auteur souhaite partager les défis auxquels il a fait face et les occasions qui se sont présentées, ainsi que ses expériences et ses perspectives, avec les enseignants autour du monde qui considèrent l'introduction d'un cours pertinent au curriculum de leur institution ou qui offrent des cours pertinents et qui sont à la recherche d'idées pour la révision du contenu et des pratiques d'enseignement.

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1. Introduction

Geographic information science and technology (GIS&T) education has evolved drastically over the last thirty years. The complex and dynamic interaction between technology, the GIS industry, and academia [*Unwin et al*. 2012b] transformed the niche courses in a small number of academic departments of the '80s into the ubiquitous GIS&T courses of today, that are offered in almost all geography and environmental studies programs, as well as many other disciplines in social studies, humanities, education and business [*Tate and Unwin* 2009; *Sinton* 2012]. The GIS&T Body of Knowledge [*DiBiase et al*. 2006] is one of the most significant achievements in GIS&T education. It provides a systematic thematic catalogue with the learning outcomes for the discipline, and can support the development of sound curricula. On the other hand, the great breadth of the GIS&T Body of Knowledge makes it difficult to know what to include in a particular course or module [*Foote* 2012].

Web mapping and the geospatial Web is a fast evolving area in cartography and geomatics. The concepts associated with this area were already reflected in GIS&T Body of Knowledge [*DiBiase et al*. 2006] and further elaborated in GIS&T version 2 [*Ahearn et al*. 2013]. At the same time, the emerging need for education and training of students and professionals in this area over the last decade, has led to the development and delivery of relevant courses worldwide (e.g., *PennState* [2012]).

This paper summarizes the challenges, practices and outcomes of a seven-year experience in the education and training of senior undergraduate and graduate geography and geomatics students in European and Canadian institutes in web mapping and the geospatial Web. This includes the development and delivery of multiple courses in both class-based and online mode, which were recently formulated into the syllabus of two courses: an introductory and an advanced course. Lately, the introductory course has also been transformed into online mode.

The challenge in teaching a web technology course to students with limited skills in programming and computer networks has been alleviated by applying various innovating developments in

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teaching, such as open educational resources, web-based instructional materials, and active pedagogy techniques [*Schultz* 2012; *Balram and Dragicevic* 2008]. Enthusiasm overwhelms the students, within the first couple of weeks in the introductory course, when they realize that building web applications is feasible even with limited computer programming background. Upon completion of the course(s), students recognize the value and declare willingness to deepen their technical knowledge into advanced topics on web mapping and the geospatial Web. As for the instructor, it is encouraging to see the students building neat web applications, and kindly competing for the best outcome, often including methods and tools never taught in class to enhance functionality.

This paper is structured as following. Section 2 presents the challenges and opportunities in developing and delivering courses on web mapping and the geospatial Web. Section 3 and 4 portray the syllabus of the introductory and advanced courses, respectively. Section 5 presents the online version of the introductory course, which was recently released. Section 6 comments on the learning paradigms used and highlights the experiences gained after teaching these courses. Finally, Section 7 concludes the discussion and presents the author's future plans.

2. Challenges and Opportunities

The design of a web course for geography and geoscience students has many challenges as they usually have limited programming skills. However, there are exceptions as most students have taken at least one introductory course in programming or are familiar with GIS and Remote Sensing software packages, in combination with being advanced Internet users. In addition, they are acquainted with the spatial dimension, the spatial reference and projection systems as well as the spatial data sources available on the Web.

The development of applications on the Web requires some basic knowledge in computer network infrastructures as well as programming skills in script languages. One of the main challenges is that there is not enough time and space for the teacher to initiate the students into these technologies. On the other hand, web technology, although sophisticated, has some features that ease its understanding by non-experts in computer science.

For instance, XML-based languages are human readable and built on top of constructs that are few and simple (i.e., element and attribute). In addition, script programming (e.g., JavaScript) is easy to understand and portable from one application to another. The option to browse the source code behind the web pages also helps non-programmers to catch up on missing knowledge when trying to build their own web maps. Apparently, the fascinating tutorials and example pages built for developers (e.g., Google and OpenLayers Development Examples) encourage non-programmers to improve their skills in building advanced web mapping applications.

All these tools and resources have been incorporated in the course content (in both the lectures and labs) to support a blended learning approach [*Bersin* 2004]. These practices turned out to be very efficient and led to rather positive experiences as is explained in Section 6.

The following assumptions have been made in the development of the courses:

a) senior undergraduate and graduate students with a major in geography, geomatics or a relevant subject take the course;
b) students have limited or no experience in programming, markup languages, computer networking and web technologies;
c) each course will consist of a dozen of lectures and lab sessions as a regular term-long course; and
d) each course will be implemented in free and open source tools, so that there is no need for purchasing any software.

Regarding the latter assumption, it is important to note the risk of disservice to students by excluding proprietary software. To remedy this, the instructor should clearly explain to the students that proprietary software provides advanced solutions and support to the development of geospatial web applications. Links to proprietary software resources and example solutions must be provided to the students throughout the courses.

The course syllabuses presented in the next sections are the outcome of an evolution from a series of courses, tutorials and seminars delivered by the author in several European and Canadian institutes, mostly to geography and geomatics students, since 2007. Specifically, the author has taught:

a) a senior undergraduate course entitled "Special Studies in Digital Mapping," in the Department of Geography at Harokopio University of Athens (2007–11, annually);

b) a graduate course entitled "Web Mapping and Spatial Data Infrastructures" in the Department of Geography at Harokopio University of Athens (2007–11, annually);
c) a graduate seminar on Geospatial Web in the Department of Informatics at the University of Piraeus (2007–11; twice);
d) a graduate seminar on Web Mapping and Map Mashups in the Department of Geography at the University of Aegean (2009; once);
e) a graduate seminar on Geospatial Web in the School of Rural and Surveying Engineering at the National Technical University of Athens (2010; once);
f) a module on Web Services as part of a distance-learning course entitled "Advanced Geographic Databases" at the BW Munich and University of Nova Lisbon under eduGI program [eduGI 2007] of eduGI network (2007–14; annually);
g) a tutorial entitled "Web Services for Mapping" in the 3rd International Conference on Internet and Web Applications and Services [*Stefanakis* 2008];
h) a technical elective course (addressed to senior undergraduate and graduate students) entitled "Web Mapping and Geospatial Web" in the Department of Geodesy and Geomatics Engineering at the University of New Brunswick (2011–13; annually); and
i) a graduate course entitled "Geospatial Web" in the Department of Geodesy and Geomatics Engineering at the University of New Brunswick (2013–15; annually).

The most recent proposal of the author for the education and training of web mapping and the geospatial Web has been formulated to [*Stefanakis* 2013a,b]:

a) an introductory course entitled "Web Mapping and Geospatial Web Services;" and
b) an advanced (follow up) course entitled "Geospatial Web."

The next two sections present the syllabus of these two courses.

3. Introductory Course

The objectives of the introductory course are the following: Web Mapping and Geospatial Web Services," can be summarized in the following lines, which are aligned to the GIS&T BoK [*DiBiase et al*. 2006] learning objectives: "The course focuses on both the theoretical and practical issues related to the dissemination of mapping/geographic content on the Web and the development of map mashups and geospatial web services. Students will learn how to design and implement advanced web mapping applications and geospatial web services using free software tools. Special attention will be given to the recent technological developments and research directions."

As for the structure, the course consists of two parts: (Part I) Lectures: a series of presentations on the basic theoretical issues related to web mapping and the geospatial web services; and (Part II) Lab Sessions: a series of exercises focusing on the practical issues related to the dissemination of mapping/geographic content on the Web and the implementation of geospatial web services. After each lecture/lab session, students will be receiving an assignment to get acquainted with the methods and tools taught in the classes and labs alike.

3.1 Hardware, Software and Data Requirements

Regarding the hardware requirements, the instructor needs to have access to a computer with an Internet connection and the ability to install free software, including web server software (e.g., Apache) and ftp server software (e.g., Filezilla). Similarly, the students also need to have access to a computer (a regular PC or laptop) with both an Internet connection and the ability to install free software.

Table 1 summarizes the software requirements for instructor and students in the introductory course. All software components are free and most of them are open source [*OSGeo* 2014].

Table 1: Software requirements for the introductory course.

Server side (Educator)		Client side (Students)	
Role	**S/w Name**	**Role**	**S/w Name**
Web Server	Apache	Web Browser	Google Chrome, Mozilla Firefox
Scripting Language Compiler	php processor	Desktop GIS	Quantum GIS
Map Server	MapServer, GeoServer	Desktop KML Visualizer	Google Earth
Map API - JavaScript Library	OpenLayers	XSLT Transformer	Kernow
Catalog Server	GeoNetwork	FTP Client	Filezilla Client
Database Server	PostgreSQL/PostGIS		
FTP Server	Filezilla Server		

An easy solution for an instructor with a Windows PC is to install the ms4w (MapServer for Windows) available at *MapTools* [2014]. This is a no fuss installer, which quickly installs a working environment for Apache (web server), php processor (server-side compiler), and MapServer (map server software). In addition, the instructor needs to install Filezilla (FTP server), GeoNetworks (catalog server) and GeoServer (map server; usually installed along with GeoNetworks). Optionally, the instructor may also install ProstgreSQL/PostGIS (geographic database server) and download the OpenLayers Javascript library (Map API library).

The students need to install only Quantum GIS and Google Earth (desktop clients), as well as Kernow software (XSLT transformer). Optionally, they can install Filezilla (FTP client), as alternatively they may ftp their files to the server through any file manager. Apparently, a web browser is already available in their computer. If the browser does not support SVG (latest versions do), a free SVG viewer (e.g., from Adobe) needs to be installed as well.

Figure 1 shows the framework of the student's interaction with the course server. Each student is allocated some disk space on the server side. The student is then able to upload data and applications on the server through the ftp protocol. The uploaded content can be accessed through the HTTP protocol as well. Hence, all functionality of the server software can be exploited by the student. Figure 2 shows the location of the students' disk space on the course server for an installation with ms4w on Windows operating system.

In regards to the data requirements, the students need a few shapefiles of the same region (e.g., road network, towns and counties of a province) in order to complete their assignments. Similarly, the instructor also needs a few shapefiles for running the labs. If shapefiles are not available, they can be downloaded from some public servers (e.g., Geobase: *http://www.geobase.ca/* for Canadian data). Optionally, the instructor may have some

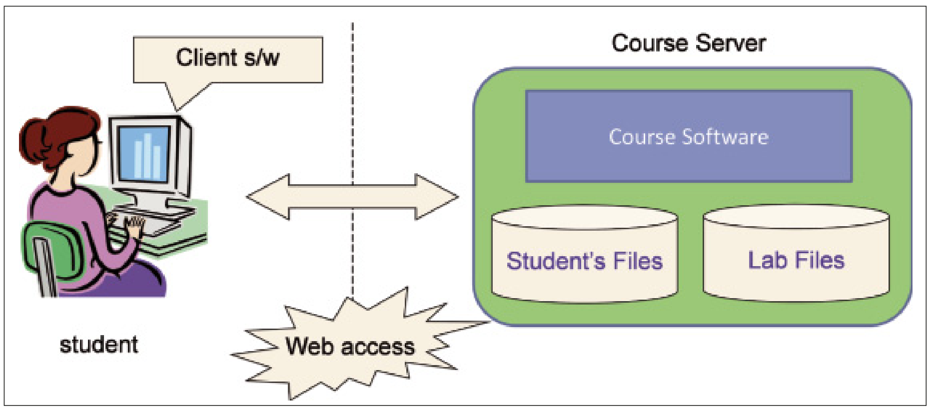

Figure 1: Student's interaction with the course server.

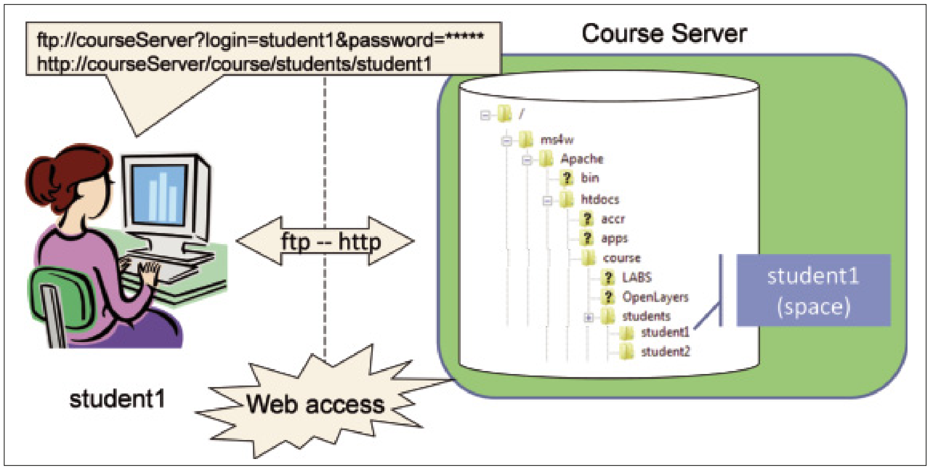

Figure 2: The student has access to allocated space on server disk through ftp and http protocols.

layers available in a PostgreSQL/PostGIS database and show the students how various methods in web mapping and web mapping services can retrieve and disseminate content that resides in a geographic database. Most of the Lab sessions and assignments make use of data available in Earth browsers (e.g., Google Maps, OSM) or raster image providers (e.g., GeoBase Landsat images repository).

3.2 Course Content

The introductory course content is summarized in Table 2. The topics have been organized in a block of 11 sessions, which fits well in a regular term (a term usually has up to 13 sessions) and gives room for a couple of sessions for course overview, midterm, review and tutoring, if needed. As mentioned previously, each session consists of a lecture and a lab; and concludes with an assignment to the students, which is due at the next session.

Weekly sessions of 3 hours duration each combining lecture and lab are recommended. Each session should begin with the presentation of the students' work on the assignment of the previous session, followed by the lecture and lab of the week. The following subsections highlight the topics of the 11 week block (Table 2). The sessions may be grouped into two parts. Part I includes weeks 1–6 and mostly focuses on web mapping languages, methods, and tools. Part II includes weeks 7–11 and proceeds to more advanced topics on the geospatial Web including spatial data infrastructures and web services for mapping.

3.2.1 Web Mapping: Weeks 1 to 6

The scope of the first part (Part I) of the course is to get the students acquainted with the basic technologies involved in web mapping applications. A series of web languages, methods, and tools are explained to the students in simple terms and through a series of examples. The following paragraphs briefly describe each session (week) in terms of lecture content, lab exercise and assignment to the students.

The first session of the course (week 1) begins with an introductory presentation on web mapping and the geospatial web services. The basic concepts of client-server architecture, computer networking, web communication, TCP/IP and HTTP protocols, and HTML language are also discussed using simple terms and various examples. The lab session focuses on the basic constructs of HTML language.

Table 2: Lecture/Lab Sessions and Assignments of the introductory course.

Week	Lecture/Lab Topics	Assignments
1	Course Overview – Computer Networks & Web Concepts. Introduction to HTML and HTML Scripts. Clickable Areas in HTML.	Create an HTML page with hyperlinks, tables, bullets, images, buttons/actions, etc. Include a map as image with clickable areas (hyperlinks).
2	Introduction to XML (Language & Technologies). Geo-XML languages (GML, SVG, KML). XSL Transformations (XML2XML & XML2HTML).	Enrich the page in Ass.1 with an SVG script/map (vector graphics & animation). Convert a SHP to KML using QGIS. Show on Google Earth.
3	Introduction to Web Feeds (RSS and Atom). Geographically tagged Feeds (GeoRSS: Simple & GML). Introduction to Mashups (Categories & Applications).	Compose a GeoRSS feed and visualize it using OpenLayers RSS Visualizer Example. Convert RSS to KML using XSLT. Show on Google Earth.
4	Map Mashups (Web-based & Server-based). Google Maps API – Google Code (Maps) Playground. Introduction to JavaScripts (client-side processing).	Create a Visualizer (in HTML+JavaScripts) for KML & GeoRSS files on top of Google Maps using Google Maps API. Visualize the files of Ass.3.
5	Introduction to php (server-side processing). Combination of php with JavaScripts. php & Google Maps API.	Create an HTML form which accepts values (eg., KML file name or location X,Y). Post values to a php script to generate an HTML page with Google Maps API JS.
6	Introduction to Web Services & Example Services (GeoNames). Implementation of Web Services using php. Web Services for Data Management (Google Fusion Tables).	Create a service in php to respond to unclear URL requests (similar to GeoNames services). Create your Fusion Tables and visualize content using GMaps API.
7	Web Services for Mapping & Example Services (GeoBase). OGC Services: WMS, WFS and WCS. Introduction to MapServer and the mapfile.	Create the WMS, WFS and WCS Services for a set of shapefiles using MapServer (compose the corresponding mapfiles). Visualize content in QGIS.
8	Thin and thick (desktop) Web Clients. Examples. Introduction to OpenLayers JavaScript Library. Development of a thin client for Web Services in OpenLayers.	Create a thin Web in OpenLayers. Activate and visualize the web services in Ass.7 using this client. Create various base maps and overlays on the client.
9	Introduction to Spatial Data Infrastructures (SDI). Catalog Servers, Geoportals & Gateways. Metadata Standards (DC, ISO19139, FGDC) & Services (CSW).	Create the metadata items (ISO19139) of two data sets in GeoNetwork server. Search them with various constraints. Access the items through CSW requests.
10	Geospatial Processing Services (OGC Web Processing Service). JavaScript Object Notation (JSON & GeoJSON). AJAX (Asynchronous JavaScript & XML/JSON) Model.	Create a WPS Service in GeoServer. Use the WPS Request Builder. Simulate an Ajax model with php, HTML and GMAP API JavaScripts.
11	Introduction to ArcGIS Online. Google Maps API Web Services (Distance, Geocoding, etc.). Bing Map App SDK. OpenStreetMap Collaborative Project.	Publish your data on ArcGIS Online. Create an HTML page with GMAP JS to implement two GMAP API Web Services. Create an OSM visualizer in OpenLayers.

The source code of a simple HTML page with a head and a body, including title, headers, paragraphs, images, internal and external hyperlinks, lists, tables and simple styling tags (CSS) is explained to the students. Furthermore, it is shown how HTML supports hyperlinks on top of images and maps (clickable areas), in addition to some example HTML scripts used to create buttons (radio or clickable) with actions attached to them. The students are exposed to the HTML specification and some representative tutorials on the Web. In addition, an HTML authoring tool is presented to them (e.g., MS Expression Web 4; currently available for free), to make them aware of the technology. The assignment of this session focuses on HTML. Students are asked to create an HTML page, presenting a site (e.g., a university campus, a touristic resort, or their home town) with various components (e.g., paragraphs, hyperlinks, tables, buttons, etc.), and a map with clickable areas. Although rarely done in practice, students are encouraged to use a simple text editor (e.g., MS Notepad or Notepad++) and compose the HTML source code manually, to get acquainted with the HTML language.

The second session (week 2) provides an introduction to XML language and family of technologies. The complementary role of XML (content) and HTML (presentation) languages is highlighted. In simple terms and through a series of examples, the basic constructs and concepts of XML (element, attribute, idref and nesting) are explained to the students. The discussion also includes the concept of self-description and the role of XML-schemas (DTD, XSD and Application Schema in GML). Then, various XML query languages and the XSLT transformation are described. The need for XML2XML and XML2-HTML transformations is highlighted, moving the discussion forward to XML languages for geography. These include three common (Geo-XML) languages: GML, SVG and KML. The schema and expressive power of these languages are described briefly. The lab focuses on the three Geo-XML languages. Several examples are shown to the students, while they are briefly exposed to the specifications and some representative tutorials on the Web. Kernow open source system is introduced to the students for XML2-XML and XML2HTML transformations. The assignment focuses on SVG and KML languages, as GML will be used later in the Web Services Session (WFS). The students are asked to enrich the page of assignment 1 with an SVG script, representing the site chosen with vector (points, lines and polygons) items, plus the movement of a visitor to the site (use of SVG animate method). In addition, students are asked to transform a shapefile to KML format using Quantum GIS plugin, examine the outcome of the transformation, and visualize it on Google Earth. This raises an interesting discussion on the spatial reference system of the source and target (WGS'84) files. Students will experiment XSLT transformation in the next session.

The third session (week 3) focuses on web feeds and the two popular standards: RSS and Atom. The need for web feeds is highlighted and the use of web feeds in smartphones is demonstrated. Surprisingly, most students have never used web feeds before. The discussion moves forward to geographically tagged feeds and specifically to GeoRSS. The two versions of GeoRSS are discussed: simple and GML. The lecture concludes with an introduction to mashups, including the mashup categories (not only map mashups) and several representative applications for each category. The lab focuses on the creation of a GeoRSS feed and its visualization on a GeoRSS visualizer (implemented in OpenLayers). The assignment requires the composition of a GeoRSS feed and its transformation to KML, so that it can be visualized on top of Google Maps. This is an XML2XML transformation, which will be executed in Kernow software that was introduced the previous session.

The fourth session (week 4) focuses on map mashups. After a demonstration of some representative examples, the API technology is introduced. Then, Google Maps API is presented. The students are given a short introduction to JavaScript and exposed to the Google Maps Developers' code examples. Through these examples, students can realize how both JavaScript and Google Maps API work. The lab focuses on a series of example HTML pages integrating GMAP API JavaScript to include Google Maps and add content and functionality on top of these maps. The assignment asks for the creation of a visualizer in HTML for GeoRSS and KML files on top of Google Maps, using the Google Maps API.

Next session (week 5) sets off with a distinction between client-side and server-side processing. Php (server-side) processor and language is introduced and compared to JavaScripts. A series of representative web mapping applications, built using merely either JavaScripts or php as well as a combination of these two, are demonstrated to the students. The lab presents some simple php scripts fed by HTML forms to the students. Some basic php processing functions as well as HTTP

GET and POST methods are explained. The option of combining php scripts with Google Maps JavaScript in web mapping are highlighted through simple example pages. The assignment of this session asks for the creation of an HTML form where a user can type the values for some parameters, such as a KML file name or the coordinates (X, Y) of a location. The values are posted to a php script running on the server to generate an HTML page with Google Maps API JavaScript.

The sixth session (week 6) proceeds further to the use of php scripts in the creation of web services. The lecture starts off with an introduction to web services. GeoNames server is used as an example server with rich content and an extended list of services. The discussion proceeds to the use of php in the creation of web services. Finally, a novel web service for data management, provided by Google and named Fusion Tables (available in Google Drive), is introduced to the students. The lab presents a series of example php scripts implementing various services, such as computing the distance of two points or reporting the population of a town. The content (if any) of the service resides in either the script itself or the tables of a PostgreSQL/PostGIS database. The php methods to access and query the database are also described and the input parameters to the php script are passed through an unclear URL. The output of all services is always served in XML format. The lab also includes an introduction to Fusion Tables with instructions to import, query and visualize CSV and KML data. The assignment requires the creation of a service in php to respond to unclear URL requests and perform some kind of calculation. In addition, the students are asked to create a Fusion Tables database and visualize its content using customized HTML pages with the corresponding Google Maps API JavaScripts in order to access the Fusion Tables.

3.2.2 Geospatial Web: Weeks 7 to 11

In the first six sessions (Table 2), the students have already built up a foundational knowledge of client and server-side processing, languages and protocols used in web mapping as well as web services. Hence, they can proceed to more advanced topics on the geospatial Web, including spatial data infrastructures and web services for mapping.

Figure 3 shows an example architecture of a spatial data infrastructure (SDI). This architecture is compatible with the proposal for GeoFOSS SDI [*Ticheler* 2007], and it has been adopted in the development of SDIs in the past [*Stefanakis and Prastacos* 2008a,b]. At the bottom layer, reside the SDI repositories. The geospatial layers can be available in shapefiles, geotiff images or Postgresql/PostGIS tables. In the middle layer (middleware), reside all the services that assist the accessibility to the data repositories. The SDI

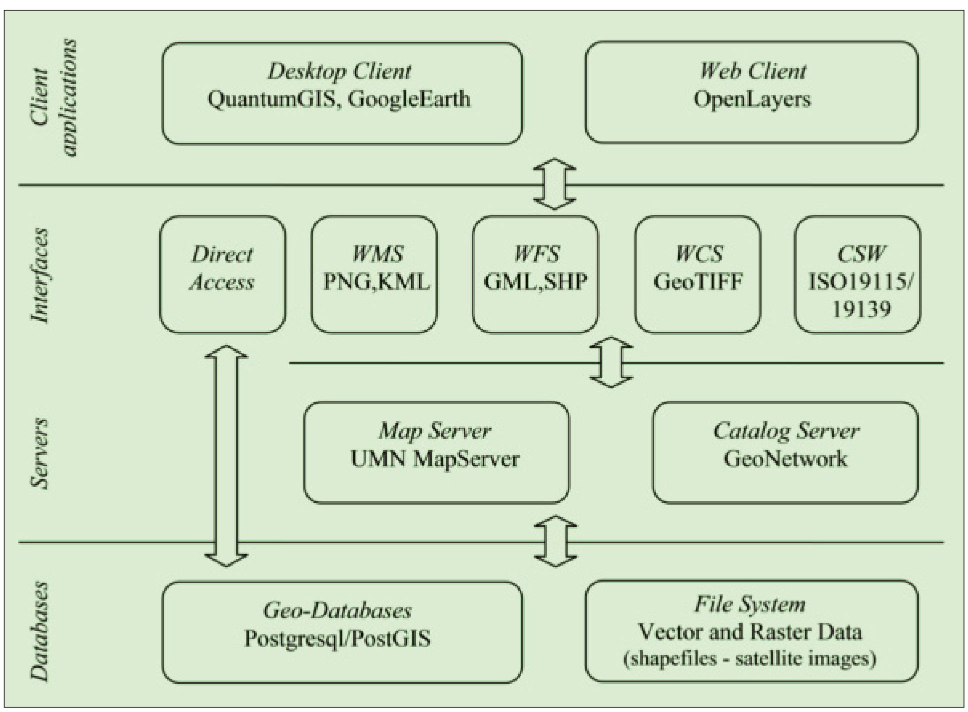

Figure 3: Example architecture for a spatial data infrastructure.

has two main servers, i.e., the map server and the catalog server. These two servers provide (serve) the geospatial content on the Web, based on standard interfaces (e.g., WMS, WFS, WCS, CSW–ISO19115/139). At the top layer (the client), reside the users and applications. The access to the SDI geospatial content is possible through either a desktop (thick) or a web (thin) client. These clients and the corresponding visualization capabilities are accessible by the SDI users.

The main scope of the next few sessions is to let the students become acquainted with the technological aspects of an SDI (basically, disseminate geographic content on the Web using widely accepted standards) through the development of a framework with an architecture similar to the one shown in Figure 3.

Specifically, the seventh session (week 7) focuses on the generation of web services for mapping. Students already know how to implement a service, and can therefore readily realize that to query a service, some knowledge of the service structure is required. The lecture highlights this issue, and makes clear the need for standardization of requests to map services. OGC standards for web services (WMS, WFS and WCS) are described. The corresponding requests per service (GetCapabilities, GetMap, GetFeature, GetCoverage and GetFeatureInfo) are explained. The students are exposed to example web services for mapping (e.g., GeoBase server). The lab session makes use of MapServer software to implement the WMS, WFS and WCS interfaces in Figure 3 for a set of shapefiles and PostGIS tables [*Stefanakis and Prastacos* 2008a]. The structure of the Mapfile used in MapServer to implement the services is described. The response of requests is visualized in the web browser (as image or GML file) and in a desktop (thick) client (e.g., Quantum GIS). The assignment of this session asks the students to create the WMS, WFS and WCS services for a set of shapefiles using MapServer (which is available at the course server).

The eighth session (week 8) introduces the thin web clients and a JavaScript library to implement them. The lecture makes a clear distinction between thick (desktop) and thin (web browser) clients and highlights their advantages and disadvantages. Then it introduces the OpenLayers JavaScript library and examines closely some representative example codes. The lab presents the implementation of a thin web client with multiple base (Google Maps, Satellite, OSM, etc.) and overlay (GeoBase; or WMS, WFS and WCS services implemented in session 7) layers. The assignment requires the creation of a thin web client on top of the web services developed in the previous session using OpenLayers and including multiple base layers from various Earth providers (Google Maps, OSM, etc.).

Next session (week 9) introduces the spatial data infrastructures (SDI) and focuses on the metadata items and geoportals. Specifically, the lecture sets off with the description of an SDI and its architecture (Figure 3). The students realise that they have already built part of an SDI in the previous two sessions. The discussion proceeds to the need for metadata, catalog servers, and geoportals in an SDI. The basic metadata standards (DC, ISO19139, FGDC) are introduced. Then, OGC catalog service for the Web (CSW) is described. The lab presents GeoNetwork Opensource software and shows how a catalog server and the corresponding CSW services can be implemented for a couple of layers and services used in the previous sessions. The assignment asks the students to create metadata items for their layers and services implemented in the previous sessions. Then they need to create an interface to access the catalog though CSW requests.

The last two sessions (weeks 10 and 11) are reserved for some advanced and/or relevant topics as well as some recent developments in the geospatial web industry. The content of these two sessions is dynamic and depends on the availability of time in the term. The following topics are of high priority (Table 2): OGC WPS Service, JSON and GeoJSON languages, AJAX model, ArcGIS Online, Google Maps API Web Services, Bing Map App SDK, and OpenStreetMap collaborative project. These topics are accompanied by lab exercises and relevant assignments (Table 2).

4. Advanced Course

The content of the advanced course— entitled: "Geospatial Web"—is summarized in Table 3. This course was designed with the assumption that the introductory course (Section 3) be a prerequisite. Hence, students taking the advanced course have a good background on web mapping and the geospatial web services, as of Table 2.

The content of the advanced course is focused on the key methods and technologies that turn the traditional Web into an interoperable framework, easily interpreted by machines and software components. Through this content, students get a deeper understanding of the web mapping services and tools that comprise the geospatial Web.

Table 3: Lecture/lab sessions and assignments of the advanced course.

Week	Lecture/Lab Topics	Assignments
1	Course Overview – Open Geospatial Consortium (OGC). OGC and ISO Standards. OGC Abstract Specification and OGC Reference Model.	Develop a WMS-Time Service on MapServer to disseminate the content of an ST shapefile. Extend the service with the GetFeatureInfo functionality.
2	Geography Markup Language (GML). ISO19100 Series and GML. GML 3.2 and 3.3 Specifications. GML Schema, Profiles and Application Schema. GML Validation.	Create a prototype CSV2GML converter in php for point features. Test the prototype using the csv file of a point shp. Validate the gml/xsd files in Kernow.
3	CityGML application schema. Advanced Web Mapping Services: Transactional Web Feature Service (WFS-T). Web Services technologies (SOAP/USDL/UDDI) vs RESTful services.	Create the 3D Model of a UNB Building in SketchUp. Use plugin to (a) export the model into CityGML; and (b) visualize (import) the CityGML in SketchUp & GE.
4	Introduction to Semantic Web. Limitations of traditional web. Introduction to Semantic Web impact and technologies. Search XML documents using XPATH.	Use XPATH to extract data from the response of Google Map API Web Services. Create a navigation tool using GMAP JS, GMAP WS and XPATH.
5	Describing web resources in RDF. Drawbacks of XML. Resources, properties, values (statements). RDF and RDF Schema. RDF in XML and RDF graphs. Common vocabularies.	Write an RDF file to link a unit (a person) to places on earth with descriptions in GeoNames database. Validate. Make use of geoRDF and other vocabularies.
6	Query language for RDF: SPARQL. SPARQL Specification. SPARQL query tools and example queries. GeoSPARQL Specification: vocabulary, operations and examples.	Extract information from the RDF file of Assignment 5 using SPARQL queries. Experiment with GeoSPARQL using an online tool.
7	Ontology languages. Introduction to Web ontology language (OWL). Limitations of RDF Schema. Reasoning support for OWL. OWL DL and RDF. Introduction to Protégé and reasoning.	Using protégé s/w browse the ontologies in Protégé Wiki. Choose one and present the classes, properties and individuals as defined or inferred by the reasoner.
8	Introduction to WebGL: Web Graphics Library. Advanced Geospatial Services: GeoClustering. Linked Open Geodata. LOD datasets, components and agents.	Using protégé s/w re-write the rdf file of Ass.5. Import ontologies, add your own classes, properties and individuals. Save the ontology in rdf. Validate.
9	Geolocation. IP addresses and IP locating. Databases and APIs. Geotagging, GeoSMS, and GeoURI. Standards for Gazetteers. Geospatial Metadata Standards.	Create an app for mobile devices using W3C Geolocation API and Google Static Maps API. It will report/visualize the location and distance from 3 POIs
10	Collaborative GIS and VGI. DBPedia and DBPedia Mobile. Crowdsourcing and Crowdmaps. Introduction to Ushahidi and services for validating and filtering real-time information.	Create a crowdmap in Ushahidi. Define the appropriate map settings, categories, and theme. Post reports and manage statistics.

The settings of the course are similar to those of the introductory one. Each session (week) includes:

a) a lecture on the technical foundations, enabling technologies and research directions of the geospatial Web;
b) a lab focusing on the practical aspects of the corresponding lecture; and
c) an assignment to the students on the session (lecture and lab) content.

All software components used are free or open source tools. In addition to those used in the introductory course (Table 1), students need to install into their computer the following packages: Protégé Ontology Editor and Knowledge Acquisition System, the SketchUp by Trimble, and a CityGML plugin for SketchUp. A series of web accessible tools are also used in the course, such as W3C RDF validator, KONA GeoSPARQL editor, XPATH Editor, etc. Students' deliverables are uploaded through the ftp protocol to the course server and are accessible for the instructor and all students through the Web (Figure 2).

The course content consists of three parts (Table 3). Part 1 (weeks 1–3) offers a deep understanding on interoperability issues, the role of standards, and the work undertaken by the Open Geospatial Consortium (OGC) and the International Organization for Standardization (ISO). Geography Markup Language (GML) and OGC Web Services, discussed already in the introductory course, are revisited and examined closely. The lab sessions include the WMS-time service, CSV to GML conversion, GML validation, CityGML application schema, and a two-way conversion among all three SketchUp files, KMZ, and CityGML.

Part 2 (weeks 4–7) introduces the semantic web concepts and technologies and their geospatial web dimension. Students get familiar with the basic semantic web languages, i.e., RDF and OWL, as well as some well-established vocabularies and ontologies such as FOAF, DublinCore, and GeoNames. The lab sessions include the compilation, validation, and visualization of RDF files in triples and graphs, the extension of existing vocabularies to describe the semantics of a geospatial domain on the Web, the definition and extension of ontologies in Protégé, and the inference of knowledge by applying appropriate reasoners. In addition, the XPATH (for XML files) and SPARQL/GeoSPARQL (for RDF files) languages are examined closely.

Part III (weeks 8–10) covers some advanced topics on the geospatial Web. Among them are geolocation services, crowd maps and services, and WebGL graphics library. A series of labs have been developed to get the students acquainted with these topics and the representative systems (Ushahidi) and services (Swift River). Obviously, there is much more that could be included into Part 3, such as geosensor web standards, as well as new technologies that are being developed in this rapidly-evolved area. These can be considered in future versions of the course.

5. *Online Course*

Due to the increasing demand for online courses in academia and the nature of the topic, the development of an online course on web mapping and the geospatial Web has always been a main goal of the author. Recently (as of December 2014), the development of an online course—mostly based on the content of the introductory course—has been concluded.

The course is designed for students with previous experience in geographic data handling using Geographic Information Systems (GIS) and other mapping tools but limited skills in computer programming and networks. The potential students include senior undergraduate and graduate students, as well as professionals with expertise in geomatics, geography, forestry, earth sciences, geology, education, archaeology, history, etc., and an interest in building web applications and/or disseminating geographic and map data on the Web.

The course is being delivered as an open entry course through UNB College of Extended Learning, since January 2015 [*GGE5403* 2015]. It is offered as a university-wide course at various UNB faculties (e.g., Engineering, Forest and Environmental Management, Earth Sciences, Business, Biology, Education). In addition, the course is also open to non-UNB students through the Canadian Virtual University (CVU) network.

The instructor offers a welcome session in synchronized mode (using UNB Elluminate online training platform) within the first week of each month. The scope of this "personal contact" is to motivate the students as well as to provide guidance on how to use the online material and study for the course. If a student is unable to attend the synchronized session, s/he is able to watch a recorded session.

The course content is organized in 10 sessions (or modules) (Table 4). Each session corresponds to a 10-day workload of a regular 3ch course. Each session consists of (a) recorded lectures (slides and audio), (b) recorded labs (slides and audio), (c) tutorials and other reading material, and (d) an assignment. All teaching material is delivered through UNB Desire2Learn learning management system platform. Students will have access to a course server with a configuration similar to the one described in Section 3 (Figures 1 and 2).

After the submission of an assignment, the student gets access to the next session. The instructor

Table 4: Content and learning objectives of the online course.

Session	Lecture/Lab Topic	Learning Objectives After completion of this Session, students should be able to:
0	Welcome Session Course Content, Teaching Material Course Server, Learning Management Platform	understand the general topics and inter-relationships in the course; identify the location of the teaching materials and be able to use them; select needed infrastructure (software) for installation on local computers.
1	Introduction to Web Mapping HTML - Clickable areas in HTML Data Sources	understand the methods used to create interactive web maps; read and write HTML documents; create clickable areas with hyperlinks on top of scanned maps/images.
2	XML and JSON XML Family of Technologies (DTD, XSD, XSLT) Geo-XML (GML, SVG, KML) and GeoJSON	understand XML and JSON constructs and structure; describe geographic features in XML-based languages and GeoJSON; encode simple web mapping applications using SVG and KML.
3	Map Mashups Introduction to JavaScript Google Maps API	understand the Client-side processing; embed simple JavaScript code into HTML; use Google Maps API and create interactive maps and map mashups.
4	Introduction to php (server-side processing) Combining php with JavaScript Processing on both the Client and Server	understand the Server-side processing; embed simple php scripts into HTML and create HTML forms; pass parameter values to a server, report the results back to the client.
5	Web Services Google Maps API Web Services HTTP Requests and Unclean URLs	understand the Web Services; use Rest-compliant Web Services to retrieve content from services; create a simple Rest-compliant Web Service using php.
6	Web Services for Mapping Implementing WMS, WFS using MapServer MapServer and Mapfile	understand the Web Services for mapping; write WMS and WFS requests to consume content in Web Map Servers; set up a WMS or WFS Server and share their geo-content over the Web.
7	Thin and thick Web clients Introduction to OpenLayers JavaScript Implement a Thin Client using OpenLayers	understand the thin Web mapping clients; implement dynamic maps in Web pages using OpenLayers; integrate content from various mapping servers with own data.
8	Spatial Data Infrastructures (SDI) Catalog Servers and Services GeoNetwork OpenSource	understand the Spatial Data Infrastructures and Catalog Servers; attach standardized metadata items to a geographic resources; edit, post, search geo-resources using GeoNetwork catalog server.
9	GeoLocation API Combining GeoLocation JavaScript with Google Maps API	understand the GeoLocation API; integrate GeoLocation JavaScript into HTML; visualize GeoLocation results on top of Google Maps.
10	Web Maps using Online Tools ArcGIS Online, Google MyPlaces, Google Fusion tables, Google Earth, SketchUp	understand the online mapping tools; use ArcGIS online to share geo-content or create interactive maps; use Google Fusion Tables to manage geo-data, share, and visualize it.

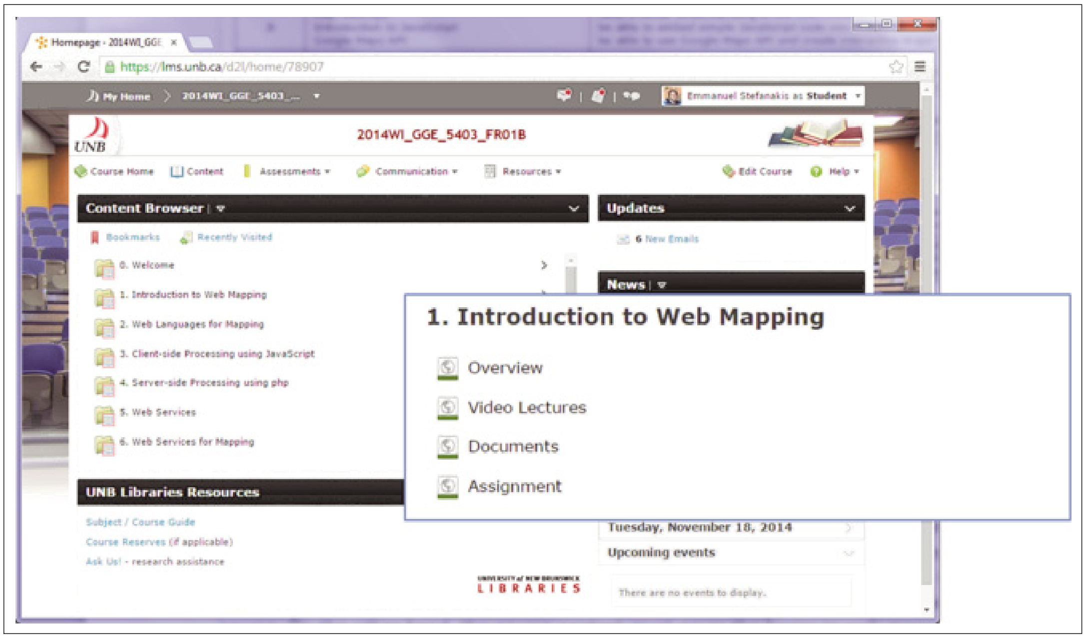

Figure 4a: Course content in the Learning Management System platform (UNB Desire2Learn).

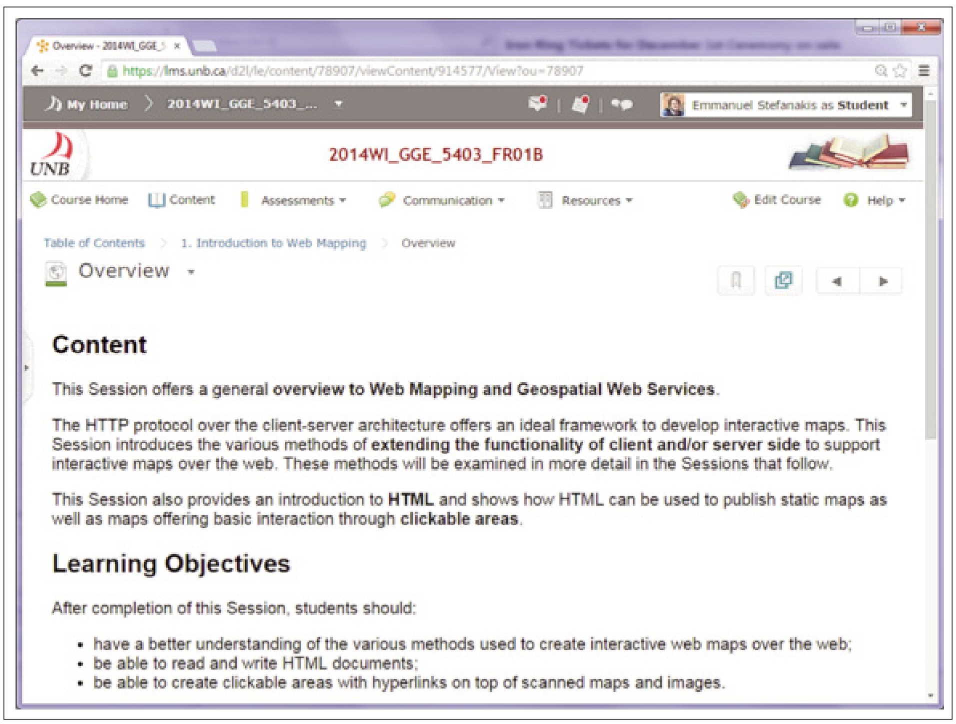

Figure 4b: Overview—Content and learning objectives.

evaluates and scores any submitted assignment within 7 days. The instructor provides assistance to the students throughout the course via email communication. A written or oral exam takes place after completion of the 10 sessions.

Table 4 summarizes the content of the 10 sessions along with the learning objectives per session. Figure 4 shows the structure of Session 1 in the learning management system platform (Desire2-Learn). The content of each session is organized into four sections (Figure 4a):

a) Content and Learning Objectives (4b);
b) Documents, which also include four subsections (4c): slide presentations, lab examples, tutorials and further reading;

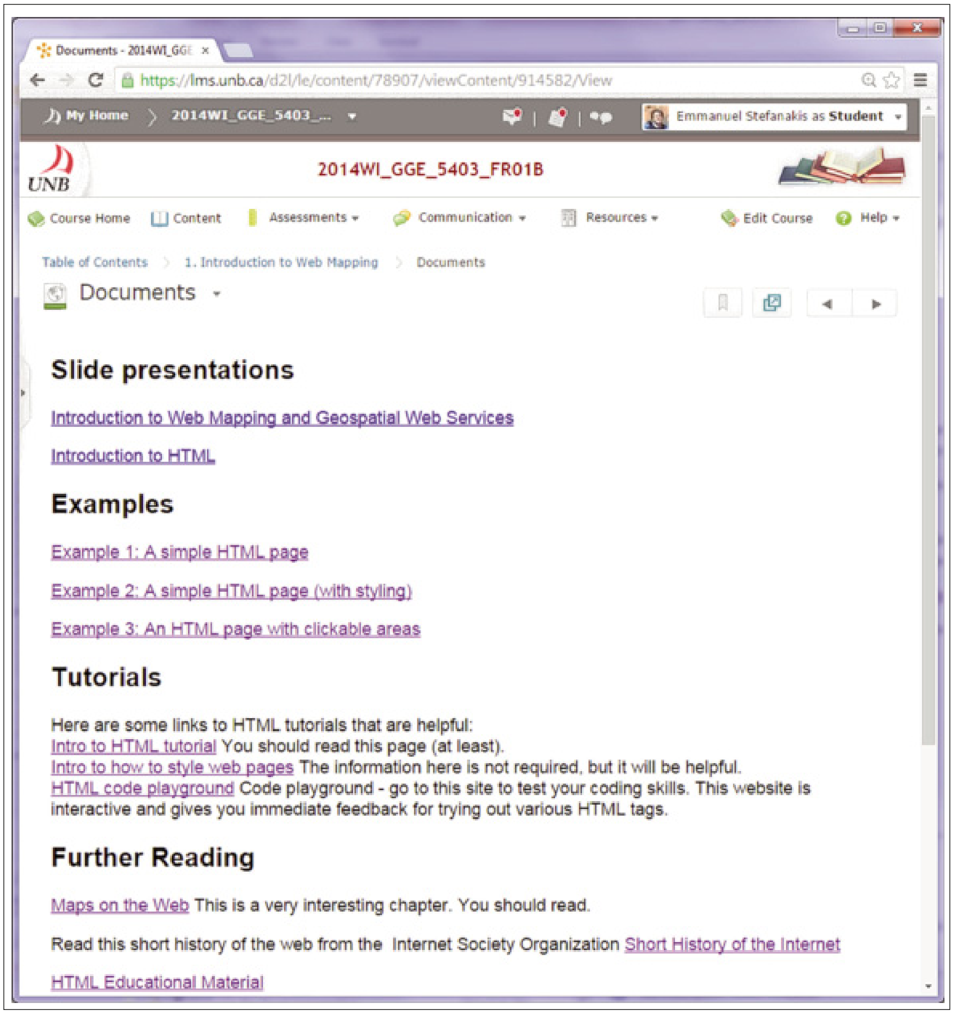

Figure 4c: Documents and its subsections: slide presentations, lab examples, tutorials and further reading.

Figure 4d: Video lectures.

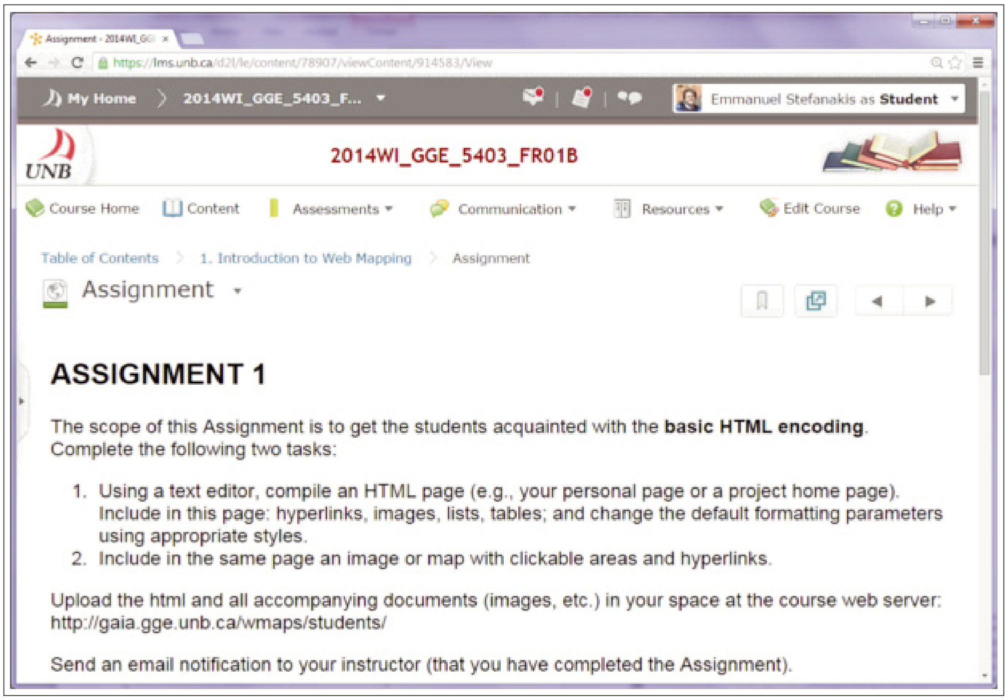

Figure 4e: Assignments.

c) Video Lectures; and
d) Assignment.

6. Practices and Experiences

As explained in Section 2, the main challenge in running a web mapping and geospatial web course is how to make the students acquainted with the technology and the tools, while at the same time avoid spending time in teaching fundamentals in informatics, such as programming techniques, computer networking, communication protocols, etc. There are some contradictory facts in order to achieve this. On one hand, the students have limited background in informatics, which seemingly is a barrier in teaching them such a course. On the other hand, the course content is wide and should fit in a term, consisting of a limited number of sessions.

Although it sounds unattainable, the blended learning approach followed in the design and delivery of the courses turned out to be rather successful. Blended learning [*Bersin* 2004] is an education basis in which the student's training combines delivery of content and instruction via digital and online media along with classroom (face-to-face) teaching (Figure 5a). This approach allows time for deeper class discussions and alleviates the content versus time limitations mentioned in the previous paragraph.

Various blended learning strategies have been applied in the two class-based courses. Each course session (week) includes both a lecture and lab session. The lecture focuses on the concepts and objectives of each method or tool taught, while the lab highlights these through examples. Then, students are encouraged, through an assignment, to experiment and learn based on active training. In addition, innovative open educational resources and web-based instructional materials (e.g., online tutorials, code playgrounds, and developers' code examples) are used to assist the students in the learning process. All teaching material (presentation slides, sample assignments, quizzes, practice tests, program codes, examples, etc.) and links to relevant resources (web and library resources) are available a week ahead (via UNB Desire2Learn learning management system platform) so that students can prepare before the class as well as elaborate and extend the learning process after the class (through further reading and work on the corresponding assignment).

Another practice applied in the courses and proven very effective, is the posting of the students' deliverables to the course server, in a space which is visible by all course participants, followed by a presentation in the class (in a weekly basis). This helps them to strengthen their skills and confidence in web application development. It is awesome for the instructor to realize that within the first couple

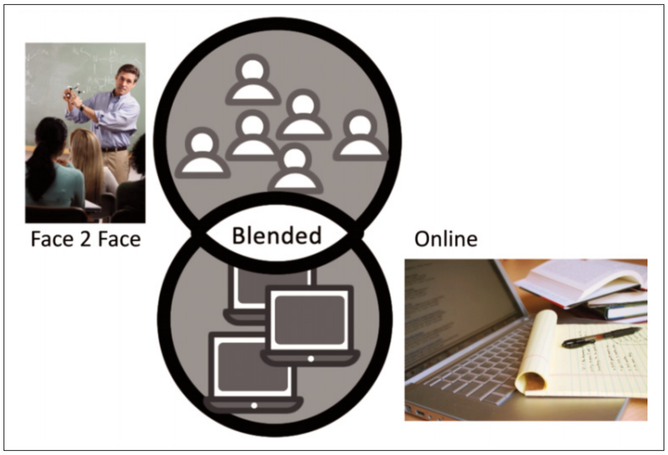

Figure 5a: The blended learning paradigm.

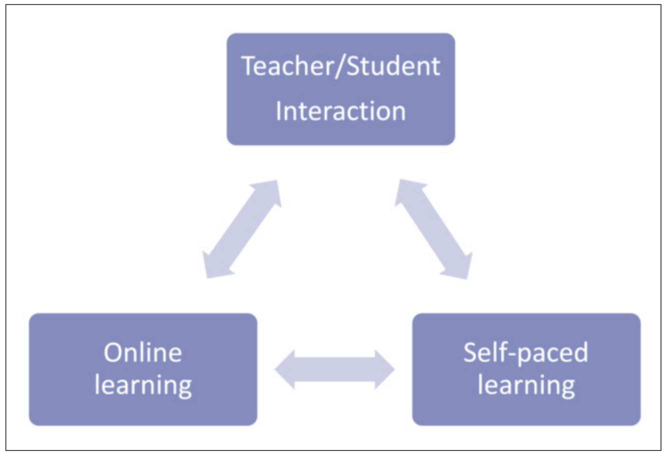

Figure 5b: Components of the online learning basis.

weeks of each course, a significant number of students (an average of 30% each year) produce deliverables of quality and kindly compete with each other for the best outcome.

A total of 150 students (80 senior undergraduate and 70 graduate students) have taken the introductory course as taught at Harokopio University of Athens, UN Lisbon, BW Munich, and the University of New Brunswick (Section 2), since 2007. With minor exceptions, the students assessed the course with a top mark for all aspects. Many of them stated that they really enjoyed the course, primarily because it helped them become familiar with the web mapping technology and strengthen their skills in web mapping programming. The instructor has taken care to collect their comments for improvements systematically, throughout the last six years. The students' comments were considered carefully and helped the instructor to evolve both the course content and teaching practices. The course syllabus, as summarized in Table 2, incorporates most of these comments.

The advanced course was taught twice so far and the results of the student opinion surveys were similar to those of the introductory course. The course has been taken by 25 graduate students (course and research-based Masters) from the Department of Geodesy and Geomatics Engineering. The instructor has received (verbally) very positive comments for this course from the majority of the students. Students expressed clearly that the advanced course offered them a better understanding of the geospatial web concepts and technology, while after completion they felt more confident about their web programming skills.

The online course is being delivered since January 2015. Student assessments are not available yet. However, the first five students currently (as of February 2015) enrolled in the course have already expressed many positive comments regarding both the course content and advantages of online learning. The online learning basis combines the instruction using various electronic (web-based) approaches with an active teacher/student interaction (Figure 5b). The latter can be synchronous or asynchronous. As explained in Section 5, the welcome session is offered in synchronized mode. The communication is then supported mainly through emails as well as blogs (asynchronous mode). Students can enjoy the self-paced learning (Figure 5b), which is limited to a maximum duration of six months (as of UNB/CEL regulations) to avoid any abuse.

In online learning, it has been observed that almost 40% of the students taking a given course fall behind on the material and as a result "they watch several weeks' worth of videos in one sitting" [*Mayer* 2001]. To prevent that, students need to submit an assignment for each session (week), and it is only after submission that they have access to the next session (Section 5).

The fast changes in technology remain a real challenge in running the courses, an issue which should be reflected in the syllabus as soon as possible. In the introductory course, two sessions (weeks 10 and 11) have been reserved to accommodate new developments and tools. In the advanced course, a similar approach applies for the last three sessions (weeks 8 to 10).

Obviously, the instructor must be checking the availability of web resources used in the courses, on a regular basis, as their providers might decide to cancel them at any time. This has happened quite a few times since 2007 for the material used in the introductory course. Some representative examples are:

a) the NASA JPL WMS service, which was not supported for a period in 2010, while currently it provides limited functionality;
b) the Integrated CEOS European Data Server (ICEDS), which was suddenly ceased in the summer of 2012; and
c) the Google Playground which has not been available since August 2014.

It is interesting to mention that case (b) happened while a course session on web services for mapping was running and the author was then forced to urgently change a series of examples built on top of ICEDS server to an alternative one (GeoBase server). As for the recent case of Google Playground, students are currently pointed to Google developers' examples.

7. Conclusion

The syllabuses of both an introductory and advanced course on web mapping and the geospatial Web, as evolved over a seven-year period, are introduced in this paper. The courses have been taught by the author in several European and Canadian institutes and were addressed mostly to geography and geomatics students at both a senior undergraduate and graduate level. At the same time, the author had active research in the area (e.g., *Stefanakis and Prastacos* [2008], *Stefanakis* [2012], *Pelekis et al.* [2012], *Tienaah and Stefanakis* [2014], *Muthu et al*. [2013], *Gupta et al*. [2014]) and a clear understanding of the technology as well as the learning objectives of such courses. The assessments (verbal and/or those of student opinion surveys) of over 200 students have been very positive and the experiences gained by the author very encouraging. An online course was recently released, with content mostly based on that of the introductory course.

The short-term goals for the future include:

a) a continuous improvement and update of the content and teaching practices;
b) the compilation of the teaching materials, lab exercises and assignments in a form that can be released to others as a sound educational resource; and
c) the delivery, collection of student evaluations, and improvement of the online course.

The long-term goals include:

a) the authoring of an up-to-date text book in the topic [*Stefanakis* 2009; *Stefanakis* 2008];
b) the development and delivery of the advanced course and the corresponding teaching materials in online mode; and
c) the incorporation of teaching modules on industry—standard proprietary software (e.g., *Esri* [2015], *Caris* [2015]) in the courses to provide the students a spherical training on web mapping and the geospatial web technology.

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Examining urban expansion in the Greater Toronto Area using Landsat imagery from 1974–2014

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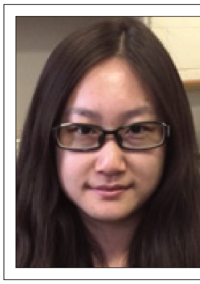
The Greater Toronto Area is the most vital economic centre in Canada and has experienced rapid urban expansion in the past 40 years. This research uses Landsat images to detect the spatial and temporal dynamics of urban expansion in the Greater Toronto Area from 1974 to 2014. We quantitatively analyzed the extent of urban expansion and spatial patterns of growth from classified Landsat images. We then integrated our expansion findings with population data to observe the relationships between urban growth and population. We found that the Greater Toronto Area had significant growth of 1115 km², expanding mainly in radiated and ribbon expansion modes. There was substantial correlation between urban extent and population in the period of study. These results demonstrate the efficacy of combining statistical population data with remote sensing imagery for the analysis of urban expansion.

La région du Grand Toronto est le centre économique le plus important au Canada et a connu une expansion urbaine accélérée au cours des 40 dernières années. Cette recherche utilise des images Landsat pour détecter les dynamiques spatiale et temporelle de l'expansion urbaine de la région du Grand Toronto entre 1974 et 2014. Nous avons analysé, sur le plan quantitatif, l'expansion urbaine et les tendances spatiales de croissance à partir des images Landsat classifiées. Ensuite, nous avons intégré nos résultats aux données de population afin d'observer les liens entre la croissance urbaine et la population. Nous avons déterminé que la région du Grand Toronto avait connu une importante croissance de 1 115 km² de même qu'une expansion principalement dans les modes en rayonnement et en ruban. Il y a eu une importante corrélation entre l'étendue urbaine et la population pendant la période étudiée. Ces résultats démontrent à quel point il est efficace de combiner les données statistiques de population et les images de télédétection pour analyser l'expansion urbaine.



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1. Introduction

Urbanization represents the absorption of less developed areas, such as agricultural and forest land, by built-up areas, such as residential and commercial land. Some researchers suggest that urban expansion is an indicator of a region's economic vitality [*Yuan et al*. 2005]. Urban expansion is typically a product of the development of suburban areas into high-density built-up areas and the replacement of rural areas with low-density built-up areas. Urban expansion not only affects the economics in the region, but also influences ecosystem balances, as reflected in changes in water quality and receding agricultural and forest areas [*Squires* 2002]. As a result, studies of urban expansion are quite important for local or regional planners, as well as policy makers in helping them to make reasonable and effective decisions for planning, environmental management, and land resources integration [*Yuan et al*. 2005; *Dewan and Yamaguchi* 2009].

Decision-makers require the latest geographical information on urban sprawl patterns in both quantitative and qualitative ways; therefore, it is important to keep geospatial information of urban expansion up to date. In recent years, remotely-sensed images have become a great data source for urban expansion research. There are an increasing number of studies that focus on using remote sensing technology to monitor urban dynamic changes. Some studies have shown that remote sensing can provide an accurate measure of land use and land cover (LULC) changes, which are able to represent urban expansion, especially at medium scales [*Yuan et al.* 2005; *Schneider* 2012; *Bagan and Yamagata* 2012]. Compared to traditional LULC monitoring methods, such as field surveys, remote sensing offers a more efficient, cost -effective, and less labor-intensive technique in detecting LULC changes. Mapping LULC changes at various spatial and temporal scales is facilitated using remote sensing techniques [*Elvidge et al.* 2004]. For instance, at small scales, the Moderate Imaging Spectroradiometer (MODIS) sensors can provide daily image products at 250 m and 500 m spatial resolution, and the Advanced Very High Resolution Radiometer (AVHRR) sensors can supply 1.1 km resolution images every 12 hours. Since the first Landsat satellite was launched in 1972 (initially as ERTS-1), the Landsat series of satellites have been collecting multi-spectral data at 80 m (1972–1982) and 30 m (1982–present) spatial resolution and at 16 or 18 days temporal resolution. Since they are easily accessible through the United States Geological Survey (USGS) Landsat Data Archive, and have relatively high spatial resolution and long historical data archive, Landsat images have been commonly used to detect LULC changes at different scales [*Manandhar et al.* 2009]. Images of Landsat Multispectral Scanner (MSS), Landsat Thematic Mapper (TM), Landsat-7 Enhanced Thematic Mapper Plus (ETM+), and Landsat-8 Operational Land Imager (OLI), were used in this study for collecting LULC change information for the study area.

Change detection is "the process of identifying differences in the state of an object or phenomenon by observing it at different times" [*Singh* 1989]. Change detection methods that have been used for analyzing dynamic LULC changes include Principal Component Analysis, Write Function Memory, and Change Vector Analysis [*Singh* 1989]. All these methods can be classified into pre-classification and post-classification techniques [*Yuan et al.* 1998], wherein the pre-classification methods produce change/non-change maps. Although they are effective at documenting overall change, they cannot demonstrate the nature of the information change [*Singh* 1989]. The post-classification algorithm requires the user to classify images before generating the "from-to" change maps. Although the accuracy of post-classification change detection methods rely heavily on the accuracy of classification results, thematic maps and valuable "from-to" change maps can be generated by the whole procedure of the post-classification method [*Fu* 2014]. As a result, many studies focusing on LULC change and urban expansion apply post-classification comparison change detection methods to identify specific categories of LULC, and thus explore the change pattern and change effect on the surrounding environment [*Abd El-Kawy et al.* 2011; *Yuan et al.* 2005; *Sundarakumar et al.* 2012; *Peiman* 2011; *Tan et al.* 2010].

In this study, the post-classification comparison change detection approach was used, necessitating the selection of an appropriate classification algorithm. Since unsupervised classifiers need a large amount of work during the post-classification period, various supervised classification methods have been developed, such as Minimum Distance [*Wacker and Landgrebe* 1972], Maximum Likelihood (MLC) [*Otukei and Blaschke* 2010], and Artificial Neural Network (ANN) [*Erbek et al.* 2004]. Compared with traditional statistical classifiers (e.g. MLC), the Support Vector Machine (SVM) classifier is a different type of classification algorithm. SVM is a method based on the statistical learning theory and the structural risk minimization method and has had an excellent track record of image classification [*Schneider* 2012; *Huang et al.* 2002; *Yang* 2011]. Based on the previous studies, the SVM, MLC, and ANN classifiers were tested, and their relative performances were evaluated.

Satellite-based LULC changes in the Greater Toronto Area (GTA) have been the focus of several previous studies. For example, *Martin and Howarth* [1989] used SPOT multispectral imagery to detect the landscape's change in the City of Scarborough, a small part of the GTA. An object-oriented classification of IKONOS images of the City of Mississauga within the GTA, was reported by *Lackner and Conway* in 2008. *Ferrato and Forsythe* [2013] compared classification results from Earth Observing-1 Hyperion hyperspectral data with Landsat and SPOT data through iterative self-organizing data analysis. Although they validated the relative information content of each of the satellite data sources, they only used one year for classifying the land use, thereby limiting their ability to provide a dynamic change analysis of the study area. *Hu and Ban* [2008] used Landsat and RADARSAT images to monitor urban changes in the GTA between 1988 and 2002. Similarly, *Li and Zhao* [2003] presented a bi-temporal change detection study using Landsat TM images, which only focused on the City of Mississauga. Though they were able to successfully show changes, their study only identified "from-to" changes based on two years and they only applied a single classifier in their classification process. *Forsythe* [2002], *Furberg and Ban* [2008], and *Tole* [2008] proposed the use of multiple Landsat images to monitor urban sprawl. *Conway and Hackworth* [2007] used the Normalized Difference Vegetation Index (NDVI) to detect the urban land cover variation through Landsat images in the GTA with an over 90% overall classification accuracy. However, only two or three images were used to represent the urban expansion trend of decades. Overall, most of these studies used few images and only one classification algorithm to carry out an assessment of long period dynamic change that did not cover the entire GTA.

This research expands on these studies by examining the dynamic changes in the processes of urban expansion of the GTA over a period of 40 years. We applied multiple classification methods and evaluated LULC changes of bi-temporally (i.e. between years) and multi-temporally (i.e. across all years) from Landsat data sets at 5-year intervals from 1974 to 2014. Our study focused on the quantitative and qualitative analysis of regional urban expansion. Another objective of the study was to analyze the relationship between population and urban expansion. Population as one of the driving factors for urban expansion analysis has been playing an important role of urban development monitoring. *Ma and Xu* [2010] pointed out that population growth would lead to increased demand by urban residents on land resources and urban space such as residence ad traffic and public facilities. *Silván-Cárdenas* [2010] used fine spatial resolution images for population estimation in small areas and proposed that population estimation using remotely-sensed images is receiving more attention. Thus, we examine the relationship between population and urban expansion over the last 40 years.

2. Study Area and Data

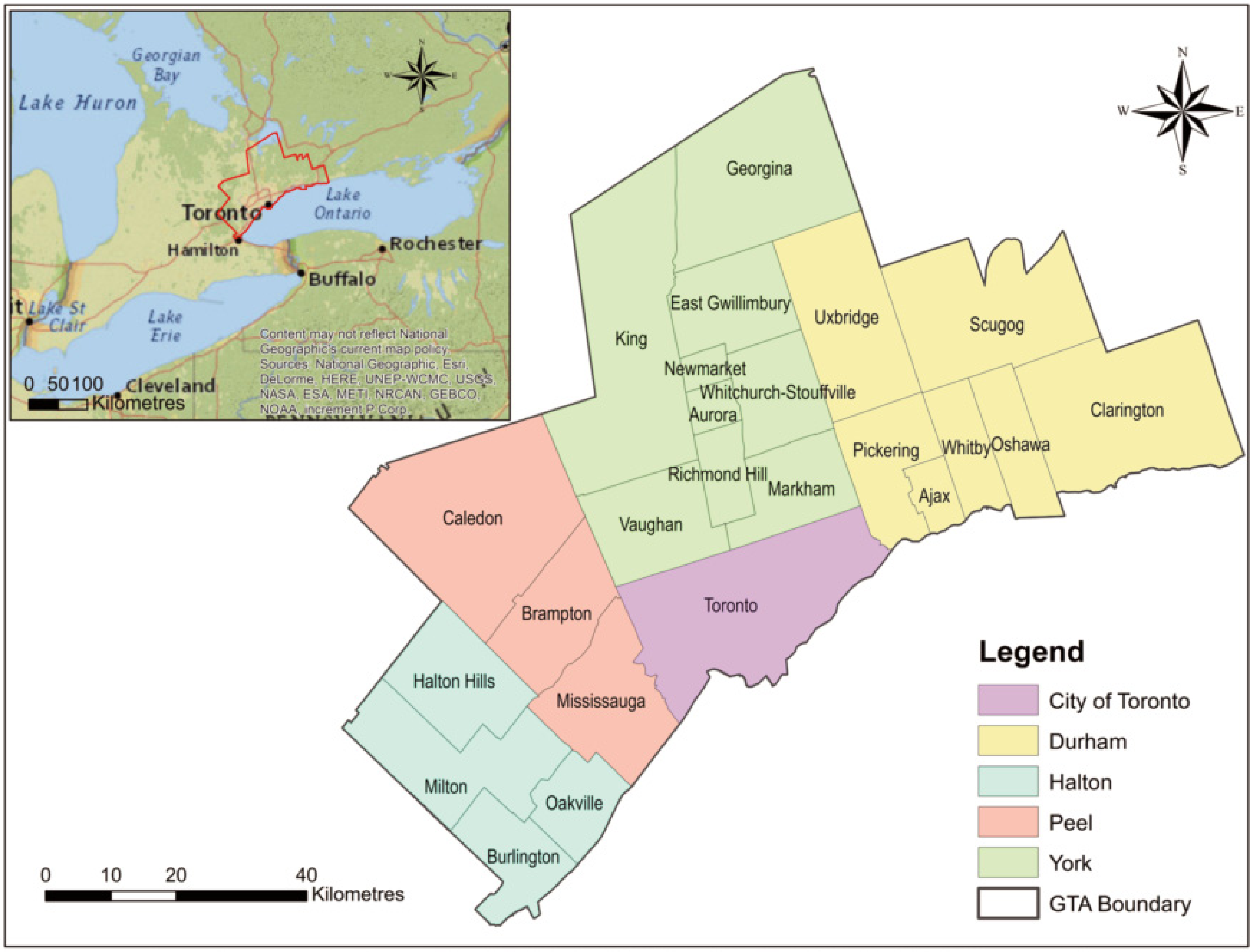
2.1 Study Area

The study area (see Figure 1) is located in Southern Ontario, Canada, including the City of Toronto, and Regions of Durham, Halton, Peel, and York [*Statistics Canada* 2011]. This area covers 7752 km^2, and is located between Lake Ontario and Georgian Bay of Lake Huron. The GTA is the economic centre of Canada and is an important metropolitan area for foreign investment, trade flows, and a hub for exchanges of culture, religion, and technology. It is also the biggest city in Canada due to a large net migration involving immigration, non-permanent residents, interprovincial and intra-provincial migration that has occurred over the past several decades. This study area includes various types of land cover types: lakes and rivers, high and low density urban areas, and rural area (agriculture land, forest landscapes, grassland). According to *Statistics Canada* [1976; 2011], the population of the GTA in 2011 was 6 054 191, a 90% increase from 1976.

2.1 Data Description

Images from the Landsat-1 and -2 Multispectral Scanner (MSS), Landsat-5 Thematic Mapper (TM), Landsat-7 Enhanced Thematic Mapper Plus (ETM+), and Landsat-8 Operational Land Imager (OLI) were the main data sets used in this study (Table 1). All these images were acquired from the Landsat Data Archive held by the USGS, and most were cloud free. We obtained these images in level-one product format. In order to obtain high-quality results of analysis, most of these data were acquired in the summer season from June to September. All images were projected in the World Geodetic System of 1984 (WGS84) and Universal Transverse Mercator (UTM) coordinates. Image pre-processing was performed using the software Environment for Visualizing Images (ENVI) version 4.8, PCI Geomatica 2013, and ArcMap version 10.1. During the image pre-processing, layer stacking for each image was performed first, followed by overlapping images registration. The PCI Geomatica ATCOR module was used to carry out atmospheric correction for each image, based on unique features of data acquisition, including date and time, sensor type, coordinates of the image centre, atmospheric definition area, and atmospheric condition. Finally, images from each year were mosaicked by geo-referenced based mosaicking tool in ENVI, with colour balance using and clipped to the bounds of the study area. The GTA boundary and region's boundaries were provided by *Statistics Canada* [2011], and the Lake Ontario boundary acquired for *DMTI Spatial Inc., Ontario* [2014].

Population changes over the last four decades were used to foster an understanding of the urbanization process of the GTA, dating back to 1976 [*Statistics Canada* 2011]. The population data of the GTA were acquired from Statistics Canada from 1976 to 2011 at 5-year intervals [*Statistics Canada* 2011]. The data were then used to analyze the relationship between the population and urban



Inset map sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Figure 1: Study area – the Greater Toronto Area (GTA).

Table 1: Satellite images with 5-year intervals used in this study.

Year	Day of the year	Sensor	Bands	Pixel Size
1974	187, 223, 240	MSS	4, 5, 6, 7	60 m
1979	170, 171	MSS	4, 5, 6, 7	60 m
1984	237, 238	TM	1, 2, 3, 4, 5, 7	30m
1989	203, 233	TM	1, 2, 3, 4, 5, 7	30m
1994	174, 178, 185	TM	1, 2, 3, 4, 5, 7	30m
1999	246, 271	ETM+	1, 2, 3, 4, 5, 7	30m
2004	172, 179	TM	1, 2, 3, 4, 5, 7	30m
2009	178, 217	TM	1, 2, 3, 4, 5, 7	30m
2014	192, 199	OLI	1, 2, 3, 4, 5, 6, 7, 9	30m

expansion. A set of full-colour 10–20 cm resolution digital orthoimages in 2009 were acquired from the Geospatial Centre, University of Waterloo as a reference map for accuracy assessment in 2009.

3. Methods

The analysis methods can be divided into three parts: image classification, change detection and analysis, and urban expansion analysis as shown in Figure 2. All image processing was performed using ENVI 4.8 and ArcMap 10.1.

3.1. Image Classification

Selecting an appropriate algorithm to classify the imagery during the initial stages of this analysis was vital, as the quality of the classified images directly impacted the performance of the change detection. To generate consistent classification results, an appropriate classification method was determined first. In this paper, the supervised MLC, SVM, and ANN algorithms were applied to the 2009 mosaic. Training samples were selected for the six Level-2 classes in the classification scheme listed in Table 2. A false colour combination (near infrared band as red, red band as green, and green band as blue) of the reflective spectral band dataset for 2009 was used to choose training samples for those three classification algorithms. A Jeffries-Matusita (JM) distance report was automatically generated to illustrate the spectral separability of the training samples. JM distance is a separability function that detects the average distance between a pair of classes that directly relates to the probability of how accurate a resultant classification will be [*Schmidt and Skidmore* 2003]. Values range from 0 to 2, and the value is asymptotic to 2, meaning that the training samples selected are more separable. After applying classification algorithms, a 3 x 3 majority filter was applied in order to remove the salt-and-pepper noise, as a larger size filter would decrease the accuracy of the final results.

After classification, a statistical accuracy assessment was built to assess the accuracy of classification maps. In order to reduce the cost and time, and to ensure it is large enough to generate an appropriate error matrix, a general guideline to collect sample size is a minimum of 50 samples for each class [*Congalton and Green* 1999]. Based on the 2009 orthoimagery, 600 pixels (100 samples for each Level-2 category) were randomly selected from the classified image of 2009. Selected pixels

Table 2: Image classification categories.

Level-1 category	Level-2 category	Description
Urban area	Residential	Low-density built-up areas, e.g. houses
	Commercial	High-density built-up areas, e.g. commercial areas and parking lots
Non-urban area	Barren Cropland	Fallow / harvested agriculture areas
	Water-body	River, lake, and pond areas
	Forest	Forest cover areas
	Vegetation	Grassland, parks, and agricultural area in production

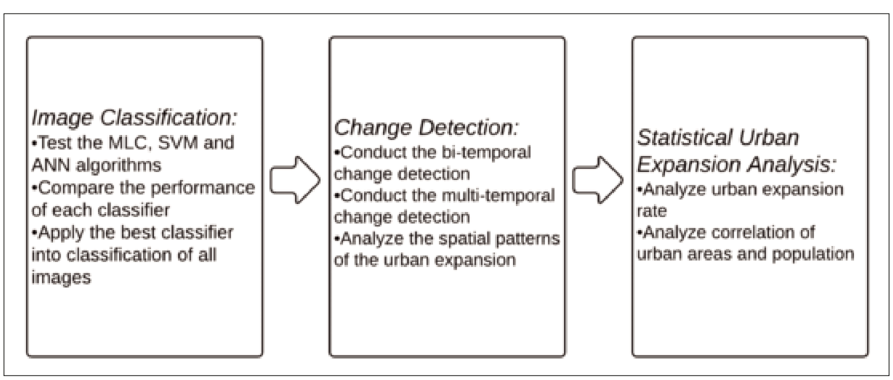


Figure 2: The workflow chart of this study.

were manually validated against the orthoimagery. The overall accuracy, the user's accuracy (the probability that a classified pixel is really in that category) and the producer's accuracy (the probability an area is correctly classified) were calculated through the error matrix [*Congalton* 1991]. An advanced measure of interclass agreement, the Kappa coefficient, was also calculated. The Kappa coefficient provides a better interclass discrimination than the overall accuracy statistic alone [*Fitzgerald and Lee* 1994].

3.2 Change Detection

In the change detection analysis process, the post-classification comparison change detection method was applied to detect land use and land cover changes. Post-classification comparison separately classifies multi-temporal images into thematic maps, and then implements a comparison of the classified images on a per-pixel basis [*Alphan et al*. 2009]. This approach can produce change maps that show a complete matrix of changes by properly coding the classification results of two dates. Before applying the change detection, the LULC classes were combined into Level-1 categories (as shown in Table 2): the urban area and the non-urban area, since we only wanted to examine which area was developed into urban area (the built-up area), and this step can help decrease the impact of classification errors. Bi-temporal and multi-temporal change maps were generated to analyze the spatial patterns of the urban expansion.

Table 3: Accuracy assessment comparison between different classifiers for the 2009 imagery.

	MLC		ANN		SVM	
Level-2 category	UA	PA	UA	PA	UA	PA
Vegetation	0.88	0.95	0.86	0.99	0.90	0.97
Residential	0.90	1.00	0.95	0.95	0.93	0.97
Commercial	0.85	0.83	0.95	0.83	0.93	0.90
Barren Cropland	0.91	0.78	0.93	0.70	0.96	0.83
Water-body	1.00	0.97	1.00	1.00	1.00	1.00
Forest	0.98	0.91	0.98	0.90	0.94	0.88
Cloud	0.50	1.00	1.00	0.50	1.00	0.33
Shadow	0.60	1.00	0.50	1.00	1.00	1.00
Overall accuracy (%)	85.34		91.48		92.63	
Kappa coefficient	0.83		0.89		0.90	
(UA = user's accuracy; PA = producer's accuracy)						

3.3 Statistical Urban Expansion Analysis

Both the rate and spatial structure of urban expansion vary across time [*Bagan and Yamagata* 2012]. We calculated the rate of urban expansion using the Land Use Change Index (LUCI), as shown in equation (1) [*Haregeweyn* 2012]. This has been shown to be a significant index for assessing urban expansion [*Bagan and Yamagata* 2012].

$$LUCI = \frac{(U_a - U_b)}{T \times U_b} \times 100, \qquad (1)$$

where Ua and Ub indicate the area of a land use class at Time a and Time b, respectively. T indicates the time period from Time a to Time b. If T's unit is in years, then LUCI will be the annual rate of change in the area for this class. In our case, the LULC class was the overall urban class. At the same time, we carried out a Pearson correlation coefficient analysis to analyze the correlations between the urban areas and the population.

4. Results and Discussion

4.1 Classification Accuracy

An error matrix was built to assess the accuracy of the classification results before choosing an appropriate classifier across all time periods. As shown in Table 3, the overall accuracy of the SVM classifier was 92.63%, and the Kappa coefficient was 0.90. In comparison, the MLC algorithm had an overall accuracy of 85.34%, with a Kappa coefficient of 0.83, and the ANN algorithm had an overall accuracy of 91.48%, with a Kappa coefficient of 0.89. Both the MLC algorithm and ANN algorithm were inferior compared to the SVM. The user's and producer's accuracies of commercial areas and barren cropland in SVM were much better than the results from the ANN and MLC. Therefore, we proceeded to classify the remaining images from the other years with the SVM classifier. During the classification process, we combined the Level 2 categories together into either urban area or non-urban areas. This process reduced misclassification.

4.2 Map Changes and Analysis

By counting the number of pixels of each image, the bi-temporal change detection results indicated an increase in the GTA's urban area of 1115 km^2 (from 1122 km^2 in 1974 to 2237 km^2 in 2014, as shown in Figure 3). By extracting and overlaying the urban area of the multitemporal classification results, the urban expansion map was compiled, including 10-year intervals from 1974 to 2014 (Figure 4). Based on Figures 3 and 4, some important spatial patterns could be observed. The spatial urban expansion in the GTA mainly followed two types: radiated expansion mode, which is a typical tendency of urban growth that from urban centres to adjoining non-urban areas by a series of concentric circles [*Burgess* 2008]; ribbon expansion mode, which is a combination type of border [*Stan* 2013] and enclave [*Stan* 2013] types, which the growth was starting with, several centres along the lakeshore of Lake Ontario.

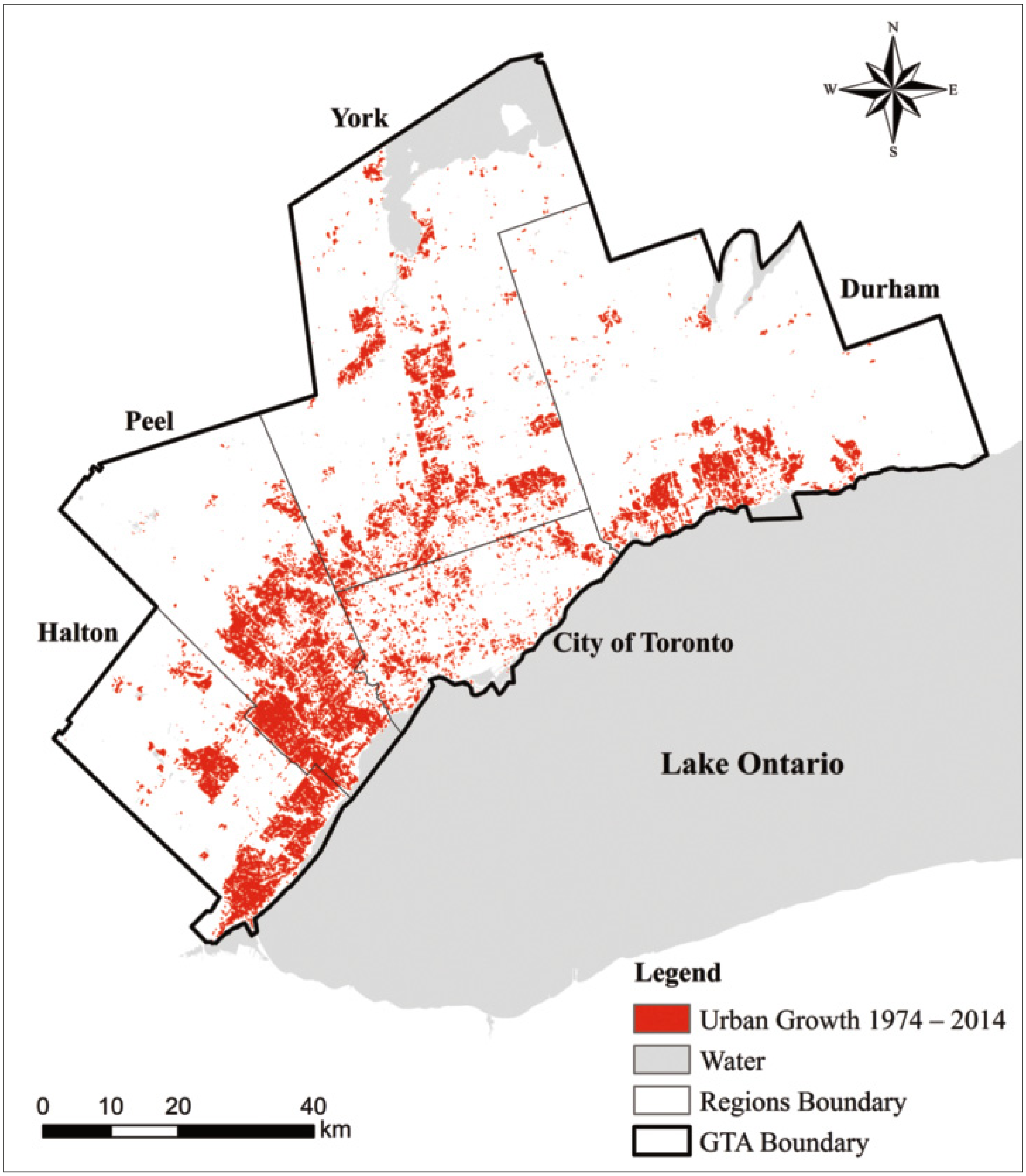


Figure 3: The bi-temporal change detection from 1974 to 2014.

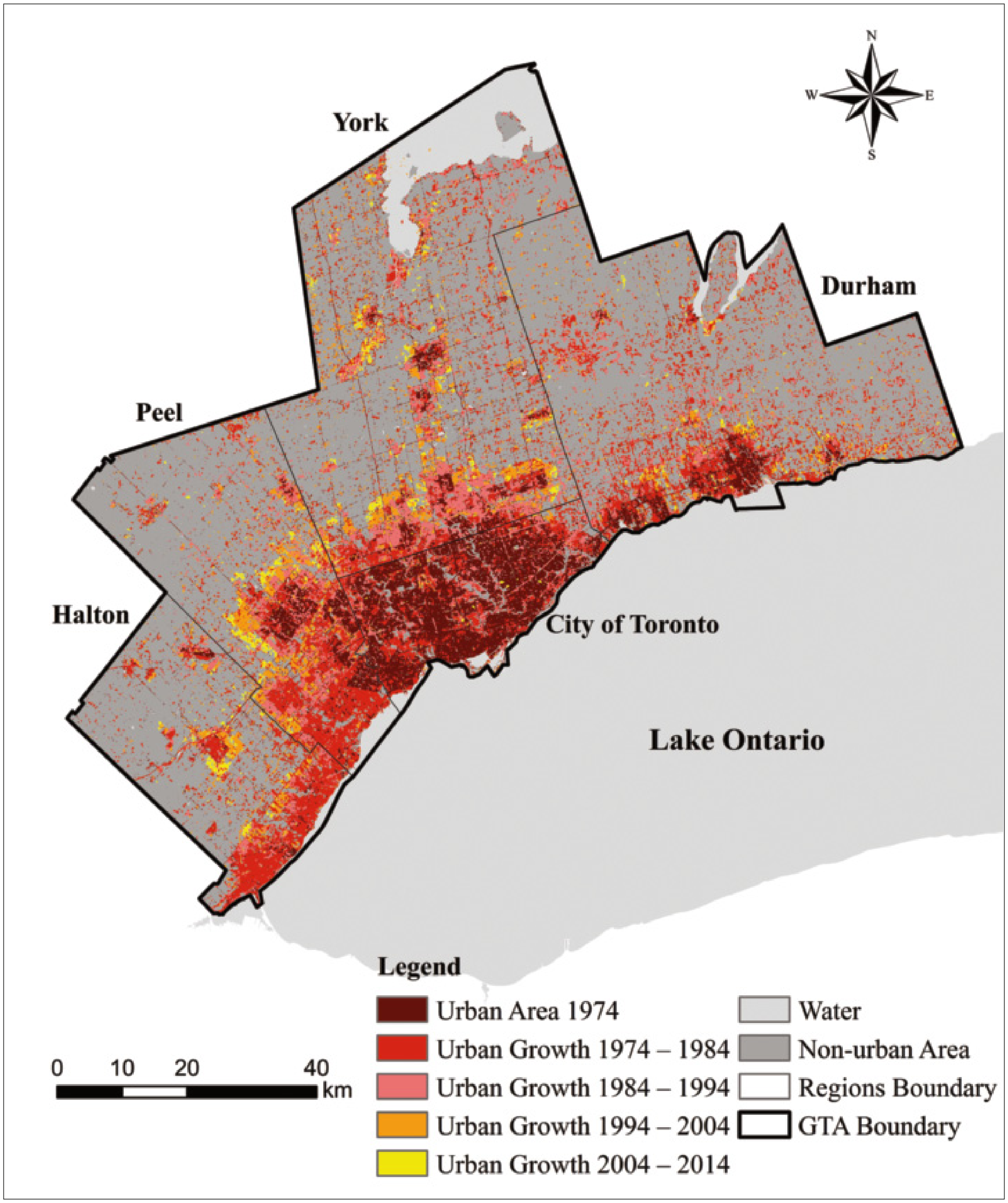


Figure 4: The multi-temporal change detection from 1974 to 2014.

Table 4: Annual growth rate of the urban area between 1974 and 2014.

	1974–1979	1979–1984	1984–1989	1989–1994	1994–1999	1999–2004	2004–2009	2009–2014
Annual growth rate (%)	-1.1	2.2	4.3	1.9	0.7	3.6	0.1	1.4
Mean annual growth rate (%) = 1.6								

The GTA expanded outward from the City of Toronto, as well as laterally along Lake Ontario's lakeshore. In addition, regional centres of Peel, Durham, and York also expanded. In 1974, many of the regional centres within the GTA existed in isolation, as shown in Figure 4, and the cities could be clearly identified individually. From 1974 to 1991, regions around the City of Toronto witnessed a significant growth along their boundaries with Toronto. In the 1990's, the regions of Peel, York, and Durham developed rapidly. All these regions expanded outward from their regional centres. After 2004, York Region's urban expansion began to slow down, while the outside regions (Durham, Peel and Halton) had a considerable growth of urban areas. From 2009 to 2014, the largest expansion occurred in the southwest part of the GTA. For instance, Brampton expanded northeast toward the City of Vaughan. After 40 years of development, some smaller urban centres had connected with each other, such as Richmond Hill and Markham. Furthermore, some cities located along Lake Ontario, such as Burlington, Oakville, and Ajax, experienced significant development. Regions of Peel and Halton had the largest increase in urban area in the GTA. Overall, the urban development in the GTA takes the form of outward extension and expansion from these urban centres, especially from the City of Toronto.

4.3 Statistical Analysis of Urban Expansion and Population

To explore the long-term population and urban growth of the GTA, we calculated the urbanized extent for each 5-year period from our classified imagery and graphed them with population data (Figure 5). As seen on this chart, both population and urban areas experienced constant growth in this time period. Correlation analysis shows that urban expansion is directly correlated to population increase. The Pearson correlation coefficient (r) between the population and the urban area was 0.979 ($p<0.01$), which identifies strong correlation between the population and the urban area in the GTA.

The mean annual growth rate of the urban area over the 40 years was 1.6% (Table 4). There was significant urban expansion during two periods. The periods between 1984–1989 and 1999–2004 saw increases of 4.3% and 3.6% in annual growth rate of the urban area, respectively. A slightly negative trend of 1.1% in 1974–1979 may have been the result of misclassification, as these images were acquired by Landsat-1 at 60 metres pixel size and only 4 bands were available for the classification process. The period between 2004 and 2009 had a lower annual growth rate of 0.1%. This may be due to two main factors: the low urban growth rate in 2004–2009 and the lower classification accuracy of the 2004 image.

According to *Bhatta* [2010], urban expansion can be caused by a variety of reasons such as population growth, economic growth, independence of decision, industrialisation and etc. As *Stan* [2013] pointed out, the three main forces that result in urban expansion are "a growing population, rising incomes, and falling commuting costs." Thus, when we explored deeper into the population changes during these 40 years, we discovered that the two significant periods of urban growth mirrored the population growth over the same time. The mean annual population growth rate over the 40 years was 1.9%, however during the two 5 year periods between 1986–1991 and 1996–2001, more substantial increases were observed of 2.6% and 2.0% were observed respectively. From 1976 to 2011, the annual population growth rate ranged between 1.5% and 2.6%. The lowest annual population growth rate was found in the period of 1976–1981 at 1.5%. It is obvious that urban expansion is typically delayed by a few years following a large increase in population, as the city requires time to respond. The fluctuations in the annual growth rate of the urban area and the annual population growth rate were relatively consistent.

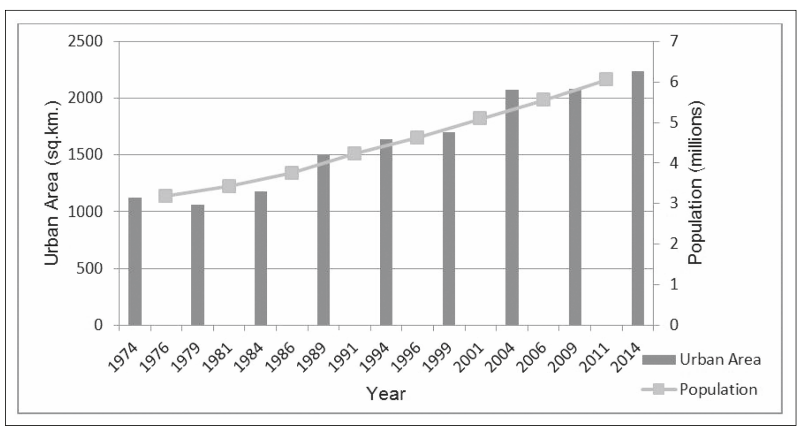


Figure 5: Population growth and urbanization in the GTA from 1974 to 2014.

5. Conclusion

In this paper, dynamic changes of the urban growth trend of the GTA were successfully detected using a series Landsat images acquired over time. The selection of an accurate classification process was an important part of this study, as it determined the reliability of the final change detection results. In our tests, we found that the SVM classification method performed better than the MLC and ANN approaches. We noted that urban growth occurred mainly in a radiated expansion mode, in which the city expanded outward from the City of Toronto. The GTA also expanded in a ribbon expansion mode along Lake Ontario. Furthermore, the urban expansion was strongly correlated to increases in population. There are some limitations in this study. Firstly, because images were acquired from different sensors, during the classification period, a different number of bands were used. Secondly, the training samples and classification results were only validated in 2009 due to lack of reference images.

In conclusion, Landsat images can be used to examine the LULC changes of the metropolitan area in long time series. The extent and spatial patterns of the GTA's urban expansion were both analyzed quantitatively and qualitatively in the study. It is feasible to integrate Landsat imagery and census data to study urban expansion of metropolitan areas or even of a global scale study over time. Since urban development policy making or urban planning usually need modeling of the urban growth tendency, knowing the urban historical development patterns and present developing situation are meaningful. Therefore, these results can be used for the regional governments or planners to make decisions regarding GTA's development in the future.

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CYBERCARTOGRAPHY, TRANSITIONAL JUSTICE AND THE RESIDENTIAL SCHOOLS LEGACY

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The increased emphasis on ethics that emerged in the 1960s has given rise to a decolonizing trend in research, policy and education that both acknowledges and aims to redress the injustices of colonization. The Residential Schools Legacy provides a good example of assimilative attitudes underlying British and later-Canadian government colonization policies, and of attempts to reform these attitudes. In cartography, maps have a history of aiding colonizers with a thirst for power over land, resources, people and rights. Reflecting the trend toward decolonization, many contemporary cartographers have adopted new attitudes, and are seeking instead to understand and use cartography's power to tackle complex social and economic challenges. The Cybercartographic Atlas Framework provides a useful context for the theoretical and applied development of decolonizing cartographic projects, including the Lake Huron Treaty Atlas. The Residential Schools component of the Atlas provides an innovative tool for transitional justice with respect to the intergenerational effects of Residential Schools. This paper begins to explore the benefits of this Atlas component to Residential Schools reconciliation processes by appealing to David Crocker's *[1999] transitional justice-oriented approach to reckoning with past wrongs as an interpretative framework.*

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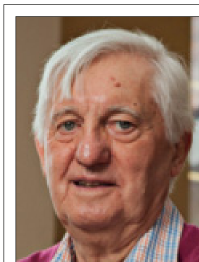
L'importance grandissante de l'éthique qui a connu un essor dans les années 1960 a mené à une tendance de décolonisation en matière de recherches, de politiques et d'éducation qui reconnaît et vise à réparer les injustices de la colonisation. L'héritage des pensionnats indiens est un bon exemple des attitudes d'assimilation découlant des politiques de colonisation des gouvernements britannique et ensuite canadien, et des tentatives ultérieures du gouvernement de réformer ces attitudes. En cartographie, à travers l'histoire, les cartes sont venues en aide aux colonisateurs assoiffés de pouvoir sur les terres, les ressources, les peuples et les droits. Reflétant la tendance vers la décolonisation, plusieurs cartographes contemporains ont adopté de nouvelles attitudes et cherchent plutôt à comprendre et à se servir du pouvoir des cartes pour s'attaquer à des enjeux sociaux et économiques complexes. Le cadre d'atlas cybercartographique offre un contexte utile pour le développement théorique et appliqué des projets cartographiques de décolonisation, incluant l'atlas du traité du lac Huron. La composante de l'atlas qui traite des pensionnats indiens fournit un outil innovateur pour la justice transitionnelle en ce qui a trait aux effets intergénérationnels des pensionnats. Cet article constitue une première exploration des bienfaits de cette composante des atlas pour les démarches de réconciliation avec les victimes des pensionnats indiens en utilisant l'approche de David Crocker *[1999] à titre de cadre de référence interprétatif. Cette démarche est axée sur la justice transitionnelle pour rectifier les préjudices subis par le passé.*



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1. Introduction: Reckoning with Past Wrongs in the Residential Schools Legacy

> The burden of this experience has been on your shoulders for far too long. The burden is properly ours as a Government, and as a country. There is no place in Canada for the attitudes that inspired the Indian Residential Schools system to ever prevail again. You have been working on recovering from this experience for a long time and in a very real sense, we are now joining you on this journey. The Government

> of Canada sincerely *apologizes and asks the forgiveness of the* Aboriginal peoples of this country for failing them so profoundly (*The Right Honourable Stephen Harper, Prime Minister of Canada*, 2011).

On June 11, 2008, the Prime Minister formally apologized to the Indian Residential Schools survivors in Canada. This apology, the Indian Residential School Settlement Agreement, and the creation of the Truth and Reconciliation Commission to investigate the Residential Schools Legacy, are all part of a broader international trend toward acknowledging and redressing past wrongs, especially those inflicted on generations of Indigenous peoples by colonial or imperial systems. Many hope these efforts will be satisfactory to those whose rights are being redressed, and that they will contribute to healthy and fair intercultural relationships in the future. In referring to the survivors' experience under colonial rule as a "burden," the prime minister's apology acknowledges Canada's "failure" to contribute to positive experiences in "Aboriginal peoples;" and the desire and intention to change the attitudes that inspired such institutions as the Indian Residential Schools system.

The Residential Schools Legacy provides a strong example of assimilative attitudes underlying British and later-Canadian government colonization policies. The Truth and Reconciliation Commission's website provides an initial glimpse into the 139 government-funded, church-run schools, recognized in the Indian Residential Schools Settlement Agreement that operated between roughly 1870 and 1996; although the total number of similar institutions is greater and information concerning opening and closing dates for such schools often varies. According to the Commission, more than 150 000 First Nations, Métis, and Inuit children were forcibly taken to residential schools, and denied such things as their right to speak their language, practice their culture and communicate with their brothers and sisters while at school. At the last count, a mere 80 000 former students were currently living, a significant number of whom reported being victims of physical and/or sexual abuse and several generations of survivors' descendants have been plagued with the negative intergenerational effects of their residential schools experiences [see *http://www.trc.ca/websites/trcinstitution/index.php?p=4* for more information].

The Truth and Reconciliation Commission is pre-dated by the 1996 Royal Commission on Aboriginal Peoples, which acknowledges the pre-Confederation legacy of the Canadian government's assimilative policies respecting Indigenous peoples in Canada and extending in significant ways to education:

> It was a policy designed to move communities, and eventually all Aboriginal peoples, from their helpless 'savage' state to one of self-reliant 'civilization' and thus to make in Canada but one community—a non-Aboriginal, Christian one […] Of all the steps taken to achieve that goal, none was more obviously a creature of Canada's paternalism toward Aboriginal people, its civilizing strategy and its stern assimilative determination than education" [*Canada, Royal Commission on Aboriginal Peoples* 1997, chapter 10].

Approaching the wind-up of the Truth and Reconciliation Commission's five-year mandate, James Anaya, the United Nations' Special Rapporteur on the Rights of Indigenous Peoples, intimated the need for continued effort in the area of righting past wrongs with respect to the Residential Schools and their intergenerational effects:

> A particularly distressing part of the history of human rights violations was the residential school era […] during which indigenous children were forced from their homes into institutions, the explicit purpose of which was to destroy their family and community bonds, their languages, their cultures and even their names. Thousands of indigenous children did not survive the experience and some of them are buried in unidentified graves. Generations of those who survived, grew up estranged from their cultures and languages, with debilitating effects on the maintenance of their indigenous identity. That estrangement was heightened during the "sixties scoop," when indigenous children were fostered and adopted into non-aboriginal homes, including outside Canada. The residential school period continues to cast a long shadow of despair on indigenous communities, and many of the dire social and economic problems faced by aboriginal peoples are linked to that experience [*Anaya* 2014, 4–5].

The call for continued reconciliation efforts to redress the effects noted by the Royal Commission on Aboriginal Peoples, the Truth and Reconciliation Commission of Canada and the UN Special Rapporteur on the Rights of Indigenous Peoples, does not discount the education and outreach efforts of countless survivors groups, non-governmental organizations, university research centres and other groups and individuals—all focused on Residential School reconciliation initiatives. Examples include the Legacy of Hope Foundation [see *http://legacyofhope.org/*], the National Centre for Truth and Reconciliation [see *http://umanitoba.ca/centres/nctr/index.html*], the Shingwauk Residential Schools Centre (SRSC) at Algoma University and the Children of Shingwauk Alumni Association, a Shingwauk Residential School survivors group that guides and works closely with the SRSC [see *http://shingwauk.org/srsc/* to access both]. A good example of an ongoing outreach project involving all of these entities is the collaborative ongoing multi-partner work on the Residential Schools Map of the cybercartographic Lake Huron Treaty Atlas [*Pyne* 2013].

Cartography has a long history as a powerful tool for colonizers with a thirst for jurisdictional control over land, water, resources, people and rights [*Harley* 1988, 1989; *Nietschmann* 1995]. In contrast, many contemporary cartographers have adopted new attitudes, and are seeking to understand and use cartography's power in a de-colonizing context. Since at least the eighties, work in critical cartography has extended to the conceptual and ethical arenas with a new post-colonial focus. Instead of being used solely as a means to exert authority over territory and people's understanding of it, mapping is increasingly being thought of as a means to include multiple and previously ignored perspectives in a global effort that could be summarized as a "justice for all" movement: justice for the people, the land, the water and for all the creatures on the earth. Concomitant with the relatively recent shift to more aware and engaged research processes is the increase in inter-, multi- and transdisciplinary approaches to understanding and addressing complex socioeconomic and cultural political issues [*Rescher* 2001]. Cartographic approaches such as cybercartography can be especially useful when it comes to organizing this knowledge, and documenting knowledge gathering processes in intuitively appealing and epistemologically effectual ways [*Brauen et al.* 2011; *Pyne* 2014]. In general, the past 50 years has seen a dramatic transformation in cartography's scope and methods in an effort to "reckon with past wrongs" [*Crocker* 1999] and to contribute to healthy relationships in the present and future. Today's cartography extends to participatory collaborations with individuals from a variety of knowledge communities. It can be "on the ground," and involve art, experience and immediacy, on one hand; and involve technologies, on the other [*Carver* 2003; *Craig et al*. 2002; *Irwin et al*. 2009; *Parker* 2006]. There is increasing practical and theoretical attention being given to the intersections between art and cartography [*Caquard and Taylor* 2005; *Harmon* 2003; *Irwin et al*. 2009; *Pyne et al*. 2009] and there is growing attention towards mapping experience, emotions, and Indigenous perspectives [*Caquard* 2013; *Harmon* 2003; *Hirt* 2012; *Louis* 2007; *Louis et al*. 2012; *Pyne* 2013, 2014; *Taylor and Lauriault* 2014].

Fraser Taylor [1991] recognized the new digital context of maps with his definition of cartography as "[t]he organization, presentation, communication and utilization of geo-information in graphic, digital or tactile form. [Cartography] can include all stages from data presentation to end use in the creation of maps and related spatial information products." This broadening of cartography has given rise to discussions related to motivation, ethics, epistemology and ontology as "a wider range of topics […] has opened academic cartography's doors to art historians, literary intellectuals, and legal scholars as well as experts on information technology and public administration" [*Monmonier* 2013]. Mapping practices are increasingly being engaged in and pursued as central components of the solutions to complex social and economic challenges, as critical cartographers join in the collective quest to de-colonize knowledge and knowledge-gathering processes. To this end, deconstructive approaches to map interpretation generally question the motives and context of the map maker [*Harley* 1988, 1989] while, reconstructive approaches often include making maps through participatory processes and community collaboration [*Caquard* 2013; *Corner* 1999; *Cosgrove* 2005; *Crampton* 2001, 2009; *Crampton and Krieger* 2006; *Elwood and Ghose* 2004; *Fox et al*. 2005; *Harmon* 2003; *Kitchin* 2008; *Kitchin and Dodge* 2007; *Pearce* 2008; *Pearce and Louis* 2007; *Pyne* 2013; *Turnbull* 2007; *Taylor and Lauriault* 2014].

In "Reckoning with Past Wrongs: A Normative Framework" *David Crocker* [1999] introduces a transitional justice-oriented approach to human rights abuses, which provides a useful framework for illustrating the strengths of cybercartographic approaches, such as that taken in the development of the Residential Schools component of the Lake Huron Treaty Atlas. Crocker uses the phrase "reckoning with" frequently in this paper, underscoring his commitment to a multidimensional and holistic approach to transitional justice. Going beyond a uni-dimensional approach, which favours either criminal or social justice measures or "tools" such as trials or truth commissions, Crocker's multidimensional approach to transitional justice extends to both of these; in addition to other measures, including international criminal tribunals; social shaming and banning of perpetrators from public office; public access to police records; public apology or memorials to victims; reburial of victims; compensation to victims or their families; literary and historical writing; and blanket or individualized amnesty or legal immunity from prosecution, depending on the context [*Crocker* 1999]. As an example of a project undertaken within the Cybercartographic Atlas Framework, the Residential Schools map component of the cybercartographic Lake Huron Treaty Atlas is consistent with this approach, and can—if not provide another tool—provide a valuable medium for the implementation and assessment of some or all of these other tools.

2. Transitional Justice Goals

David Crocker [1999] outlines the following eight multi-cultural goals of transitional justice based on his comprehensive survey of "worldwide moral deliberation on transitional justice" [*Crocker* 1999]: truth; providing a public platform for victims; accountability and punishment; rule of law; compensation to victims; institutional reform; long-term development; reconciliation; and, public deliberation. There are three types or dimensions of truth:

1) forensic truth, which relates to the facts of moral and legal rights violations;
2) emotional truth relating to psychological and physical impacts; and
3) general truth concerning systemic injustices.

Different tools tend to draw attention to different types of truth and applying more than one tool in balance with the others, enhances the potential for accountability, minimizes the potential for "whitewash or social amnesia," fosters "respect for due process" and compensates victims for previous unjust policies and practices. Institutional reform and long-term development are linked, especially in terms of the potential for greater respect of due process, which includes: "the judiciary, police, military, land tenure system, tax system, and the structure of economic opportunities" are important "to remedy what caused human rights violations and protect against their recurrence" *Crocker* [1999].

Crocker casts "reconciliation" in terms of relationships and distinguishes between minimal and richer meanings of this goal. Going beyond the minimal requirement of "simple coexistence" *Crocker* [1999], people may continue to maintain different perspectives and understandings, although they must "hear each other out, enter into a give-and-take about matters of public policy, and build on areas of common concern […] to forge principled compromises with which all can live." The richest form of reconciliation is the most difficult to attain and includes "forgiveness, mercy (rather than justice), a shared comprehensive vision, mutual healing, or harmony;" these features are more likely to develop in transitional approaches to justice that include a similarly rich approach to democracy featuring fair compromise and mutual intercultural understanding. Truth commissions and other reconciliation mechanisms can be assessed according to the eight goals of transitional justice *Crocker* [1999].

In "Mapping Indigenous Perspectives in the Making of the Cybercartographic Atlas of the Lake Huron Treaty Relationship Process: A Performative Approach in a Reconciliation Context" [*Pyne and Taylor* 2012], we discussed a two-pronged approach to designing and developing an online, interactive multimedia—cybercartographic—atlas. This approach is similar to the decolonizing approach put forward by *Johnson et al*. [2006] in "Critical Cartographic Literacies in Indigenous Communities" in the way that it combines critical academic perspectives with Anishinaabe approaches to ''tell the story'' of the Robinson Huron Treaty process over time and across space. The project's motto, 'building awareness to bridge relationships,' is linked to its aim to enhance awareness of Anishinaabe perspectives, while exposing the epistemological and ontological roots of colonialism [*Pyne and Taylor* 2012]. The project's success in reflecting Anishinaabe perspectives and providing the basis for intercultural understanding, extends to the Residential Schools component of the Lake Huron Treaty Atlas, which could itself be used as a transitional justice tool, in addition to being useful in the assessment of other approaches to reckoning with past wrongs.

3. Cybercartography and the Lake Huron Treaty Atlas

A primary concern for cartography is whether or not cartography is capable of meaningfully conveying such things as experience, Indigenous perspectives and knowledge, and critical academic approaches to the status quo [*Johnson et al*. 2006; *Turnbull* 2007]. The multimedia, multisensory, multimodal, interactive and/interdisciplinary nature of the cybercartographic approach to atlas making [*Taylor* 1997, 2005; *Taylor and Caquard* 2006; *Taylor and Pyne* 2010] positions itself well to be able to address this concern. Cybercartography takes a broad, inclusive approach to both science and art, and acknowledges the holistic relationship between science, which includes geospatial technologies, and art, extending to storytelling. This position guides the design and development phases of cybercartographic atlas projects in the direction of more adequately conveying multiple perspectives. An important part of this enabling process lies in the reflexive integration of art with geospatial technologies in order to address the challenges associated with incommensurability of knowledge systems, or multiple ontologies [*Turnbull* 2007], in critically innovative and creative ways [*Caquard and Taylor* 2005]. The collaborative project to create the cybercartographic Lake Huron Treaty Atlas shares cybercartography's main features, in addition to critical cartography's concerns with deconstruction and ontological skepticism. The project puts some of the abstract ideas, such as "relational space" and "performativity" into practice in the context of its broadest aim: building awareness to bridge relationships by acknowledging and incorporating Anishinaabe ways in the making of the Atlas. Together, the framework and the Atlas have provided the basis for continuing development of the Residential Schools component of the Atlas, which draws on each, in terms of its form and approach [*Pyne* 2013].

3.1 The Framework

In 2003, a year after receiving a $2.5 million research grant from the Social Sciences and Humanities Research Council (SSHRC) for the Cybercartography and the New Economy Project, *Fraser Taylor* [2003] released a formal definition of cybercartography as, "... the organization, presentation, analysis and communication of spatially referenced information on a wide variety of topics of interest and use to society in an interactive, dynamic, multimedia, multi-sensory format with the use of multimedia and multimodal interfaces." Cybercartographic atlases are transdisciplinary and holistic in nature, with an emphasis on storytelling, knowledge sharing, and enhancing awareness of different perspectives. The name of the software developed to create atlas modules—Nunaliit—illustrates the community orientation of the project. The word "nunaliit" means "settlement," "community," or "habitat" in Inuktitut; the name given to the dialects of the Inuit language in Canada. This name was given to the cybercartographic framework to emphasize the community based approach that was driving the development of the software in different domains: (1) open specification approaches; (2) modularity; (3) "live" data; (4) geospatial storytelling; and, (5) audio-visual mapping [*Caquard et al*. 2009; *Hayes et al*. 2014].

While at first glance, a cybercartographic atlas may be seen as an interactive multimedia website with maps, it is much more and includes the collaborative processes that go into making the Atlas maps. Although they are often referred to simply as "maps," these webpages are more accurately described as "map modules;" they have generous space for an interactive digital map, and side panel, which displays information and media (content) that is relevant to particular points on the map.

The cybercartographic Nunaliit Atlas Framework, which underpins this type of website, is Free and Open Source Software [*Hayes et al*. 2014; see *http://nunaliit.org/*]. As a holistic approach to online atlas development, cybercartography is consistent with Indigenous worldviews. As a relationship-focused approach, it involves reciprocity and engaging people in the production of maps to tell the stories they wish to tell, and giving these stories back to communities for education and further input [*Taylor* 1997, 2003, 2005, 2009; *Taylor and Caquard* 2006; *Taylor and Pyne* 2010; *Pyne* 2013; *Taylor et. al*. 2014].

Cybercartography "(1) is multimedia using vision, hearing, touch and eventually smell and taste; (2) uses multimedia formats and new telecommunications technologies such as the World Wide Web; (3) is highly interactive and engages the user in new ways; (4) is applied to a wide range of topics of interest to society, not only to location finding and the physical environment; (5) is not a stand-alone product like the traditional map but part of an information/analytical package; (6) is compiled by teams of individuals from different disciplines; and, (7) involves new research partnerships and the private sector" [*Taylor* 2003].

While listing the main characteristics of cybercartography is useful for providing a general idea of the parameters of the approach, it is necessary to "practice" cybercartography in order to get a fuller understanding of what cybercartography is all about. Cybercartographic atlases develop over time through a series of iterative

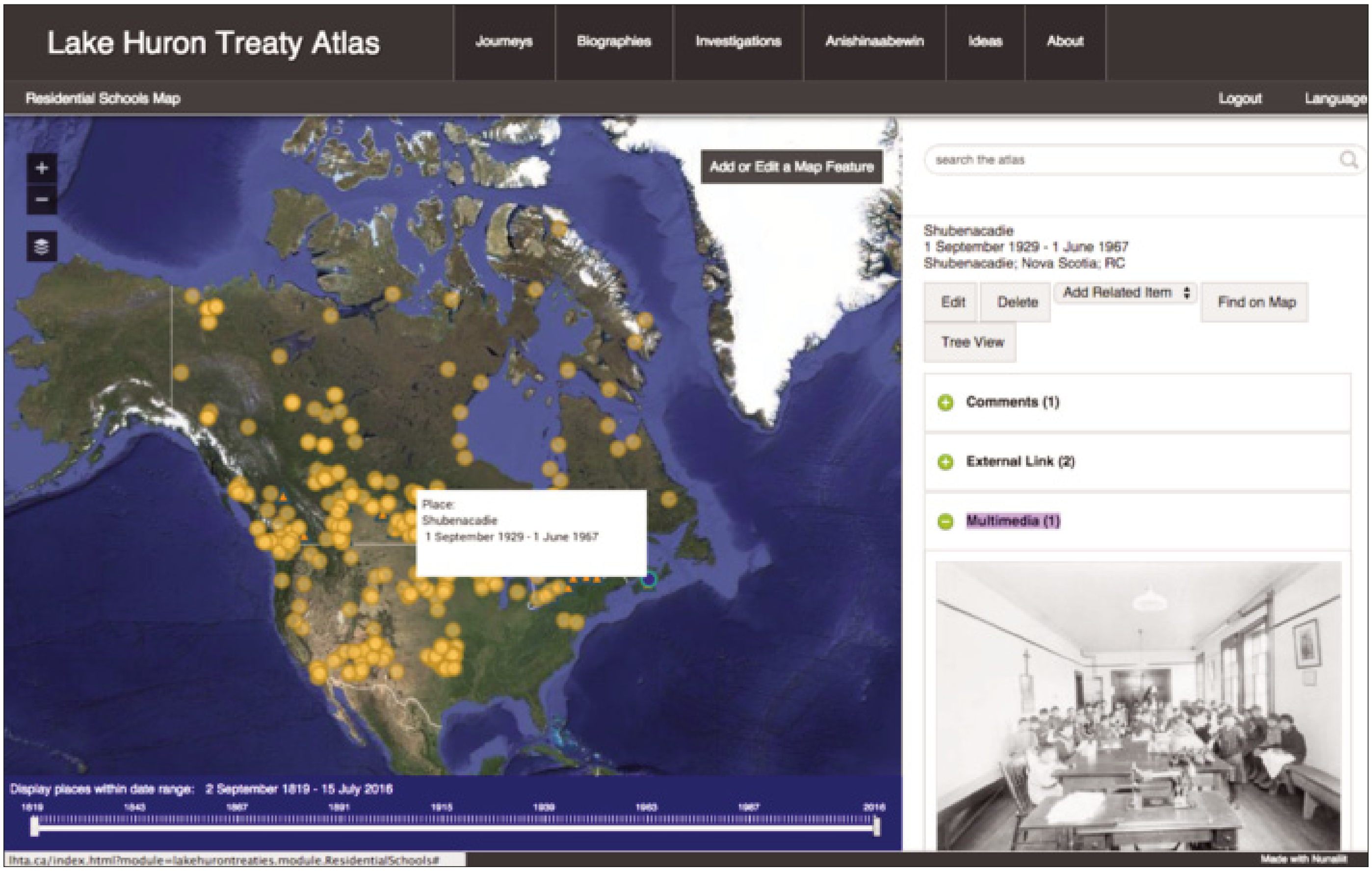

Figure 1: Screenshot showing the Atlas module for Shubenacadie Indian Residential School in the Residential Schools Map of the cybercartographic Lake Huron Treaty Atlas.

processes involving design, implementation and testing phases. Prototypes, both paper and digital, are developed throughout these phases. Discussions of the cartographic possibilities occurring around these prototypes result in alterations in map structure and function over time. Discussions between team members with differing knowledge specializations result in design and development decisions that give rise to the emergence of maps [*Brauen et al*. 2011; *Pyne* 2013].

As a productive theoretical and methodological framework, cybercartography provides a satisfactory framework for the development of atlas projects, while remaining flexible enough for individual projects to evolve in unique ways. In this way, cybercartography is similar to *Amartya Sen*'s [1992, 1999] capability approach to human development, which is neither too over-specified nor too underspecified [*Pyne* 2013]. Just as the capability approach has provided the conceptual conditions for the emergence of a wide variety of theoretical and applied approaches to human development [*Robeyns* 2003; *Crocker* 2006], a growing family of mutually inter-related atlases and atlas-related prototypes have emerged within the developing cybercartographic theoretical and methodological framework. The flexibility of cybercartography's Nunaliit Atlas Framework [*Hayes et al*. 2014] allows a range of atlas projects to share technological and other innovations amongst each other. Examples include: Views from the North [*Payne et al*. 2014]; the Inuit Siku (sea ice) Atlas [*Ljubicic et al*. 2014]; the Kitikmeot Place Names Atlas [*Keith et al*. 2014]; the Gwich' in Atlas [*Aporta et al*. 2014]; the Arctic Bay Atlas [*Taylor et al*. 2014]; and, the Lake Huron Treaty Atlas project, which was funded by two successive SSHRC grants [*Pyne* 2013, 2014]. Each cybercartographic atlas project evolves uniquely. The cybercartographic research framework guides all projects and is further developed through them. Collaborative relationships are essential to cybercartographic atlas development. And atlas contributors come from a variety of diverse yet inter-related communities of practice [*Pyne and Taylor* 2012; *Pulsifer et al*. 2011]. In the case of the Lake Huron Treaty Atlas (the Atlas), these contributions result in a diverse range of map themes reflecting a complex multidimensional approach to treaty-related history that extends to such themes as the Residential School Legacy [*Pyne* 2013].

3.2 The Atlas

Phase I of the Lake Huron Treaty Atlas project involved the production of the prototype Treaties Module under an Inukshuk Wireless Foundation Grant from May 2007–2008 [*Caquard et al*. 2009]. The initial expansion of the Treaties Module into an atlas occurred in phase II between 2009 and 2012, under a three-year SSHRC Standard Research Grant, with the creation of the Atlas and the addition of 27 new working maps to complement the three prototype maps in the Treaties Module; and, improvements were continued in terms of research relationships, content and technological development in phase III under a 2012–2014 SSHRC Outreach Grant [*Pyne* 2013]. The Atlas maps include biography maps; maps related to Anishinaabe language and culture; detailed historical background maps; and maps relating to current affairs. The Atlas has been publicly accessible via the World Wide Web since August 2012, and provides a broadly geographical research and education framework for public participation in both learning and continuing to "grow the maps" in a distributed and collaborative manner [*Pyne and Taylor* 2012; *Brauen et al*. 2011]. The ethic of inclusion that is practiced in the process of providing an online cartographic space for Anishinaabe perspectives and sharing knowledge across disciplines and specialty areas, is a central aspect of cybercartography, and an important factor in enriching Anishinaabe education, renewing relationships between youth and Elders, reviving traditional culture and language, and fostering intercultural mutual understanding [*Pyne* 2013]. The emphasis on awareness, inclusivity, reflexivity and emergence in the project, gives rise to synchronicity in collaborative research relationships and empowerment both in individuals and with respect to the project's ability to contribute to enhanced awareness and improved relationships [*Pyne* 2013].

In the spirit of reconciling relationships, the Lake Huron Treaty Atlas project:

1) acknowledges "the power of maps" [*Wood and Fels* 1992] and mapping processes;
2) endeavors to direct this power in ways that contrast with the colonial settler project; and,
3) adopts a critical cartographic, Indigenous, processual approach to mapping that includes:
    i) using old maps in new ways;
    ii) alternative mapping practices;
    iii) collaborative mapping; and,
    iv) multimedia mapping.

Described as a reconciliation tool [*Pyne and Taylor* 2012; *Pyne* 2013, 2014], the Atlas spatializes history by:

1) "revisiting" the historical geography of Lake Huron Treaty-based relationships from a variety of perspectives in order to appreciate their various dimensions;
2) questioning the epistemological and onto logical assumptions associated with the colonial "world view;"
3) using Anishinaabe teachings (kinoomagi) involving the past, the present and the future, as guides in the Atlas design and development process;
4) employing a collaborative investigative approach involving broad community participation, and
5) taking a multidimensional approach to reconciliation that recognizes the need for reconciliation not only "between peoples" (intercultural reconciliation), but also between people and the land (environmental reconciliation), in addition to the need for "epistemological and ontological reconciliation" [*Pyne* 2013; *Pyne and Taylor* 2012].

Operating at the intersection of critical geography and decolonizing indigenous studies, an important goal of this project is to contribute to the reconciliation of treaty-based relations by enhancing awareness of the historical geography of these relations in a way that transcends the epistemological and ontological vestiges of colonialism. As a virtual geospatial public outreach and education interface, the Atlas is being designed and developed to shed light on a variety of themes over time and across space, including treaties, institutional processes, biographies and Residential Schools. In addition to the inaugural Survey Journeys Maps, which provide the basis for critically tracking the survey portion of the Robinson Huron Treaty process, the Atlas includes biography maps and other maps intended to reflect contextual details relevant to understanding the treaty story. The Residential Schools Map is a significant example of a context map that has taken on a life of its own in terms of usage and relevance to reconciliation processes that are part of the Truth and Reconciliation Commission's mandate. For example, the map was used in the implementation of plans to carry out the 2013–2014 joint Aboriginal Healing Fund-Assembly of First Nations' National Indian Residential Schools Commemoration Project, and could serve as an innovative interface to the digital archives of the National Centre for Truth and Reconciliation, providing geospatially organized access to various collections [*Pyne* 2013].

4. Evolution of the Residential Schools Map Component

The Residential Schools Map component of the Lake Huron Treaty Atlas includes the Residential Schools Map (see Figure 1), which takes a comprehensive approach to mapping knowledge and the E.F. Wilson Biography Map (see Figure 2), which takes a more personalized approach to tracking the life of Edward Francis Wilson, the principal of the Shingwauk and Wawanosh schools in Sault Ste. Marie, Ontario from 1873–1893. Wilson also built schools at Sarnia, Garden River, Batchewana, Nipigon, Elkhorn (Manitoba), and Medicine Hat (Alberta) and travelled extensively throughout Canada and the United States visiting and studying Indian languages, cultures and education.

This component has evolved within the broader scope of the Atlas development project, which in turn has evolved within the even wider context of the Cybercartographic Atlas Framework. This section will take a closer look at the Residential Schools component to examine its potential as a transitional justice tool that can also be applied as a meta-tool in the implementation and assessment of other tools such as truth commissions [*Crocker* 1999; *Pyne* 2013; *Pyne and Taylor* 2015, in press].

The Residential Schools Map emerged in April 2011 as a function of new relationships between Geomatics and Cartographic Research Centre (GCRC) team members and members of the

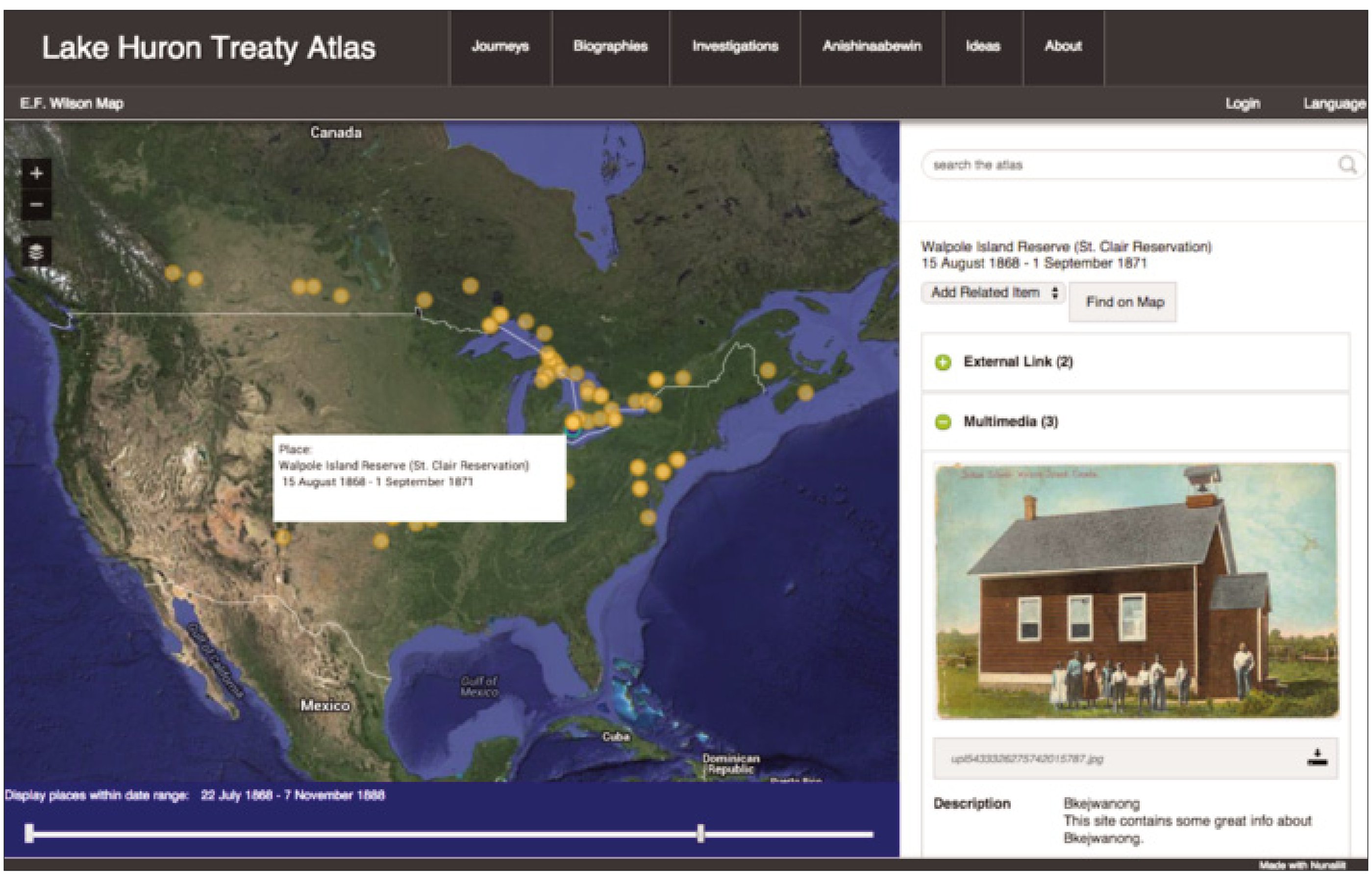

Figure 2: Screenshot of the E.F. Wilson Map of the cybercartographic Lake Huron Treaty Atlas.

Shingwauk Residential Schools Centre (SRSC) at Algoma University. After describing the Atlas project and its purpose to an individual from Whitefish River First Nation during an atlas field trip to the Shingwauk University, this individual suggested immediately that we meet the people working across the lawn at the SRSC. So we did. As it turned out, the time was ripe for beginning discussions and actions toward mapping Residential Schools. That day, we met Tina Priest, an undergraduate intern working with the SRSC. We suggested that if the centre was interested, it could have a virtual map to supplement the large map on the wall in front of us, full of thumbtacks representing schools. This initial conversation evolved into a working partnership between GCRC and the SRSC and a partnership that has involved development across several dimensions.

By June, Tina had been issued a username and password and was able to make a visit in person to the GCRC in Ottawa, along with others from the SRSC in Sault Ste. Marie. During the year that followed, Tina worked from the SRSC in collaboration with GCRC team members, talking over issues and concerns on the phone and in person from time to time, exchanging email correspondence and interfacing through the online cybercartographic Nunaliit Atlas Framework itself. Through her work contributing to the development of the Residential Schools Map, Tina was able to learn through practice and interaction with individuals from a variety of knowledge spaces, including others in the Residential Schools education, research and healing community. The map development process also included talks and email correspondence with the SRSC's then-director, Don Jackson, concerning the potential for a Residential Schools Atlas to grow from this pilot work. Such an atlas would complement the work of the residential schools research, education and reconciliation community. In addition to drawing attention to the geospatial dimensions of the Residential Schools Legacy, such an atlas could aid in information dissemination, network building and public participation. During one of these talks, Don brought out the original copy of a sketchbook/diary that had belonged to Reverend Edward Francis Wilson, the founder of Shingwauk Residential School along with Chief Augustin Shingwauk. Soon after this discussion, Tina was tasked with a second assignment: to begin the journey of mapping of the life of E.F. Wilson across time and space. As it turned out, Don had been waiting to digitize the sketch book, which lent itself well to mapping, due to E.F. Wilson's extensive lifetime travels to Residential Schools across North America. The technique used to begin tracking Wilson's life—referred to as the geo-transcription method of documenting archival documents [*Caquard et al*. 2009; *Pyne* 2013]—was first developed in the iterative processes that included Anishinaabe ways, social interaction, learning, mapping epiphanies, and evolving technology, leading to the creation of the Survey Journeys Maps in the Lake Huron Treaty Atlas [*Pyne* 2013, 2014].

By the same time the next year, the Residential Schools Map would include points accurate to the community level for most of the schools in North America, going beyond the 139 schools acknowledged in the Indian Residential Schools Settlement Agreement. An initial "scour for any and all information" approach was taken to the Internet search portion of the map-making project. This approach allowed for the discovery of often inconsistent information concerning opening and closing dates for schools. For example, another important inconsistency concerned the number of buildings associated with each school over time. After the launch of the Lake Huron Treaty Atlas in August 2012, Don Jackson gave several presentations on the Residential Schools component of the Atlas to a variety of individuals in the Residential Schools education and reconciliation community, including Trina Bolam, then-director of the Aboriginal Healing Foundation. In April 2013, Trina contacted us at the GCRC to inquire about collaborating on the map component of the National Indian Residential Schools Commemorative Marker Project with the Assembly of First Nations as part of the commemorative phase of the Indian Residential School Settlement Agreement [see *http://www.aadnc-aandc.gc.ca/eng/1100100015638/1100100015639*].

After our initial meeting, we (the GCRC team members) learned of the general desire for a comprehensive set of site specific Residential School locations amongst the reconciliation research and education community. Seeing this as a good opportunity to improve the school locations in the Residential Schools Map and to explore a public participatory approach to gathering school location information, we initiated pilot participatory outreach activities for gathering school location-related information, and reviewed and refined some of the school coordinates in the Residential Schools Map. Through this process, we became more aware of the diversity of school sites and the rich potential for education and outreach associated with them. Despite our awareness of the need for a more in depth participatory mapping project to implement this potential, we began pilot outreach activities with some communities to engage people in visiting the sites to obtain accurate site readings and media. We then used models from archaeology to generate a site survey toolkit. Emerging from this process, the vision for a new project began to crystallize, largely due to conversations and collaborative mapping activities with the survivors who participated in the pilot outreach activities; and throughout the year, there were ongoing discussions with various people working in the area of Residential Schools' reconciliation. The need to find more accurate locations for the schools provided an opportunity to both use and improve the Residential Schools Map. This inspired deeper questions regarding the role of Residential School sites in reconciliation processes, and is leading to new opportunities for education and collaborations. Exploring and developing these opportunities in collaboration with others is the subject of a 2014–2016 SSHRC post-doctoral fellowship devoted to expanding the Residential Schools Map into an atlas of its own.

5. The Residential Schools Map Component as a Transitional Justice Tool

According to Crocker, "forensic truth" is a minimal requirement in order to meet the challenge of reckoning with past atrocities. Public acknowledgement and awareness of emotional truth is necessary to eliminate continued abuses comprising the intergenerational effects of Residential Schools such as homelessness, alcoholism and drug addiction, suicide and missing and murdered Indigenous women. The Residential Schools component of the cybercartographic Lake Huron Treaty Atlas can contribute to the multi-cultural goals of forensic, emotional and general truth in both a direct and an indirect manner. For example, with respect to forensic truth, a map layer could be created in the Residential Schools Map for court cases related to the abuses of Residential Schools. With respect to emotional truth, the Truth and Reconciliation Commission was tasked to gather testimonies from Residential School survivors, and postdoctoral research is underway to facilitate the creation of a Residential Schools Atlas for public dissemination of the results of the Commission's efforts. While all of the maps created as part of the Residential Schools Atlas will contribute to general truth, a map devoted to geo-transcribing the Royal Commission on Aboriginal Peoples (chapter 10) and Residential Schools, would provide for an interesting geo-referenced interpretation of this work (in addition to providing a precedent for future geo-transcriptions of the Royal Commission on Aboriginal Peoples). At the same time the new Residential Schools layers and maps reflect these truth-gathering institutional processes, they provide the basis for the assessment of these tools. The Residential Schools Map component can also contribute to the generation of all three types of truth in a sometimes more personalized way than truth commissions or trials may allow for as they involve the unique approach to cartography developed through the processes designed to make the cybercartographic Lake Huron Treaty Atlas [*Pyne and Taylor* 2012; *Pyne* 2013].

As both an online and an on the ground reflection of collaborative map-making processes, the interactive wiki potential of the Residential Schools Map component by definition, provides a public platform for victims to share their perspectives, memories and understandings of the Residential Schools, including their buildings and sites. Despite the capacity of the map to host an unlimited number of remote users, face-to-face interactions and communication via other media have been important aspects of the collaborative map-making process from the beginning. Involving a variety of individuals with a variety of perspectives from the start of a map idea, makes a public platform "by" the people "for" the people more likely.

"Accountability and punishment" and "compensation to victims" are certainly two relevant goals in the case of implementing transitional justice with respect to the Residential Schools Legacy. In using the geo-transcription approach to document archival documents referred to above [*Caquard et al*. 2009], progress of the relevant accountability and progress tools can be tracked with a map layer in the Residential Schools Map, or as a map of its own. This would be most useful as meta-tools in the assessment process of other tools, such as the criminal justice system and the Truth and Reconciliation Commission. While work remains to be started in the development of a map layer reflecting the criminal justice system's history, with respect to Residential Schools-related punishments, progress has been made since discussions officially began in the spring of 2014 to create a cybercartographic extension for the National Centre for Truth and Reconciliation's project to disseminate information gathered under the Truth and Reconciliation Commission's mandate. In addition to the contributions this mapped component will make, in terms of drawing attention to the geospatial aspects of compensation and accountability initiatives, it will provide a tool in its own right for broad-based democratic public deliberation and volunteered geographic input.

The "rule of law" requirement of transitional justice speaks to the heart of its transformative nature. Inherent in the adjective "transitional" is acknowledgement of systemic culpability. In the case of Residential Schools in Canada, their horrific legacy is primarily attributed to successive government policies in corroboration with a variety of religious organizations. Work to design and develop the Governance Paper Trail Map of the Lake Huron Treaty Atlas provides a template for maps tracking government and church policies over space and time with respect to Residential Schools. These maps would extend to the present and contribute to the assessment of policy trends and evidence of policy transformation to determine whether they are consistent with the "rule of law" goal [*Pyne* 2013]. An example of a potentially useful and revealing map is the planned Residential Schools Food Economy Map, a multilayer map tracking different aspects of this economy including policies at various government levels, inventory records such as invoices and financial reports, and other relevant materials and then mapping them for each school location. This potential cybercartographic map project would make an ideal research focus for a graduate student interested in taking a multi-scalar approach to understanding an important dimension of the Residential Schools Legacy in an innovative way. Institutional Reform consistent with transformed policies should naturally follow, if the tools for achieving transitional justice in the case of the Residential Schools Legacy are effective.

Although Crocker may not have intended such a broad interpretation of long-term development, a broad view extends to the individual and includes (personal) empowerment via research and education in cybercartography (including economic benefits, self-esteem enhancement, enrichment of knowledge, and the satisfaction of contributing to the creation of a social justice and education tool). This is relevant to the other goals, including especially public deliberation and reconciliation [*Pyne* 2013]. For example, between January and June 2010, a high school student who was experiencing difficulties succeeding in the school system became a co-op student with the Atlas project. In addition to having a rich and challenging learning experience, the student arrived at a new awareness of Anishinaabe worldviews and contributed to the project in a way that reflected his skills and interests. He also earned the final credits he needed to graduate with honours, and gained the self-esteem and direction to proceed to college in a program related to his co-op assignment [*Pyne* 2013].

Going beyond Crocker's focus on the relationship dimension of "reconciliation," Brenna Bhandar characterizes reconciliation as "a widely accepted objective and guiding principle in attempts to deal with the aftermath of painfully repressive regimes around the world" *Bhandar* [2004]. According to Bhandar, reconciliation-oriented initiatives such as commissions, investigations and hearings often include projects aimed at producing an "official truth" or "official history" [*Bhandar* 2004]. However, the "official" nature of fact-finding commissions with their Crown appointed commissioners and their rather formal protocol for providing testimony, has been critiqued as a further manifestation of colonial attitudes in the guise of a quest for reconciliation. Bhandar expresses difficulties with the extent to which a "single universe of comprehensibility" can be created through the official production of such knowledge; and asks some very relevant questions: "Who actually produces the knowledge? Who collects and interprets the data that come to form the official history? Are the data rendered through testimonials of the victims? Are they rendered through the testimony of those in power? What is left out?" In the end, Bhandar questions whether or not these circumstances will lead to a merely "partial" reconciliation.

In order for the richest form of reconciliation identified by Crocker to be realized, history must be "spatialized." In *Pyne and Taylor* [2012], we discussed several ways the cybercartographic Lake Huron Treaty Atlas "spatializes history" by including multiple perspectives, multiple modes of expression and multiple dimensions in its approach to mapping socioeconomic, cultural and political phenomena. Work completed so far in the Residential Map component of the Atlas shares this approach, by emphasizing the multidimensionality of the Residential Schools Legacy through maps that highlight social, economic, cultural and individual dimensions over time and across space.

The transdisciplinary approach to cybercartographic atlas development extends to the ongoing design and development of the Residential Schools Map component of the Lake Huron Treaty Atlas, and provides an example of applied deliberative democracy that gives rise to enhanced interpersonal awareness and understanding, and personal and social development. The enhanced awareness that results from participating in the creation and use of the Residential Schools component of the Atlas optimizes communication, expression and understanding, which are key aspects of the rich form of public deliberation required for success in reckoning with past wrongs associated with Residential Schools [*Young* 2000]. An important vehicle for deliberative democratic communication is storytelling. One of the deliberative democratic dimensions of cybercartography is its inclusive approach to narrative. Brenna Bhandar agrees with *John Borrows* [1999] and others on the significance and roles of "colonial" stories to undergird current legislative and policy regimes. In response, de-colonizing story-making and sharing is fast becoming an internationally popular pastime (for example, see *Lessard et al*. [2011]). Keeping up with the pace, digital cartographies are providing a powerful medium for expressing these stories. In this regard, the approach to cybercartography that has emerged out of the Lake Huron Treaty Atlas project could be described as a reflective, investigative and emergent approach to collaborative cartographic documentary investigation. This approach has given rise to various forms of geonarrative in the Lake Huron Treaty Atlas, including the Residential Schools component, which provide an effective medium for the expression of otherwise incommensurable perspectives. Education and awareness are essential components of "deliberative democracy," especially when it comes to the need for transformation in attitudes that the prime minister has vowed never to let prevail again. Over the years, the cybercartographic Lake Huron Treaty Atlas project has expanded to include students of all ages in these map-making processes [*Pyne* 2013].

6. Conclusion: Cybercartography and Transitional Justice in an Unjust World

Transitional justice begins with the premise of an unjust world in need of reconciliation and rebalancing in understanding and practice [*Fung* 2006]. It is our immense need for reconciliation that justifies it as one of the primary aims of transitional justice. For example, the intergenerational effects associated with the Residential Schools Legacy include homelessness, alcoholism and drug abuse, suicide and missing and murdered Indigenous women and extend to continued discrimination and cultural, social and economic exclusion. The approach to spatializing history initiated in the Lake Huron Treaty Atlas, and continued in the project to expand its Residential Schools component, provides an innovative way to include multiple perspectives in a broad geospatial context.

There is a reflexive relationship between the means and ends aspects of the eight goals of transitional justice identified by *Crocker* [1999]; this is evident in the way various goals become implicated in the implementation of various tools. For example, public deliberations in determining compensation issues are more successful in deliberative relationships with richer approaches to reconciliation, in contrast with weaker approaches, which are bound to yield limited truths upon which the compensation is to be based. The iterative processes involved in the design and development of the Lake Huron Treaty Atlas provide a template for reflexive, holistic approaches to achieving reconciliation and the other seven goals of transitional justice. Cybercartography's emphasis on process and profiling multiple perspectives, and the ways it brings these perspectives together, indicate the broader potential for cartography to give rise to a different kind of understanding an awareness than factual transmission [*Cheers* 2013; *Gartner* 2013; *Monmonier* 2013; *Taylor* 2013].

It is important to overcome challenges associated with misappropriation of Indigenous knowledge and related challenges associated with intercultural incommensurability in the design and development of the Residential Schools Maps. Inviting Anishinaabe input in the design and development process is one way to begin to do this, departing from centuries of misappropriation and exploitation of Indigenous knowledges in a colonial context [*Belyea* 1992; *Jolly* 2007]. An important aspect of this Atlas work in general, is its concern with intercultural relationships where it does not study one culture or another ethnographically, but engages with all [*Caquard et al*. 2009; *Pyne and Taylor* 2012]. It avoids the criticism often directed at efforts to apply geospatial technologies in the presentation of Indigenous knowledge, and phenomena extending to experience, by emphasizing the importance of trails and journeys rather than particular points on a map. Furthermore it follows *Turnbull* [2007] and others referred to in this paper, in "rethinking knowing and mapping—where the key questions relate to the similarities and differences in the ways space, time and movement are performed and to how those similarities and differences are handled" [*Turnbull* 2007].

In the work to design and develop the Lake Huron Treaty Atlas, including the Residential Schools component, mapping is repurposed: instead of providing reinforcement for colonial or other hegemonic forms of domination by one group of people or institution over others, the purpose of this mapping is to track the development of knowledge over time and space, in an effort to contribute to a new space of mutual understanding [*Turnbull* 2007].

These are exciting and challenging times. According to the Seven Fires Prophecy of the Anishinabek (Anishinaabe people), these are times when people are beginning to seek healing and greater understanding in their relationships with each other, the land and themselves. This is evident in the case of reconciliation processes that have begun internationally along several dimensions. Effective reckoning with past wrongs [*Crocker* 1999] requires a broader scope than official commissions and legal proceedings, and a different way of doing things to avoid misappropriation and misrepresentation of knowledge, perspectives and ways. This will involve acknowledgement of the links between our "colonial past" and our post-colonial present, which must be constantly tested for signs of relapse. The continuing work on the Residential Schools component of the cybercartographic Lake Huron Treaty Atlas helps to establish the broader relevance of cartography to socioeconomic and cultural political policy in a way that can help implement transitional justice, with respect to reckoning with the past wrongs, including those associated with Residential Schools.

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Will C. van den Hoonaard

MAPPING LABRADOR BECAME HER RELIGION: THE STORY OF MINA HUBBARD

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1. Introduction

This article rests on a vignette about Mina Hubbard that appeared in my book, *Map Worlds: A History of Women in Cartography* [*van den Hoonaard* 2014]. Hart's edited biography [*Hart* 2005] of Mina Hubbard served as the basis of this overview. Others have written about Hubbard, including *Davidson* [1997]. I refer the reader to both of these accounts about the Labrador expeditions.

When writers offer a scholarly set of papers about a Canadian mapper, republish her travel diary, and even devote a quasi-fictional account, we are compelled to pay attention. That mapper is Mina Hubbard (1870–1956), whose trajectory took her to map one of North America's most challenging regions, namely Labrador. Even one of Canada's most gripping story tellers, Pierre Berton, could not resist speaking about Hubbard's daring sojourn [*Berton* 1978]. This article discusses Mina Hubbard's background, her stamina, and her techniques in mapping Labrador. It also delves into the contributions she made to Canadian cartography.

Figure 1: 'On the Trail'—Mina Hubbard in Labrador.[1]

2. Her Background

Born on April 15, 1870, to an immigrant family in rural Ontario, Canada, Mina Benson had six siblings. Her mother was from Yorkshire, England, and had immigrated to Canada when she was a child and her father had immigrated to Canada from Ireland during the Great Potato Famine. Mina's parents raised her and her siblings according to strict Methodist beliefs.

After teaching for 10 years in an elementary school, Mina decided to

[1] Source: *A woman's way through unknown Labrador: an account of the exploration of the Nascaupee and George rivers, by Mrs. Leonidas Hubbard*; London: John Murray, 1908.

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move to New York where she became a nurse. She worked on Staten Island as a superintendent where she met her future husband, Leonidas Hubbard (1872–1903), a journalist and adventurer; they were married in January 1901. They moved to the Catskills and invited Leonidas's friend, Dillon Wallace, to live with them. At the time, it was impossible for Mina to know how her husband's upcoming trip to map part of Labrador would revolutionize her own life and thereafter make her an iconic Canadian explorer.

In 1903, Dillon and Leonidas set off on an expedition to map the largely unknown territory of the Naskaupi and George rivers to Ungava Bay in Labrador. They were not successful in their endeavours, and Leonidas did not make it out alive. Encountering numerous setbacks, Leonidas fell ill due to exhaustion and starvation, and despite Dillon's efforts, Leonidas subsequently died. This sudden turn of events caused intense friction between Mina and Dillon, as Mina believed Dillon could have done more to save her husband's life [*Hart* 2005b: 92, endnote 119]. Mina, not having been married to Leonidas very long, was gravely affected by her husband's death. In effect, it inspired both her and Dillon to finish what their companion had started.

Mina brought four people from Labrador with her on her journey: George Elson ("with rare skill and rarer devotion"), Joseph Iserhoffm of half-Russian and half-Cree descent ("a man of Scottish accent and few words"), Job Chapies ("a Cree of cheerful disposition and little English") [*Hart* 2005: 100–101], and the 19-year-old Gilbert Blake; a "half-breed Eskimo boy trapper" [*Buchanan* 2005: 14], who had hunted and trapped along the Naskaupi River "since he was twelve" [*Greene* 2005a: 10]. In June of 1905, Mina and Dillon set off on separate missions in the attempt to finish mapping the Naskaupi and George rivers to Ungava Bay. On 27 August, 1905, Mina reached Ungava Bay. Although Dillon arrived later, he thereafter managed to scope the long coast of Labrador.

3. Her Stamina

What might have seemed deterrents to some women, Mina saw as mere challenges. The first of these being that during the early 1900s, map making and exploration were seen as something carried out by men exclusively. Secondly, she lacked any formal training in geography or any scientific disciplines and lastly, she faced her own personal struggle with issues regarding gender and race in Labrador. However, Mina was inspired to finish her husband's work and the grief over her husband's death, it is said, became her religion [*Hart* 2005: 88].

On June 16 in 1905, Mina set off on her expedition; however the tension between Mina and Dillon persisted as they planned their separate expeditions. Both requested that George Elson (a guide during the 1903 expedition) join them on their trip, but he chose to go with Mina and her group. These issues made their way to the press and people became skeptical of Mina's motives [*Hart* 2005: 97]. Some claimed that Mina was not sincere in her undertaking, believing that she was using the endeavor to find answers to her husband's death. Nevertheless, Mina remained committed to finishing her husband's journey because he could not [*Hart* 2005: 103].

Writers have already passed on to us legacy of some of the more memorable aspects of Mina's temperament that made her capable of initiating, sustaining, and finishing such a dramatic sojourn through Labrador. Randall Silvis, in *Heart so Hungry* [2004: 77], alluded to her attitude before embarking on her sojourn in Labrador, stating that "she would not be weak or cowardly," also describing her as "obstinate" [89]. We are told that along the trail, Mina felt unaffected by the torment of blackfly and mosquito bites [98]. Nothing could disturb her sense of wonder at the peace of Labrador. She was known to be absolutely fearless under all conditions and as such, led subsequent causes related to women and peace upon her arrival in England and following her sojourn in Labrador.

We learn through *William B. Cabot* [1908: 14], a descendant of John Cabot, that only some 30 explorers and *coureurs du bois* have ever visited Labrador since 1674 (until about 1903), as these visits involve "heavy portaging over rough obstructed ground [which] is quite beyond the strength and endurance of unaccustomed persons." It takes one week to portage 10 miles up a mountain of 1000 feet. [*Cabot* 1908: 18]. Cabot describes Labrador further; "its great body of cold water, chilling the warm southwestern winds, is overhung with clouds and cheerless with drizzling rain" [*Cabot* 1908: 4]. Labrador is 600 000 square miles and it is this wilderness that Mina lived in for 61 days.

When Randall Silvis summarized her work in his historical fiction based on her life [*Silvis* 2004: 260], he concluded that Mina possessed the most compelling personality of all the participants in this drama, and that "she has the richest most complex story, the most heartfelt and the most heart-driven." Another historian of her life, Anne Hart [*Hart* 2005b: 353], is convinced that the success of her journey through Labrador demonstrated "...strong capacities for determination and control." Using more contemporary language, Pierre Berton stated that, "she was a tough baby" [*Berton* 1978]. *Hart* [2005: 50] captured her personality and described her as a "stubborn perfectionist, tender to those she loved, implacable to those she found wanting, ever alert to beauty, [and] she is a compelling often endearing subject."

Her Techniques

Quite unlike contemporary mapmakers of today, explorers such as Mina Hubbard had to rely on the time-tested, inductive approach to mapping, which involved walking on foot through *terra incognita*. Mina travelled nearly 970 km in a region entirely inhospitable to outsiders, and one with such delightful names as Bald Mountain, Barren Grounds River, Cold Creek, Crooked River, Devil's Dining Table, Hades Hills, Koksoak River, Muddy Lake, Shag

Rocks, Slanting Lake and Swampy Bay River.

Her techniques were equally simple. She "made observations and notes in her journal, wrote about the Indian graves... [and] described the abandoned camps" [*Silvis* 2004: 179]. Through *Silvis* [2004: 85], we learn that she took readings with her sextant and compass. *Greene* [2005b: 44] informs us that she used "a sextant and artificial horizon to determine latitude." Occasionally, Mina would obtain a crude map of a trail from one of the local Indians [*Silvis* 2004: 87]. Whenever she had the opportunity—and there were many—she would ascend a major hill to get her bearings and anticipate the direction of rivers and rapids that she would need to traverse or follow. Portage was *de rigeur*. When comparing Mina's map with later maps, *Greene* [2005b: 44] learned that "she has considerable difficulty determining latitude," and that "she consistently places [sic] herself north of her actual position, by amounts ranging from twelve to twenty miles." *Greene* [2005b: 45] offers other details about her techniques, and how the use of water, instead of mercury in her artificial horizon led to her errors. Her record of distances travelled each day, as Greene says, helped her to make appropriate adjustments.

5. Her Contributions

One of the initial reasons for the 1905 expedition was to meet the Naskaupi people, who were at the time, said to be the most isolated Indians in North America. Consequently, Mina's maps were seen as a major scientific contribution. They "served as the basis for official maps of the region until the advent of aerial mapping in the 1930s" [*Greene* 2005b: 44]. "Hers," Greene further avers, "were the pioneer maps of the Naskapi and George River systems, and the first map to indicate that Seal Lake and Lake Michikamau were in the same drainage basin and that the Naskapi and Northwest Rivers were not two distinct rivers, as has been generally assumed, but one and the same" [*Greene* 2005b: 45–6]. Greene leaves us with other insights about her training, experience, and contributions, namely that she had no training in geography, but that her maps were "surprisingly accurate" [*Greene* 2005b: 44].

Following Mina's mapping of Labrador, she did not return to her regular occupation. She was no longer teaching or nursing. She began lecturing, writing articles, and working on formally documenting her time in Labrador, while speaking publicly in numerous settings. In the first half of 1906 alone, Mina spoke as the "Ladies night" speaker at the Methodist Men's Social Union in Williamstown, as well as at the Present Day Club of Princeton, New Jersey, the Adams School Teachers' Association, and the Hamilton Club of Brooklyn, New York banquet, in addition to her involvement with a lecturing trip within Canada, and her continued lecturing when she returned to New York [*Hart* 2005b: 355–357]. In 1907, she moved to England, where she continued to discourse about her work. In the meanwhile, she named a number of geographical features in Labrador after some of her young nieces, such as Lake Agnes, Marie Lake, and Maid Marion Falls [*Hubbard* 2005: 193].

While on her lecture tours, she continued to work on her book of exploration, entitled *A Woman's Way Through Unknown Labrador*, completing it in 1908. Published by the American Geographical Society and adopted by the Canadian Geological Survey, Mina saw her book as a "purely pioneer work" [*Hart* 2005b: 369]. The British (and later the American and Canadian) press awarded the book "approving if patronizing, reviews" [*Hart* 2005b: 365]. By 1920, her book was out of print. Nevertheless, during the 2005 centennial of her sojourn in Labrador, *Buchanan and Greene* [2005] produced a lengthy commentary about Mina, which included her diary and a biography by Anne Hart [*Hart* 2005].

As part of his background research for his fictional-historical work, Randall Silvis [*Silvis* 2004: 256] declared that, "her accomplishments were recognized by the scientific community," which included her work in *Bulletin of the American Geographical Society*. It is widely agreed that she "has accomplished a remarkable feat. She has made a journey that has never been accomplished before with the exception of the trader McLean in 1838 and 1841" [*Hubbard* 2005: 341]. An editorial in the New York *Sun* [1 December 1905: 6] summarizes Mina's feat: "Not a few strong men inured to the hardships of pioneer exploring have been baffled in Labrador; but this little woman, fragile in appearance and accustomed to the refinement of life, has done exactly what she set out to do."

As aforementioned, the expedition of Dillon Wallace was one keenly vied with Mina's to finish the mapping of Labrador. In the opinion of Durgin, "The main geographical results of both expeditions are the maps which the books contain, and it must be admitted that Mrs. Hubbard's contribution to the cartography of Labrador is far superior to that of Wallace. It is both on a larger scale and more carefully plotted ... It would require a third exploration to show whether Wallace or Mrs. Hubbard is the more accurate surveyor, but from the extremely sketchy character of Wallace's maps we may hazard the opinion that the lady would prove the safer guide" [*Durgin* 1908: 135].

6. Later Life

Aside from her short marriage to an heir of the Rowntree family in England (through which, with the help of good lawyers, she was able to obtain a secure life when the divorce was finalized in 1915), she was heavily (and fearlessly) committed to the Women's Enfranchisement Movement, and followed Theosophy and the teachings of Rudolf Steiner. She was impervious to, and unafraid of, the bombings of London during World War II. Prior to this however, she eagerly pursued the idea of establishing a literary salon in her home in London, and becoming host to such figures as Bernard Shaw, Rudyard Kipling, H.G. Wells, Tagore, and Rudolf Steiner. At the age of 56, she became a member of the Royal Geographic Society.

Mina Hubbard died on May 4, 1956, at the Coulsdon South Station. Rather than using the passageway to get to the train, she "opened a gate bearing a sign, 'Please Do Not Cross The Line' [and] walked straight into the path of an oncoming train." She was struck by the train, and died in the ambulance on the way to the hospital [*Hart* 2005b: 432].

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CANADIAN NATIONAL COMMITTEE FOR THE ICA

Roger Wheate, Chair

Canada's membership in the International Cartographic Association is held by the Canadian Institute of Geomatics (CIG), Canada's oldest surveying and mapping organization. Founded in 1882, and originally known as the Canadian Institute of Surveying, the CIG has a broad mandate to represent the diverse aspects of geomatics in Canada, including surveying, charting, remote sensing, navigation, geographic information systems, and cartography.

Recognizing that there exist within Canada other national associations with interests in geomatics, notably the Canadian Cartographic Association (CCA) and the Association of Canadian Map Librarians and Archives (ACMLA), the Canadian Institute of Geomatics formed the Canadian National Committee (CNC) for the International Cartographic Association. As defined in a Memorandum of Understanding (MOU) between the CIG and the CCA, the CNC is chaired by a CIG member who also serves as the Technical Councillor for cartography on the CIG executive. Membership of the CNC, as described in a 2007 revision to the original 1993 MOU, includes a representative from the CIG, CCA and ACMLA, along with three other members who coordinate ICA activities such as the National reports, Canada's contribution to the International Map Exhibition and the Children's Map Competition. The CNC is currently made up with representation as follows:

- Canadian Institute of Geomatics (CIG) and Principal ICA Delegate—Roger Wheate;
- Canadian Cartographic Association (CCA)—Jeff Wielki;
- Association of Canadian Map Librarians and Archives (ACMLA) —Siobhan Hanratty;
- Deputy Delegate to the ICA—Janet Mersey;
- Coordinator for the International Map Exhibition—Janet Mersey;
- Coordinator for the Children's Map Competition—Karen Van Kerkoerle.

The Chair of the Canadian National Committee for the ICA has a four-year term of office coinciding with the time between ICA General Assemblies. According to procedures outlined in the MOU, the Chair is nominated by the Canadian Cartographic Association and ratified by the Canadian Institute of Geomatics. Janet Mersey previously held this position from 2003–2013, including an extra 'half-term' from 2011–2013. The mandate of the Canadian National Committee, articulated in the Terms of Reference document, includes the following:

- To represent the Canadian cartographic community internationally, through Canada's membership in the International Cartographic Association;
- To review and develop a national position on administrative and cartographic matters relevant to the International Cartographic Association;
- To ensure that Canada is appropriately represented on ICA standing commissions, ad hoc commissions, working groups, joint inter-associations working groups, and committees.
- To prepare for each quadrennial ICA General Assembly and International Technical Conference by:

a) Publishing a national report covering government and non-government mapping activities, cartographic education, technological developments (including geographic information systems), cartographic literature, activities of professional societies, and special activities of interest;
b) Identifying key issues which will be discussed and voted on at the General Assembly, and preparing a Canadian position on these issues;
c) Considering the nomination of Canadians for executive positions and, if appropriate, encouraging such individuals to stand for election at the General Assembly;
d) Ensuring that high-quality technical papers are prepared by Canadian authors for presentation at the International Technical Conference and publication in the conference proceedings; and
e) Providing a national exhibit illustrating advances in Canadian cartography by displaying representative maps, charts, atlases and other cartographic developments since the previous conference, and to encourage Canadian participation in support of ICA educational seminars, publication of cartographic texts, and similar special projects.

Canadians continue to be actively involved in ICA activities, both through serving on ICA commissions and working groups, and by preparing national submissions for ICA conferences. Positions currently held by Canadians on ICA commissions and working groups include:

Commission on Mapping from Satellite Imagery
Vice-Chair: Jonathan Li (University of Waterloo)
Commission on Art and Cartography
Chair: Sébastien Caquard (Concordia University)

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Dr. Li has been nominated to start a term as Chair commencing this year, and Dr. Caquard has been re-nominated for Chair of his commission.

At the 26th International Cartographic Conference in Dresden, August 2013, D.R. Fraser Taylor became the first Canadian recipient of the ICA Carl Mannerfelt Gold Medal, awarded to cartographers of outstanding merit who have made significant contributions of an original nature to the discipline of cartography. Éric Loubier, director of the Centre of Topographic Information, NRCan, presented a keynote address on “The Transformation of National Mapping Approaches in the Context of Geomatics Democratization.”

The conference welcomed a further delegation from Canada, many of whom presented papers. These were Janet Mersey (U. Guelph), Roger Wheate (U. Northern B.C.), Sébastien Caquard (Concordia U.), Jonathan Li (U. Waterloo), Will van den Hoonaard (U. New Brunswick), Yaïves Ferland (U. Laval), Michael Govorov (Vancouver Island U.), Ng-Chen Taien (Concordia U.), Dany Bouchard (DBx-Geomatics), Scott Shupe (U. Fraser Valley), Julia Siemer (U. Regina), Hansgeorg Schlichtmann (U. Regina) and Jeff Wielki (U. Calgary). The conference’s Technical Exhibition included DBxGeomatics, a Canadian company based in Gatineau, Quebec, showcasing its suite of applications for interactive web-based mapping.

The International Map Exhibit entries from Canada were coordinated by Dan Duda (Memorial U. of Newfoundland), presenting 10 maps and three atlases. *The Circumpolar Health Atlas* (edited by T. Kue Young, published by the U. of Toronto Press, 2012) took second prize in the Atlas category. Janet Mersey has assembled a larger set of entries for the 2015 conference, with 16 maps and five atlases. Thanks go to Karen Van Kerkoerle (U. of Western Ontario), for again organizing the Canadian children’s map competition for 2013 and 2015, which resulted in the selection of five outstanding Canadian maps that were sent to Dresden, and six to Rio de Janeiro, for the Barbara Petchenik Children’s World Map Competition. Thanks are also due to Wendy Ripmeester (Natural Resources Canada), for arranging the display of all 53 submissions for Rio at a summit meeting in Ottawa, on April 20, 2015, and also for coordinating Canada’s International Map Year activities. ❑

Portion of the children’s map display in Ottawa, April 20, 2015.

FEDERAL, PROVINCIAL, AND TERRITORIAL GOVERNMENT ACTIVITIES 2011–2015

PARKS CANADA PARCS

Parcs Canada publie La *Géomatique à Parcs Canada* sur son site web. Cette publication périodique donne quelques exemples de la contribution que la géomatique fait au mandat de Parcs Canada. On peut trouver la publication à l'adresse suivante : *http://www .pc.gc .ca/fra/agen/SIG-GIS/SIG-GIS.aspx.*

Parks Canada posts *Geomatics in Parks Canada* to its website. This periodic publication gives a few examples of the contribution that geomatics makes to the mandate of Parks Canada. You can find *Geomatics in Parks Canada* at the following URL: *http:// www.pc.gc.ca/ eng/agen/SIG-GIS/ SIG-GIS.aspx*.

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NORTHWEST TERRITORIES

The Northwest Territories Centre for Geomatics (NWTCG) was established in 1988 to provide geomatics, remote sensing and geographic information systems (GIS) services to the Government of the NWT (GNWT). Our facilities, technical staff and large databases of NWT satellite imagery and vector data, is unmatched in the north. Staff at the NWTCG have a wide range of skills and expertise in geomatics, remote sensing, GIS and computer systems. The NWTCG is equipped with a variety of software, hardware and systems for use in project work.

The main fields of activity for the NWTCG include:

- Developing, implementing and maintaining all scales of geomatics projects;
- Creating custom maps to meet client business needs;
- Maintaining an online geospatial data portal for interactive web-mapping and data downloads;
- Providing access to satellite imagery, image classifications and spatial databases;
- Promoting the application of geomatics to all GNWT departments and assisting with projects by providing training, resources and advice.

In 2015, the NWTCG's geomatics product services will be expanded to 11 or more GNWT departments, as well as federal partners and the public. Additional operational services have been incorporated as part of the devolution of land and water management responsibilities realized in 2014. The number of client projects will continue to increase with the addition of new divisions and departments. Online mapping tool and data usage will also increase, reducing mapping requests, while increasing the use of geomatics for research, analysis, and decision support. Also, during 2015, the Land Management Decision Support System (LMDSS) implementation will begin. The LMDSS is intended to provide the foundation for a system that will provide stakeholders of the Land Use Sustainability Framework (LUSF) with the tools needed to better manage the land.

The NWTCG now has a total staff of 14, which includes GIS, remote sensing and web and infrastructure specialists. The NWTCG's portfolio continues to expand with the addition of the Western Arctic Centre for Geomatics in Inuvik.

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2011–2015 Key Activities

- SPOT imagery from 2008 to 2012 is now available as a WMS service online: *http://apps.geomatics.gov.nt.ca/ArcGIS/services/Mosaics/GNWT_SPOT_Mosaic/MapServer/WMSServer?*
- New NWTCG website design: *http://www.geomatics.gov.nt.ca*
- New Discovery Portal Website: *http://nwtdiscoveryportal.enr.gov.nt.ca:8080/geoportal/catalog/main/home.page*

  The NWT Discovery Portal is the most comprehensive online source for NWT environmental monitoring knowledge. As an information repository, the portal is a search and share tool that allows users to both access data and reports as well as contribute by uploading research and monitoring information.
- Data Storage Solution: large datasets create storage issues for many departments, and many of these large datasets are geospatial—such as satellite imagery. The NWTCG has been working with the GNWT's Technology Service Centre (TSC) to develop an affordable storage solution for large datasets. In conjunction with the TSC, the NWTCG implemented the solution in 2013/14.
- New naming conventions standards for SDE geodatabases
- Standardization on ESRI-FGDC metadata in SDE geodatabases
- New Spatial Data Infrastructure (SDI) server architecture
- Integration of Department of Lands Mining Recorders Office related mapping responsibilities
- Integration of Mineral Information Tenure System (MITS) into our spatial data infrastructure (SDI) development of Western Arctic Centre for Geomatics (WACG) in Inuvik with three new remote sensing positions. The WACG will increase the GNWT's capacity to meet the escalating demand for monitoring applications, based on remote sensing technologies including infrastructure, economic development, and land use and community monitoring.
- New spatial data viewers, Silverlight and HTML5: *http://www.geomatics.gov.nt.ca/sdw.aspx*
- WMS services built on Geocortex/ArcGIS Server platform: *http:// www.geomatics.gov.nt.ca/wms.aspx*
- Human disturbance data mapped for the entire NWT (excluding the Dehcho). The key objective of this project was to create an accurate and up?to?date human disturbance footprint that can be used for range management responsibilities of the Bathurst caribou herd and is a step towards the development of a comprehensive human disturbance dataset for the entire NWT.
- New aerial photography for Horn Plateau, Behchoko Vegetation Inventory, Talston Hydro Corridor, Tlicho Transportation Corridor, Inuvik to Tuktoyaktuk Highway Corridor and Cameron Hills
- New and simplified Protected Areas Strategy (PAS) data structure
- LiDar data acquisition in various areas of interest across the NWT
- Web published ecological land classification data (Forest Management Division)
- *Our Northern Heritage—Mapping the NWT* Video: a 24 minute production covering the history and development of geomatics in the NWT with a look to the future of remote sensing in the north. URL: *https://vimeo.com/user4261970/review/119264349/fe15fc46b1*
- Planning and development of an Unmanned Aerial Vehicle (UAV) program in 2015 for wildlife surveys and habitat assessments
- NASA's Arctic-Boreal Vulnerability Experiment (ABoVE)—The objective of the program is to analyze the historical and ongoing archive of NASA's Landsat imagery (Thematic Mapper, Enhanced Thematic Mapper, and Operational Land Imagery) to obtain a comprehensive, wall-to-wall overview of slow and rapid landscape changes that are relevant to natural resource managers and environmental researchers in the Northwest Territories (NWT).

GNWT GIS User Updates

Kathleen Groenewegen—Forest Management Division

- Forest Management Division (FMD), together with the Wildlife Division, has completed the delineation and attribution of the NWT Ecological Land Classification dataset. This includes producing a web mapping application that showcases the EcoRegions in addition to over 60 000 hyperlinked photos that visually document the NWT landscape. Please see: *http://www.geomatics.gov.nt.ca/ecosystem_class_photomap.aspx*
- Forest Management Division continues to work with NWT communities to develop community-based timber harvest plans that include producing detailed timber supply analyses and maps that take into account boreal caribou recovery strategy indicators, land use planning processes, and forest vegetation inventory scenario analyses.

Matthew Coyle—Forest Fire Division, Fort Smith

- Development of SPARCS Map, has produced an interactive mapping application used for wildfire intelligence and decision support. Its development was led by FMD and its architecture is based entirely upon source software and strictly adheres to open standards.
- Landsat imagery is now almost exclusively being used to map final wildfire perimeters as a result of 2014's record breaking wildfire season, which necessitated a more economical and accurate approach to fire mapping than aerial GPS.
- Work is underway to develop a methodology to semi-automate the derivation of burn severity data for all wildfires in the NWT. Once implemented, this data will help land managers better understand how wildlife interact with burned

areas, predict post-fire succession of ecosystems and has many other potential implications that range from better understanding wildfire behavior, to gauging the effects of climate change.

Northwest Territories Geological Survey—Doug Irwin

On April 1, 2015, the Northwest Territories Geoscience Office (NTGO) changed its name to the Northwest Territories Geological Survey (NTGS). The new name better reflects its government origins and the range of services that it provides. The NTGS advances geoscience knowledge of the NWT for the benefit of northerners and Canadians through the delivery of geoscience research, analysis of mineral and petroleum resources, and by offering excellence in digital data management.

NTGS is a division of Industry, Tourism and Investment (ITI) that provides research, analysis, information and advice for individuals, communities, governments, and the mining and petroleum industry, based on the work performed in regional bedrock mapping, mineral deposit studies, petroleum geology, mineral and petroleum resource assessments, GIS and remote sensing, and community outreach.

Geomatics component of NTGS:

- Provides extensive use of geomatics information technology in geological mapping programs, geological compilations (NWT geological compilation in progress), mineral deposit studies, petroleum resource studies, and community consultations;
- Maintains in-house spatial geological and geomatics data;
- Supports NWT Cumulative Impact Monitoring Program (CIMP) and permafrost activities;
- Supports natural resource assessments that are linked to the Protected Areas Strategy;
- Continues the development and evaluation of mobile GIS applications (ArcPad) using handhelds (Trimbles) and tablets in geological field projects, and is currently evaluating iOS and Windows-based tablets and relevant software;
- Provides mobile GIS application training to field crews, University of Alberta field school students and support to industry partners;
- Contracts airborne geophysics (which includes DEM generation);
- Serves as a geomatics (and research) partner and contributor in several programs within the Geo-mapping for Energy and Minerals (GEM) initiated by the Geological Survey of Canada (GSC);
- Provides geomatics and ground support for regional geochemical sampling, and contributes to the National Geochemical Reconnaissance program, using iPads to collect spatial data and is currently delineating a detailed watershed dataset of the Mackenzie Mountains to analyze and interpret the geochemistry data;
- Currently in the process of modernizing NTGS's web mapping application presence as directed by the NTGS Strategic Plan and the ITI's Mineral Development Strategy. We anticipate using SQL Server, ArcGIS Server, Geocortex as well as the Google Maps API to allow easy display, discovery and dissemination of the extensive public domain data.
- Maintains web-based spatial data access applications using Oracle 10g and a Map Server Portal (NTGoMap, GoData). Accessible data includes mineral showings data, reference metadata, geophysical metadata, diamond/kimberlite drillhole data, petroleum drillhole data, National Air Photo Library collection and other related geoscience datasets;
- Maintenance of a web-based data access portal, Gateway (linked to NORMIN and NTGoMap), providing download access to 60 years of scanned, industry-submitted geological assessment reports and NTGO publications.

Ryan Chenkie,
Geomatics Services Team Leader,
NWT Centre for Geomatics

GOUVERNEMENT DU QUÉBEC

L'information géospatiale (IG) constitue un actif important qui fait partie intégrante des connaissances acquises au fil des ans par les ministères et organismes du gouvernement du Québec (MO). Cette information éclaire les décisions et est mise à profit dans toutes les phases ayant trait à la réalisation des missions de l'État. L'utilisation de l'IG et de la géomatique est implantée depuis longtemps dans les MO à vocation territoriale et ceux dont la vocation est à prédominance socioéconomique en font une utilisation croissante.

En tant que responsable de la gestion de l'infrastructure foncière et géographique du Québec, le ministère de l'Énergie et des Ressources naturelles (MERN) est l'un des acteurs les plus importants en IG au gouvernement du Québec. Il est notamment responsable de la production, du maintien et de la diffusion :

- de l'information géographique de référence du Québec (ex. : référence géodésique, cartographie officielle, levés géospatiaux);
- de l'information foncière (ex. : arpentage des terres publiques, tenue du registre foncier et du cadastre, démarcation des frontières et des limites entre les terres privées et publiques).

Le MERN a également la responsabilité de mettre en œuvre une approche de coopération interministérielle appelée ACRIgéo. Cette approche a pour but de mettre à profit l'expertise répartie au sein de l'État, d'accroître le patrimoine informationnel (couverture en imagerie numérique, production de bases de données cartographiques, développement d'outils et de services communs) et d'en promouvoir l'utilisation, dans le souci d'optimiser l'efficacité gouvernementale. En misant sur le décloisonnement, la mise en commun des actifs et le développement de partenariats, l'ACRIgéo contribue à répondre aux défis que représentent notamment la gestion durable des ressources naturelles, la lutte contre les changements climatiques, la consolidation des finances publiques et la croissance de l'économie.

Cet article présente un survol de quelques initiatives gouvernementales en géomatique et en IG ayant eu cours entre 2011 et 2015 ainsi qu'un aperçu de quelques projets à venir. Une attention particulière est portée sur les projets présentant un intérêt pour le public et ceux réalisés en partenariat.

Bases de données géospatiales gouvernementales

La période 2011-2015 a été marquée par de grandes avancées en matière de production et de diffusion des bases de données géospatiales. En octobre 2011, Adresses Québec a fait son entrée sur le marché. Issue des données de mission de quatre partenaires gouvernementaux (ministère des Transports du Québec, ministère des Affaires municipales et de l'Occupation du territoire, Directeur général des élections du Québec et MERN) et de la collaboration du milieu municipal, Adresses Québec est la géobase de localisation officielle du Québec. Elle est composée de près de 143 000 km de routes (comprenant l'information sur les noms de routes, les tranches d'adresses, la classification routière et l'information permettant la gestion de parcours) et de plus de 3 250 000 adresses avec code postal MO. Adresses Québec est une géobase mise à jour mensuellement qui est précise, exhaustive, intégrée et cohérente. Elle se décline en plusieurs produits pour répondre à un vaste éventail de besoins. Déjà, elle se trouve au cœur des activités de plusieurs MO ainsi que dans plusieurs entreprises privées. Un des produits de cette géobase est d'ailleurs offert gratuitement à toutes les clientèles et est accessible pour téléchargement sur le site : *www.adressesquebec.gouv.qc.ca.*

Des travaux concernant l'intégration à la géobase Adresses Québec des routes d'accès au territoire, des routes forestières, des chemins de fer et des voies cyclables sont sur le point de se terminer. C'est ainsi près de 500 000 km de réseau supplémentaires, ou plus de 800 000 segments linéaires, qui seront incessamment accessibles aux utilisateurs. Ce nouveau produit sera diffusé par Géoboutique Québec.

Le projet de la mise en place d'une géobase du réseau hydrographique du Québec (GRHQ) a aussi évolué considérablement ces dernières années. Ce réseau est produit en partenariat par le MERN et le ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques. À ce jour, 97 % de la production est achevée pour le sud du Québec. Au cours des prochains mois, des travaux seront entrepris pour assurer l'arrimage des données hydrographiques de la partie sud du Québec avec celles de la partie nord provenant du Réseau hydrographique national produit par Ressources naturelles Canada. Dans les prochaines années, des travaux auront cours afin d'enrichir la première version de la GRHQ en intégrant des informations provenant d'autres partenaires.

Imagerie numérique

L'imagerie numérique (imagerie satellite et photographies aériennes) occupe une place importante dans la réalisation des missions du gouvernement du Québec. Elle sert notamment d'assise pour la caractérisation des milieux, l'aménagement et la gestion durable des forêts, la cartographie du territoire, la gestion et la planification des interventions lors de situations d'urgence ainsi que dans le cadre du programme d'assurance agricole, pour ne citer que ces exemples.

Le MERN est le principal maître d'œuvre de l'acquisition de l'imagerie numérique pour le gouvernement du Québec. Un important patrimoine de plus de 100 téraoctets de photographies aériennes a été constitué au fil des ans. La majeure partie de cet actif a été acquise dans le cadre d'ententes de partenariats rassemblant des MO et le milieu régional. Depuis 2013, sept MO assument annuellement l'acquisition des photographies aériennes avec, pour objectif, de couvrir de manière continue l'ensemble des régions au sud du 52^{e} parallèle sur une période de 5 à 10 ans. En ce qui concerne l'imagerie satellite, plus de 6200 images de divers capteurs sont accessibles dans la Banque de données satellitaires du Québec. Des mosaïques couvrant l'ensemble du Québec ont entre autres été acquises, dont la plus récente est une mosaïque RapidEye à 5 m de résolution spatiale (2010–2013). À cette dernière s'ajoutent la mosaïque SPOT (2005–2011) ainsi que les mosaïques Landsat, acquises depuis 1972, assurant ainsi un patrimoine historique intéressant de l'évolution du territoire québécois.

Considérant le potentiel des données lidar pour une multitude d'applications, le ministère des Forêts, de la Faune et des Parcs, appuyé par plusieurs partenaires du gouvernement du Québec, du gouvernement fédéral et de l'industrie, a récemment analysé les retombées d'une acquisition de données lidar à l'échelle du Québec. Les résultats préliminaires obtenus portent à croire qu'un rendement de l'investissement intéressant pourrait être attendu. Les gains les plus notables pour le gouvernement du Québec sont associés au processus de l'inventaire forestier, mais d'autres domaines d'activités y voient aussi des bénéfices, notamment dans le domaine du transport, de la géologie et de l'environnement. Près de100 000 km^2 sont déjà couverts par ces données ou sont en cours d'acquisition en 2015, et une croissance des demandes d'acquisition est attendue.

Connaissances géographiques liées au développement nordique

Ces dernières années, le Québec s'est montré très actif dans l'acquisition de connaissances géographiques sur les milieux nordiques. De 2010 à 2013, 4,5 millions de dollars ont été investis par le gouvernement du Québec pour améliorer la connaissance de ces vastes milieux afin de répondre aux nouveaux enjeux de développement et aux besoins des communautés locales. La majorité de ces projets a été mise en œuvre par le MERN et a été menée en partenariat avec d'autres MO. Dans plusieurs cas, l'expertise de l'entreprise privée a été mise à profit. Voici quelques exemples des projets réalisés :

- production d'une couverture d'images satellite de tout le territoire au nord du 49e parallèle (1 216 885 km^2);
- acquisition de données précises du relief (lidar) pour les 14 villages inuits, 8 villages cris, les routes d'accès à certains villages cris, la ville de Fermont et celle de Schefferville;
- acquisition de photographies aériennes de grande précision des localités de Fermont et de Schefferville afin de soutenir la gestion de leurs infrastructures municipales;
- cartographie à l'échelle de 1/20 000 d'un secteur de la Basse-Côte-Nord sur une superficie de 18 402 km^2;
- cartographie à grande échelle (1/2 000) des 14 villages inuits, de 9 villages cris et d'un village naskapi;
- implantation et mise à jour de nouveaux points géodésiques de grande précision dans différents secteurs du nord du Québec.

Outils communs et partage de l'expertise

Le gouvernement du Québec applique depuis peu un nouveau modèle de collaboration interorganisationnel pour développer des outils géomatiques. Ce projet, entrepris par le ministère de la Sécurité publique, est appelé « Infrastructure géomatique ouverte » ou IGO. Il est développé à partir de logiciels libres et fait appel à des standards ouverts. IGO comporte un navigateur cartographique qui est utilisé par la communauté gouvernementale depuis le printemps 2015. Il intègre aussi un service de géolocalisation, des cartes Web, des modules pour la requête spatiale et l'édition en ligne ainsi qu'un service d'itinéraires.

IGO fournit aux MO du gouvernement du Québec l'occasion d'allier leurs efforts et leur expertise et de retirer plusieurs bénéfices, comme ceux-ci :

- accès à un code source libre et de qualité, pouvant être réutilisé par une communauté élargie;
- mise en commun et optimisation de ressources humaines et financières, réduisant les coûts et la durée de développement des outils;
- partage des responsabilités entre les organisations partenaires;
- accroissement de l'expertise gouvernementale grâce aux échanges avec une communauté d'experts active.

IGO sera sous peu distribué publiquement sous une licence libre du gouvernement du Québec, permettant à des contributeurs de partout dans le monde de proposer des améliorations au logiciel. Actuellement, les partenaires du projet, soit le ministère de la Culture et des Communications, le ministère de la Sécurité publique, l'Institut national de la santé publique, La Financière agricole du Québec, le ministère des Transports du Québec, la Commission de la protection du territoire agricole du Québec et le Centre d'expertise en logiciel libre du gouvernement du Québec, participent activement au développement et à l'évolution de IGO (*http://www.cspq.gouv.qc.ca/a-propos-du-cspq/centre-dexpertise-en-logiciel-libre/*).

Accessibilité à l'information géospatiale

L'information géospatiale gouvernementale constitue un intrant d'intérêt pour les citoyens et les professionnels. De nouveaux projets visant à améliorer l'accès à cette information grandement prisée ont vu le jour ces dernières années au gouvernement. D'abord, le MERN a mis en ligne Géoinfo, l'outil de recherche, en octobre 2014. Cet outil permet de découvrir et d'explorer l'important patrimoine du gouvernement québécois en matière d'IG. Il offre un moteur de recherche ainsi qu'un navigateur cartographique qui présente des données gouvernementales fiables et souvent inédites, comme les images RapidEye couvrant l'ensemble du Québec et les orthophotographies des villages du nord du Québec mentionnées précédemment. À l'heure actuelle, plus de 130 fiches portant sur diverses connaissances du territoire sont répertoriées dans Géoinfo, mais ce contenu s'enrichit constamment, grâce à la collaboration d'une vingtaine de MO partenaires du projet. Géoinfo est hébergé au sein du portail *Le Québec géographique* et il y ajoute une dimension géographique interactive et innovante (geoinfo.gouv.qc.ca).

L'année 2014 a aussi été celle marquant le 250e anniversaire d'existence de la fonction d'arpenteur général du Québec, une fonction qui incombe au ministre de l'Énergie et des Ressources naturelles du Québec. Le Greffe de l'arpenteur général du Québec, un registre public qui permet de conserver et de diffuser l'ensemble des documents préparés sous l'autorité de l'arpenteur général du Québec, a connu un important virage numérique pour l'occasion. Une application Web a été déployée permettant aux arpenteurs-géomètres et aux autres clientèles de consulter gratuitement, en ligne, plus de 170 000 documents, y compris des cartes, des plans et des carnets d'arpentage (*http://www.mern.gouv.qc.ca/foncier/arpentage/arpentage-greffe.jsp*).

Mentionnons également la mise en ligne, à l'été 2012, du portail de données ouvertes du gouvernement du Québec (donnees.gouv.qc.ca). Ce site, qui contient des données et des applications permettant à l'ensemble des citoyens et des entreprises de prendre des décisions éclairées, témoigne de l'engagement de transparence du gouvernement du Québec. Aujourd'hui, une quarantaine de données géospatiales sont offertes dans des formats géomatiques ouverts et des dizaines de couches de données peuvent y être visualisées ou obtenues par l'intermédiaire de services Web géographiques interopérables. Géré par le Secrétariat du Conseil du trésor, le portail de données ouvertes bénéficie de la contribution d'une vingtaine de MO.

Finalement, dans le cadre de sa collaboration avec le gouvernement fédéral en matière d'information géographique, le Québec a signé, en février 2015, l'Accord canadien de géomatique 2014–2019. Cet accord, qui constitue un renouvellement de l'Accord canadien de géomatique 200–2012, est une entente intergouvernementale canadienne qui a pour but de mettre en place un cadre permettant aux organismes fédéraux, provinciaux et territoriaux qui exercent des activités de géomatique, de collaborer afin de rendre plus efficaces la collecte, la distribution et la mise à jour des données dans ce domaine. Les signataires de l'Accord viennent ainsi réaffirmer leur intention de collaborer à des initiatives de géomatique avantageuses pour toutes les parties.

Par cet accord, le Québec confirme ainsi son adhésion au principe de base voulant que les données géographiques soient recueillies une seule fois, le plus près possible de la source et de la manière la plus efficace afin d'éviter la duplication et les chevauchements, et ce, dans le respect des compétences de chacun des signataires. Des initiatives concrètes ont d'ailleurs été menées ces dernières années en appliquant les principes de ces accords. C'est le cas notamment des collaborations entreprises pour la constitution du Réseau routier national, du Réseau hydrographique national ainsi que celles concernant le partage des données sur les découpages municipaux et le réseau ferroviaire.

Perspectives

Le gouvernement du Québec entend poursuivre le déploiement de l'ACRIgéo. En poussant encore plus loin les pratiques de collaboration mises en place, les prochaines années devraient être marquées par l'adoption d'orientations gouvernementales en matière d'IG. Des actions concrètes, de portée horizontale, seront définies et réalisées pour contribuer à ces orientations. Elles permettront :

- d'actualiser davantage l'information géospatiale gouvernementale, de la mettre en valeur et d'en faciliter l'accès, notamment par le déploiement de plus de services Web géographiques;
- de renforcer la synergie entre les MO dans toutes les sphères entourant la production, l'utilisation et la diffusion de données géospatiales et le développement d'outils géomatiques;
- de développer des liens avec d'autres acteurs des secteurs privés et de l'enseignement.

La mise en œuvre de ces actions contribuera à réaffirmer l'importance stratégique que revêt l'IG pour le gouvernement du Québec et pour la société en général.

Mario Hinse, directeur de la Direction
de la cartographie générale
et administrative
Direction générale de l'information
géographique, Secteur du territoire
Ministère de l'Énergie et des
Ressources naturelles

YUKON

Geomatics activities in the Yukon are managed by a central geomatics agency, Geomatics Yukon, and by departmental mapping agencies. Geomatics Yukon is responsible for the core Yukon Government spatial data infrastructure, enabling the departments to focus on operational data management and applications. The primary departmental mapping agencies in Yukon Government (YG) are the Department of Energy, Mines and Resources; the Department of Environment; and the Department of Highways and Public Works' Transportation Division.

There has been a dramatic increase in geomatics activities throughout all YG departments in the last few years. This has resulted in the incorporation of geospatial data in many government applications, as well as in geospatial data becoming an important element in many day-to-day decision making processes. The increased use of geospatial data within YG is the result of the growing availability of sophisticated desktop and web-based mapping tools.

Geomatics Yukon

The mission of Geomatics Yukon is to provide corporate coordination, support and liaison for geomatics activities within YG, to manage YG's spatial data infrastructure and to enable open data. This unit has recently moved into a new E-services branch within the Information & Communications Technology Division of the Department of Highways & Public Works. This change follows a trend towards leveraging the internet for service delivery in the public sector.

YG's spatial data infrastructure includes the corporate spatial warehouse, the enterprise operational database, web mapping, the image repository and the metadata portal. All these components continue to be important; however, over the last four years there is an increasing emphasis on improving the web mapping and imagery management infrastructure. This is due in part to Yukon now having a strong data management foundation, which enables YG to focus on distribution capabilities and base mapping.

A new web-based browser application, GeoYukon (*http://mapservices.gov.yk.ca/GeoYukon*), was released in late 2014, providing access to Yukon Government's most up-to-date and comprehensive collection of geospatial data, including imagery. GeoYukon allows users to view, search, extract and download Yukon geospatial data and related metadata. This application and its associated map services distribute all the YG geospatial data to the public via standard formats, providing Yukon's commitment to a national geospatial data infrastructure.

A major initiative over the last 10 years has been to improve Yukon's base maps. Four years ago Geomatics

Yukon was still struggling to determine the most suitable methods and tools for producing higher resolution and more accurate base maps. In the last few years, advancements in high resolution satellites, especially in regards to automatic geographic positioning and on-board data storage, have provided revolutionary mapping tools for the north. Using these satellites, large areas can be accurately mapped using very few or no ground control points, greatly reducing the costs of producing new base maps. The result of mapping with high resolution satellites is that Geomatics Yukon has had to develop methodologies for storing, processing and distributing terabytes of image data. Geomatics Yukon has worked extensively over the past two years to optimize the Yukon Government image repository including improvements to image acquisition, integration, management and dissemination processes. The outcome is a comprehensive, stable, more easily managed repository of Yukon imagery.

Energy, Mines & Resources

The Department of Energy, Mines & Resources (EMR) is the heaviest user of geomatics data and tools within the Yukon Government, with significant mapping activities in the following branches: mining, oil and gas, forestry, lands, land planning, agriculture, client monitoring and inspection, Yukon Geological Survey, energy solutions, and abandoned mines. Most of the GIS expertise is in the branches.

This department has worked extensively on operational geospatial data modelling, including integrating their non-spatial databases with geospatial data and web applications. There is a major effort to make as much data as possible available on the web via applications, for purposes such as conflict resolution, land use and land interest, and commercial and personal permitting. More recently, EMR has implemented solutions for enabling data entry via web application and improving their mobile field collection systems. While some paper map products still exist, these are rapidly being replaced with their digital successors.

Within EMR, the Yukon Geological Survey (YGS) has undergone significant data modelling improvements, moving from separate independent databases to a centrally integrated database for all geological information. Their bedrock geology map has changed from a static product to a compilation map product that is updated regularly based on all ongoing field mapping. Over the last 3 years, YGS has implemented digital field mapping solutions to streamline workflow and data collection and has moved away from a paper-based process. They have successfully released 4 field mapping applications for bedrock geology, oil and gas, placer, and mineral exploration.

Environment

Geomatics activities within the Department of Environment are centrally managed in one unit. The Geomatics Unit of Environment is primarily focused on adding value to their existing departmental data, such as hunting and trapping concessions, outfitter areas and territorial parks. A great deal of effort was expended to improve the accuracy of regional base data to ensure better accuracy for their corresponding departmental data. A new Bathymetry data set was created to map subsurface waterbodies.

Transportation Division

Geomatics activities have increased significantly over the last 4 years in the Transportation Division of the Department of Highways and Public Works. They recognize the huge value of geospatial data and services and are focusing on improving geospatial data modelling, data distribution via web applications, and creating geospatial field collection tools. Transportation is planning to implement a division-wide asset management system that is fully integrated with the Yukon spatial data infrastructure, including developing a linear referencing network.

Over the coming years, Yukon will continue to grow its geomatics potential. Our vision is to make as much geospatial data and imagery available to the widest possible audience. We believe the world is a better place when geospatial data is easily available for the broadest range of users. ❑

Lauren Crooks and Nicole Parry
Spatial Data Administrators,
Geomatics Yukon, ICT
Highways and Public Works,
Government of Yukon

NATIONAL SOCIETIES AND ASSOCIATIONS REPORTS

Association of Canada Lands Surveyors (ACLS)

The Association of Canada Lands Surveyors (ACLS) is a national, self-regulating, professional association. It has over 625 members located across Canada (and the world), who have expertise in surveying, photogrammetry, remote sensing, geodesy, hydrography and land information systems. Licensed Canada Lands Surveyors (CLS) are the only ones authorized by the Canada Lands Surveyors' *Act* to perform cadastral (legal) surveying on Canada lands, which include Aboriginal lands (specified in the Canada Lands Surveys *Act*), national parks, all lands in the three territories and the offshore portion that is not under provincial jurisdiction.

Certification of Hydrographic Surveyors

The fall 2014 Report of the Commissioner of the Environment and Sustainable Development concluded that there is: "a significant gap in the area of surveying and charting — a foundational requirement of safe navigation. While some surveys and charts are improved each season in the Arctic, many higher-risk areas remain inadequately surveyed and charted, and capacity to conduct this work is limited."

No doubt, the Canadian Hydrographic Service (CHS) of the Department of Fisheries and Oceans will have to depend on private industry to help in the surveying and charting of the high-risk areas of the Arctic. The ACLS has been aware of a need for increased capacity in the field of hydrography for a long time and has been working since 2002 on building a program for the certification of hydrographic surveyors which, once implemented, will assure the CHS that industry contractors have the competencies needed to fulfill their obligations to the benefit of all Canadians.

After many years of gathering support from learning institutions, government and industry, the ACLS provided a submission to the FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC) in January 2014, for accreditation of the ACLS program under the international standards. Many countries have established hydrographer certification schemes and recently Australia's Spatial Sciences and Surveying Institute (SSSI) earned the first accredited hydrographer certification program. The ACLS was represented at the April 2014 IBSC meeting in Tokyo, Japan, to defend its certification model.

Internationally, countries with marine interests have continued to develop accredited training programs for hydrographic surveyors, however, Canada has not, though it is a nation with one of the most extensive navigable inland waterways, coastal and offshore areas, and a nation that has played a significant role in the International Hydrographic Organization (IHO), and in promoting the United Nations Convention on the Law of the Sea (UNCLOS).

Hydrographic certification is necessary in order to:

- Provide a formally recognized and structured career path for hydrographic surveyors, particularly for those in the private sector.
- Establish an expectation of expertise and competency.
- Provide a catalyst to encourage Canadian academia to seek international accreditation of their hydrographic training programs.
- Reduce the risk associated with unqualified and inexperienced persons providing hydrographic services to the public.
- Accommodate the increased level of responsibility bestowed upon hydrographic surveyors.
- Increase the availability of qualified services in the private sector.

The ACLS, being a national, bilingual, self-regulated, non-governmental, professional organization, which holds jurisdiction over offshore Canada lands, has the capacity to provide an effective administrative and regulatory framework to support a national certification model.

Unfortunately, the ACLS program did not obtain international accreditation, however the IBSC did encourage the ACLS to proceed in implementing the program and provided very constructive feedback to improve it. We will re-submit our application for accreditation when IBSC feedback has been addressed.

GeoEd

GeoEd is a collaborative program that seeks to include all provincial and federal surveying associations in Canada in promoting accessible continuing professional development. The initiative was conceived and developed by the ACLS for the benefit of all surveyors in Canada. ACLS continues to maintain

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the portal in what will hopefully become a cooperative effort to share resources and expertise towards the development of national learning. Other surveying associations as well as a private business have joined GeoEd as registered providers. More and more course offerings are added every year. For more information, go to: *http:// www.geoed.ca*.

National Surveyors' Conference

Next year's conference will be held in Edmonton, Alberta from May 4th to 6th, 2016. Conference information is available on the ACLS website at: *http://www.acls-aatc.ca*.

David Thompson National Geomatics Awards

The Association of Canada Lands Surveyors and Professional Surveyors Canada present the David Thompson National Geomatics Awards every year.

The David Thompson National Geomatics Awards are presented for excellence in the profession of surveying according to three categories:

- "Innovation in Geomatics" recognizes a project that involved the most innovation, such as using never- or seldom-used technology to solve a survey problem.
- "Contribution to Society" recognizes a project that has the most positive impact on society, such as important involvement in new infrastructure in Third World countries, major contribution in cases of natural disasters, or technological transfer and capacity building in less fortunate communities.
- "Challenging Applications in Cadastral Surveying" recognizes a project that applied cadastral surveying methods and technology to solve the most challenging technical problem.

The next awards will be presented on May 5th, 2016 in conjunction with the National Surveyors' Conference in Edmonton. The deadline for submissions for this year's awards is March 31, 2016. For more information and to access an application form, go to: *http://www.davidthompsonawards.ca*.

ACLS Scholarship

The scholarship program was introduced in 2003. Three $1500 scholarships are awarded every year to worthy candidates. To obtain an application form and further information on the ACLS Foundation Scholarship Program, visit the ACLS website at: *www. acls-aatc.ca*. The deadline for application is May 15 of each year. The Association of Canada Lands Scholarship Foundation Inc. is a registered charitable organization, and so it is authorized to issue tax receipts.

Jean-Claude Tétreault
Executive Director
Association of Canada
Lands Surveyors
http://www.acls-aatc.ca

Association des arpenteurs des terres du Canada (AATC)

L'Association des arpenteurs des terres du Canada (AATC) est une association professionnelle nationale autoréglementée. Elle est composée de plus de 625 membres répartis aux quatre coins du Canada (et du monde) qui ont une expertise en arpentage, en photogrammétrie, en télédétection, en géodésie, en hydrographie et en systèmes d'information foncière. Seuls les arpenteurs des terres du Canada, qui sont titulaires d'un permis de pratique de l'AATC, sont autorisés, en vertu de la Loi sur les arpenteurs des terres du Canada, à pratiquer l'arpentage foncier sur les terres du Canada et les terres privées dans les territoires qui comprennent essentiellement les réserves autochtones, les parcs fédéraux, toutes les terres dans les trois territoires et la partie de la zone extracôtière qui n'est pas sous juridiction provinciale.

Certification des hydrographes

Le rapport de l'automne 2014 de la commissaire à l'environnement et au développement durable conclut que : « …nous avons constaté une importante lacune en ce qui concerne la réalisation de levés et de cartes marines — une exigence fondamentale pour la navigation sécuritaire. Bien que certains levés et cartes marines de l'Arctique soient améliorés chaque saison, ceux-ci sont inadéquats dans de nombreuses zones à risque plus élevé, et la capacité d'effectuer ce travail est limitée. »

Nul doute que le Service hydrographique du Canada (SHC) de Pêches et Océans Canada devra compter sur le secteur privé pour l'aider à l'arpentage et à la cartographie des zones à haut risque de l'Arctique. L'AATC a depuis longtemps pris conscience de la nécessité d'accroître la capacité dans le domaine de l'hydrographie et travaille depuis 2002 à l'élaboration d'un programme de certification des hydrographes qui, une fois mis en œuvre, assurera le SHC que les entrepreneurs de l'industrie ont les compétences requises pour s'acquitter de leurs obligations au profit de tous les Canadiens.

Après de nombreuses années passées à obtenir l'appui des établissements d'enseignement, du gouvernement et de l'industrie, l'AATC a présenté une soumission au Comité international FIG-OHI-ACI sur les normes de compétence pour les hydrographes et les spécialistes en cartographie marine (IBSC) en janvier 2014 visant l'agrément du programme de l'AATC selon les normes internationales. De nombreux pays ont mis en place des systèmes de certification des hydrographes et, récemment, le Spatial Sciences and Surveying Institute (SSSI) d'Australie s'est vu décerner le premier agrément d'un programme de certification des hydrographes. L'AATC a été représentée à la réunion d'avril de l'IBSC à Tokyo, au Japon, pour défendre son modèle de certification.

Sur le plan international, les pays ayant des intérêts maritimes ont continué à développer des programmes de formation agréés pour les hydrographes, tandis que le Canada, un pays avec l'un des plus vastes réseaux de voies navigables intérieures, de zones côtières et extracôtières; une nation qui a joué un rôle important dans l'Organisation hydrographique internationale (OHI) et dans la promotion de la Convention des Nations Unies sur le droit de la mer (CNUDM), n'en a aucun.

La certification hydrographique est nécessaire pour :

- fournir un cheminement de carrière formellement reconnu et structuré pour les hydrographes, plus particulièrement ceux du secteur privé;
- établir une attente d'expertise et de compétence;
- fournir un catalyseur pour encourager les universités canadiennes à obtenir un agrément international de leurs programmes de formation hydrographique;
- réduire le risque associé à la fourniture de services hydrographiques au public par des personnes non qualifiées et inexpérimentées;
- accommoder le niveau de responsabilité accru accordé aux hydrographes;
- accroître la disponibilité de services qualifiés dans le secteur privé.

L'AATC, étant un organisme professionnel national, bilingue, autoréglementé, non gouvernemental dont la compétence englobe les terres extracôtières du Canada, a la capacité de fournir un cadre administratif et réglementaire efficace pour soutenir un modèle national de certification.

Malheureusement, le programme de l'AATC n'a pas obtenu l'agrément international, mais l'IBSC a encouragé l'AATC à aller de l'avant avec la mise en œuvre du programme et a fourni des commentaires très constructifs pour l'améliorer. Un groupe de travail spécial de l'AATC se penche sur les détails de mise en œuvre. Nous allons resoumettre notre demande d'agrément lorsque les commentaires de l'IBSC auront été abordés.

GeoEd

GeoEd est une démarche collaborative qui vise à inclure toutes les associations provinciales et fédérales d'arpentage du Canada pour promouvoir un perfectionnement professionnel continu accessible. L'initiative a été conçue et développée par l'AATC lorsqu'elle a reconnu le besoin d'un forum national pour le perfectionnement professionnel continu (PPC). L'AATC continue de maintenir le portail de ce qui, nous l'espérons, deviendra une approche collaborative de partage des ressources et de l'expertise afin de développer une structure d'apprentissage nationale. D'autres associations d'arpentage de même que des entreprises du secteur privé se sont jointes à GeoEd à titre de fournisseurs enregistrés. De plus en plus de cours sont ajoutés tous les ans. Allez à : *http:// www.geoed.ca*.

Conférence nationale des arpenteurs-géomètres

La conférence de l'an prochain aura lieu à Edmonton, en Alberta, du 4 au 6 mai 2016. Les informations sur la conférence sont disponibles sur le site Web de l'AATC à : *http://www.acls-aatc.ca*.

Prix nationaux en géomatique David Thompson

Tous les ans, l'Association des arpenteurs des terres du Canada et Géomètres professionnels du Canada présentent les prix nationaux en géomatique David Thompson.

Des prix sont décernés dans les catégories suivantes pour l'excellence dans la profession d'arpenteur-géomètre :

- « Innovation en géomatique » reconnaît un projet qui a impliqué le plus d'innovation soit par des méthodes innovatrices dans un projet d'arpentage ou de techniques jamais ou rarement utilisées pour résoudre un problème d'arpentage;
- « Apport à la société » reconnaît un projet qui a eu l'impact le plus positif sur la société, tel que l'implication importante dans de nouvelles infrastructures dans les pays du Tiers-Monde, une contribution majeure en cas de catastrophes naturelles, ou de transfert technologique ou le renforcement des capacités dans des communautés moins fortunées;
- « Applications en arpentage foncier présentant un défi considérable » reconnaît un projet qui applique des méthodes d'arpentage foncier et de la technologie pour résoudre un problème technique ayant un défi de taille.

Les prochains prix seront présentés le 5 mai 2016 lors de la Conférence nationale des arpenteurs-géomètres à Edmonton. La date limite de mise en candidature est le 31 mars 2016. Pour les détails sur les prix nationaux en géomatique David Thompson, visitez : *http://www.acls-aatc.ca/fr/node/159*.

Bourses d'études de la Fondation de l'AATC

Le programme de bourses a été introduit en 2003. Tous les ans, la Fondation de l'Association des arpenteurs des terres du Canada octroie des bourses de 1 500 $ à des étudiants inscrits dans des programmes postsecondaires en géomatique. Pour obtenir un formulaire de demande et de plus amples renseignements sur le Programme de bourses d'études de la Fondation de l'AATC, visitez le site Web de l'AATC à : *http://www.acls-aatc.ca*. La date limite d'inscription est le 15 mai de chaque année. La Fondation de l'AATC inc. est un organisme de bienfaisance enregistré, et est autorisée à émettre des reçus d'impôt.

Jean-Claude Tétreault
Directeur exécutif
Association des arpenteurs
des terres du Canada
http://www.acls-aatc.ca

Association of Canadian Map Libraries and Archives/Association des cartothèques et archives cartographiques du Canada (ACMLA/ ACACC)

The Association of Canadian Map Libraries and Archives/Association des cartothèques et archives cartographiques du Canada (ACMLA/ACACC) is the representative professional group for Canadian map librarians, cartographic archivists, and others interested in spatial data and geographic information in all formats. Since its inception in 1967, the achievements of the association have been notable. These include:

- A publishing program
- Advocacy for the importance of geospatial information in all formats
- Advocacy for map libraries, geospatial data centres, and cartographic archives
- Hosting annual meetings for association members
- Professional development opportunities for individuals working or aspiring to work in the map libraries, geospatial data centres, map/cartography archives, and other fields related to maps and geospatial data
- The development of cartographic citation tools, cataloguing tools for cartographic materials, and related resources

Objectives

The association has several important objectives: to engage in activities that further the awareness, use, and understanding of geospatial and cartographic materials for the Canadian research community, the public sector, and the public at large; to represent and promote the collective interests of Canadian cartographic/geographic information users by establishing contacts with government agencies and striving to influence policy decisions; to create and maintain an active communication network for the exchange of information within our association and beyond; and to support the research and professional development activities of members through publications, conferences, and seminars.

Conference and Annual Meetings

Members of our association meet at our conference/annual meeting at venues across Canada: Quebec City in 2011; Toronto in 2012; Edmonton in 2013 (with the Canadian Cartographic Association); Montreal in 2014; Ottawa from June 16 to 19, 2015. These conferences provide our members with opportunities to learn about recent developments in the field of map and GIS librarianship, as well as a chance to share our experiences. Some of the major themes in the past five years include: geospatial data preservation, curation of historical cartographic collections, geographic information literacy, managing and curating geospatial data and print map collections.

The meetings are also an opportunity for our members to learn about cartography and geomatics initiatives at the local and regional level; and we connect with cartography and GIS professionals who are involved in projects or initiatives in the education, government and private sector. The association is open to holding joint meetings with other like-minded organizations. We also welcome individuals in the geomatics/ cartography professions to participate in our conferences when we are not meeting jointly with other associations.

Publications and Communications

We continue to publish the *Bulletin*, our flagship publication, three times per year. Most issues of the *Bulletin* contain research articles, book reviews, geospatial and map reviews, and updates from various map libraries and archives in Canada. In addition, the *Bulletin* acts as a primary mode of communication about our association. Past issues of the *Bulletin* (No. 1, 1968 to No. 145, Fall 2013) are available online (*http://collections.mun.ca/cdm/search/collection/acmla*), courtesy of the Memorial University of Newfoundland's Digital Archives Initiative.

Our most recent online publication, "ACMLA Recommend Best Practices in the Citation of Cartographic Materials," was compiled by Alberta Auringer Wood, with assistance from the Bibliographic Control Committee. This publication provides citation examples for Canadian and international cartographic sources, in formats such as geospatial data in shapefile format, raster datasets, satellite imagery, historical maps, topographic maps, and online maps. This publication is available on the ACMLA website: *http://www.acmla-acacc.ca/tools.php*. A French version will be published in 2015.

We continue to offer for sale on our website, our monographs, the facsimile map series, and the Bird's Eye Views of Canadian Cities. We also have a website (*http://www.acmla-acacca.ca*), and the CARTA listserv (*carta-l@listserve.utoronto.ca*), which is an open discussion forum on topics, events, and issues relating to cartographic and geographic information in Canada. The association also maintains its own members-only online discussion list.

Advocacy and Partnerships

Over the past few years, ACMLA has actively supported the work of the Canadian Geomatics Community Round Table, an open and collaborative group made up of representatives from industry, academia, professional associations, NGOs, and federal, provincial and territorial governments, spanning the geomatics (geographic, geospatial, location information) sector. This group is currently involved in the development of a pan-Canadian umbrella organization called GeoAlliance Canada. Deena Yanofsky, a member of the ACMLA Executive, has represented the academic and library sector on the CGCRT Steering Committee and was a lead member of the “Education and Capacity Building” strategy plan. ACMLA has also provided financial support for the CGCRT, sponsoring the Round Table’s website. As president of ACMLA, I attended the “Geomatics Strategy, Action, and Implementation Planning Workshop” held in June 2014. Moving forward as an association, we are interested in exploring our role and function in the newly-formed Geo-Alliance Canada, focusing especially on issues surrounding preserving Canada’s born-digital and print cartographic materials, and geographic information education.

Since 2010, our members have expressed concerns about the service cuts, budget cuts, and restructuring at the Library and Archives Canada (LAC). During this time, the association monitored the changes and developments within LAC, with particular focus upon public access to the national map collections, bibliographic/cataloguing standards, and the acquisition of cartographic materials. After the resignation of the Librarian/Archivist of Canada in 2013, the association signed the “Joint Statement on Qualities of a Successful Librarian and Archivist of Canada.” Positive changes have occurred since the appointment of the new Librarian and Archivist of Canada, and we hope, as a stakeholder, we can further develop our partnerships with the Library and Archives Canada and provide professional development opportunities for their information professionals.

Member Outreach

ACMLA has had a successful mentoring program in place since 2008. It provides a mechanism for encouraging and supporting new members in their professional growth and development, and welcomes them into the association. We also continue to engage our members in open forum discussions, workshops, and general meetings at our conferences. We continue to administer several key awards, including the ACMLA Honorary Membership Award, the ACMLA Honours Award, the ACMLA Paper Award, and the ACMLA Student Paper Award. For a complete listing of recent award recipients and their respective papers, please visit our website at: *http://www.acmla-acacc.ca/awards.php*.

Looking Forward

A new bylaw was approved by our membership and it was accepted by Industry Canada in July 2014. With the new bylaw, there are changes to the structure of our organization, including two new elected positions: Vice President of Professional Development and Vice President of Communications and Outreach in addition to a new communications committee. The new structure provides us with the flexibility to do more outreach, advocacy, and collaboration with Canadian and international sister organizations in the fields of cartography, geomatics, libraries, and archives.

In addition, ACMLA will be celebrating our 50th anniversary in 2016. In honour of the 50th anniversary, we will be releasing a special issue of the *Bulletin*, and we will have special celebrations at our 2016 annual general meeting.

Rosa Orlandini
ACMLA President 2014/15

Canadian Cartographic Association / Association canadienne de cartographie

Overview

The Canadian Cartographic Association (CCA) was founded in 1975. The goals and principles on which it was founded seek to further the discipline of cartography in Canada, with the following specific objectives:

- To promote interest in maps and related cartographic materials
- To further the understanding and knowledge of maps by encouraging research in the field of cartography both historical and current
- To provide for the exchange of ideas and information and for the discussion of mutual concerns through annual meetings, the website, publications and through social media
- To advance education in the field of cartography and promote the use of maps and mapping applications

The association’s mandate is to offer a forum for the exchange of ideas and the sharing of cartographic knowledge. In the new millennium, the CCA considers its constituency to extend beyond cartography, embracing closely related fields, such as geovisualization and geographic information science. Members are kept informed about technological changes and opportunities that affect and influence their professional standings, through annual conferences and two publications: the international quarterly journal, *Cartographica*, owned and published by the University of Toronto Press, and the bi-annual Canadian Cartographic Association newsletter, *Cartouche*. The CCA is administered by volunteer members across Canada who are elected to the Executive Committee chaired by the president.

The CCA includes special interest groups: mapping technologies and data, history of cartography, education, and design and geovisualization. The specialty group chairpersons are tasked with organizing a session at the annual meeting and coordinating an annual report and articles to *Cartouche*.

Membership

Membership is open to anyone with an interest in any aspect of mapping and members are drawn from the ranks of government, industry, academia, and from the general public. Most members are residents of Canada, but about 25 per cent come from the United

States and other countries. The number of members has changed over the last few years and remains at slightly more than 110, with many longstanding.

The CCA is ramping up its membership recruitment by concentrating on post-secondary students and recent graduates who represent the future of the association. The CCA offers the Norman L. Nicholson Scholarship to outstanding students, and the President's Prize competition for students in both colleges and universities. The competition requires students to produce a map on assigned themes that are then judged by a panel of experts at the annual general meeting. Winners receive a monetary prize and their maps are also displayed on the association's website.

Overview of Activities: 2011–2015

CCA General Activities

The last five years have seen three association presidents, one of whom served a two-year term while the current president will be entering the second of his two-year term, starting May 2015. Over this time period there have been several changes of note, including;

- Emergence of our social media presence on Twitter (*https://twitter.com/CdnCarto*) and Facebook (*https://www.facebook.com/pages/Canadian-Cartographic-AssociationlAssociation-Canadienne-de-Cartographie/177748108946882*)
- The redesign of the association website (*http://cca-acc.org/*)
- The examination and ongoing discussion of the role of the CCA and cartography in the 21st century
- The invitation of research articles, and open calls for submissions to *Cartouche*

CCA Annual Meetings

The Canadian Cartographic Association meets annually at diverse locations across Canada, and frequently in conjunction with like-minded associations. The CCA has a program of awards of distinction, presented at the annual meeting, that honour those individuals who have made exceptional scholarly contributions to cartography, exceptional contributions to the practice of cartography, and exceptional contributions to the Canadian Cartographic Association.

The most recent meetings have been in Calgary (2011), joint with the Canadian Association of Geographers (CAG) and the Association of Canadian Urban Planning Programs (ACUPP), Waterloo (2012), in conjunction with CAG and Congress, Edmonton (2013), joint with the Association of Canadian Map Libraries and Archives (ACMLA), and St. Catharines (2014) with Congress. In May 2015, the CCA will visit the province of Prince Edward Island for the first time to celebrate the 40th anniversary of the association. Our 2016 meeting is scheduled for Winnipeg in conjunction with the Canadian Remote Sensing Society (CRRS). We look forward to seeing everyone in PEI and Manitoba in the upcoming years.

CCA and the International Cartographic Association (ICA)

The CCA plays a leading role in international cartography through its involvement with the Canadian National Committee (CNC) for the International Cartographic Association. The Canadian National Committee, chaired by the CCA nominees (Janet Mersey and Roger Wheate), is responsible for coordinating Canadian participation in the International Cartographic Association, and has such specific responsibilities as appointing representatives to ICA commissions, working groups and committees, preparing a bi-annual exhibit of Canadian cartography, publishing a bi-annual national report on Canadian cartography, and facilitating the submission of technical papers for presentation at meetings of the ICA. In addition, *Cartographica* is one of the three journals endorsed by the ICA and receives submissions of manuscripts through recommendations from the ICA's Publication Committee. ❑

Christopher Storie, President (2014–2016)
Anna Jasiak, Past President (2012–2014)
Gerald Stark, Past President (2011–2012)

Reports from Educational Institutions 2011–2015

The Educational Reports section in this issue provides a cross-section sampling of college and university programs which offer certificates, diplomas and degrees in geomatics and GIS-based geography topics. It is not intended as a complete catalogue of all opportunities in Canada, but a highlight of a robust education sector in Canada.

College of Geographic Sciences (COGS), Nova Scotia

We offer four program groups at the Nova Scotia Community College — Centre of Geographic Sciences (NSCC-COGS) site in Lawrencetown, Nova Scotia.

Two programs (Survey Technician Certificate and Geomatics Engineering Technology Diploma) train first- and second-year surveyors. These graduates are focused on geospatial data collection and analysis and find employment in the private and public sectors of the geomatics industry. The sectors may include:

- Heavy construction
- Private land surveying and engineering firms
- Oil and natural gas exploration
- Environmental and natural resources agencies
- Survey equipment sales

The diploma in Geographic Sciences is a two-year, direct-entry program with four second-year concentrations: Community and Environmental Planning, Cartography, Geographic Information Systems, and Remote Sensing. This program has a common foundational year that allows students to get acquainted with the geospatial data analysis and visualization that is required in the field of geomatics. They can then choose which area they wish to concentrate on in their second year of studies.

Our Marine Geomatics Advanced Diploma develops graduates who have cultivated the integrated geodetic skills of GPS positioning and hydrographic surveying. Students apply these skills to marine-based activities, such as bathymetric data acquisition and analysis, energy exploration activities, and projects dealing with the coastal zone and offshore areas.

The fourth program group is our advanced diploma in Geographic Sciences, which accepts students from universities and those with industry experience. This program has a common first semester, followed by concentrations from January through May in GIS, GIS for Business Applications, and Remote Sensing. Graduates are employed as GIS analysts, spatial data analysts, GIS programmers/developers, market analysts, image analysis specialists, to name a few.

We are linked with our Applied Geomatics Research Group (*www.agrg.cogs.nscc.ca*) as well. In partnership with this group, we arrange student projects and showcase to students what is happening in the world of geomatics right now. These include weather-station monitoring, coastal-zone and flood modelling, LiDAR technologies, community and cultural mapping, etc.

We also have a one-year Joint Masters of Science (Applied Geomatics) with Acadia University for qualifying graduates, and are in partnership with the Esri Canada Centres of Excellence program (*http://ecce.esri.ca/wpecce/*)

Visit us at: *http://www.nscc.ca/learning_programs/programs/ProgramListing.aspx?* or contact Dennis Kingston, academic chair, at *dennis.kingston@nscc.ca* with further questions.

You may also be interested in our historic maps which are available through our Walter K. Morrison Special Collection: *http://www.library.nscc.ca/contact_us/campuses/av_lawrencetown/*.

David MacLean
GIS Faculty
Centre of Geographic Sciences (COGS)
NSCC Lawrencetown

College of the North Atlantic

The College of the North Atlantic, Corner Brook Campus, NL, introduced the GIS Applications Specialist program (post diploma) in 2009. The nine-month intensive program focuses on project planning, project design and development, programming (Python and JavaScript), geodatabase design and implementation, geospatial analysis, geostatistical analysis, data modelling, integration of remote sensing techniques, and cartographic outputs. Offering a high student to instructional support ratio, exclusive access to personal dual monitor workstations with up-to-date software (ArcGIS, ERDAS Imagine, ERMapper, PCI Geomatica), and low tuition, the GIS program has already achieved national acclaim as one of the "hottest post-grad programs in Canada" by McLean's Magazine. The third semester of the program requires students to conduct a major GIS capstone project for an industry partner, using the skills learned to address a "real-world" problem or opportunity. The program instructors

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work as project liaisons between the students and industry to ensure that project scope, communication, and deliverables are completed in an organized and timely manner.

CNA's post-diploma faculty takes great pride in its competency-driven approach to GIS education. Course lectures, labs and assignments are often supplemented with collaborative campus/community mini-projects to help solidify both the theoretical and practical application of GIS analysis.

Current program faculty collaborative research includes:

- Development and evaluation of practical tools for prediction of stand dynamics after natural or anthropogenic disturbances
- Integrating unmanned aerial systems data with GIS and geostatistical modelling in the natural resources sector(s)
- Ethnographic multimedia network
- Utilizing community-campus partnerships to develop GIS-based asset and infrastructure management systems for small communities in Newfoundland
- Unmanned aerial systems and GIS-based lost-person-profiling for search and rescue efforts
- Predicting the next spruce budworm outbreak in Newfoundland in relation to climate change
- Modelling the distribution of advance regeneration in lodgepole pine stands in the central interior of British Columbia
- Predictive modelling of boreal felt lichen (erioderma pedicellatum) in Newfoundland, Canada

For more information, see or please contact: *http://www.cna.nl.ca/programs-courses/Show-Program-Details.aspx?program=96*.

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Memorial University of Newfoundland (MUN)

Diploma in Geographic Information Sciences

Memorial University's Faculty of Arts offers an undergraduate diploma in Geographic Information Sciences (DGI Sciences). The program draws from a wide variety of expertise. This includes faculty from within the departments of geography and computer science. In addition, members of the professional community contribute to the supervision of one of the practicum courses. The DGISciences program entails ten courses in cartography, geographic information systems, remote sensing and computer science, most of which are offered by the Department of Geography.

The diploma in GISciences is of interest to people in many fields; it is a valuable complement to undergraduate studies in social and natural sciences programs such as anthropology, biology, computer sciences, earth sciences, economics, engineering, environmental sciences, geography, health and medicine, history, physical oceanography, political science, resource management, and the study of languages.

Cartography, geographic information systems, and remote sensing provide effective methods of gathering, managing, analyzing and representing geographic information. Throughout the program, students learn to compile geo-referenced databases, design and produce maps, analyze data in geographic information system environments, produce digital elevation models, and extract information from aerial photographs and satellite images.

The laboratory components of the program's geography courses are taught in a fully operational facility for remote sensing, geographic information systems, and cartography. Supported by the Faculty of Arts and the Department of Geography, this laboratory is a place for education and research in GISciences. It includes state-of-the-art teaching equipment and specialized software.

For more information about the program or to contact the coordinator for more specific questions, please visit: *http://www.mun.ca/geog/undergrad/gis/*.

Dr. Elizabeth Simms
Department of Geography
Memorial University of Newfoundland

Queen's University: Department of Geography and Planning

Certificate in Geographic Information Science

The Department of Geography and Planning of the Faculty of Arts and Science offers a study option leading to the Certificate in Geographic Information Science (GISc). This option is available to all Queen's University undergraduate students, regardless of their degree concentration, and is intended for those who wish to enhance their undergraduate degree with a GISc certificate. Students will select from a suite of courses in geographic information systems (GIS), remote sensing, environmental modelling, spatial analysis, statistics, computer science and math. The Department of Geography manages two computer lab facilities that focus on GISc course delivery. For details on the Certificate in Geographic Information Science, please visit: *http://geog.queensu.ca/GISC%20Certificate/giscCert.asp*.

Undergraduate and Graduate Research

Although many faculties incorporate GIS and remote sensing analyses into their teaching and research, the Department of Geography at Queen's has two research facilities dedicated to GISc. These include the Laboratory for Remote Sensing of Earth and Environmental Systems (LaRSEES) directed by Dr. Paul Treitz *(http://www.geog.queen* *su.ca/larsees/*) and the Laboratory for Geographic Information and Spatial Analysis (LaGISA) directed by Dr. Dongmei Chen (*http://gis.geog.queensu.ca/*). Dr. Dongmei Chen has also established the Queen's GeoComputation and Analysis Laboratory (GCAL) for the study of population health and disease modelling. Dr. Chen and her research team are developing disease spread protocols by combining mathematical, environmental, and multi-level agent models to: (i) simulate transmission and impact of disease spread; and (ii) evaluate the vulnerability of different communities to the potential outbreak of communicable diseases.

In addition, Dr. Ryan Danby has developed a new lab facility dedicated to research on forest-tundra dynamics in a changing climate. Dr. Danby's research integrates field ecology with geospatial analysis to address questions related to the manner in which the forest-tundra transition has responded to climate change and variability in the past. His research examines the physical and biological variables that interact to influence the establishment and growth of trees and shrubs across this transition. For more information on our facilities, academic programs and research themes, please visit the Department of Geography website (*http://geog.queensu.ca/*).

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University of New Brunswick

Department of Geodesy and Geomatics Engineering

The Department of Geodesy and Geomatics Engineering at the University of New Brunswick (UNB) offers two undergraduate bachelor's in geomatics: the three-year Bachelor of Geomatics degree, and the four-year Bachelor of Geomatics Engineering degree. The Geomatics Engineering degree is accredited by the Canadian Engineering Accreditation Board, making graduates eligible to become professional geomatics engineers. Students in either degree, who take specific upper-year electives, may complete our cadastral surveying option, which is accredited by the Canadian Board of Examiners for Professional Surveyors, and meets all academic requirements to become a registered land surveyor. Our undergraduate programs are well-regarded both nationally and internationally, and are attended by a diverse community of students from across Canada and the world.

The graduate program offers three degrees: PhD, MScE (research-based master's), and MEng (course-based master's). Since our first graduate student in 1963, more than 500 students from countries all around the world have obtained postgraduate degrees from GGE. We average approximately 55 graduate students per year, representing a range of 15 to 20 different countries. The international experience in our graduate program is a major strength of our program—in terms of our students, faculty research, and graduate employment.

The Department of Geodesy and Geomatics Engineering at UNB has a long and very proud history of excellence in research and education at the graduate level. The department has consistently received a top ranking in research within the university, and it is well known internationally in the various fields of geomatics. For example, our research in GNSS and geodesy, GIS, remote sensing, engineering surveys, ocean mapping, and land administration, have all been recognized as being in the forefront of geomatics innovations.

The department hosts three research chairs: the Chair in Ocean Mapping, the Canada Research chair in Advanced Geomatics Image Processing, and the newly-established Cisco Research Chair in Big Data and Mobility Analytics.

Marcelo C. Santos
Professor and Chair of the
Department

University of Guelph

BSc Major in Environmental Geoscience and Geomatics

The Department of Geography at the University of Guelph offers a BSc Honours program in Environmental Geoscience and Geomatics. The objective of the program is to provide students with a solid foundation in two increasingly interrelated areas of scholarship; geoscience (the study of the earth and its systems) and geomatics (a discipline which integrates the acquisition, modelling, analysis and management of all types of spatially referenced information). Continuing innovationsin both fields, coupled with on-going development and application of new technologies, highlight the value of an integrative program to address both student interest and employment opportunities.

The Environmental Geoscience and Geomatics major provides the opportunity for study of the processes and properties of the biophysical environment, along with a core foundation in spatial analytical techniques, such as remote sensing, geographic information systems, and cartography. Graduates of the program that have selected courses required for a "professional geoscientist" designation will meet the academic eligibility requirements for membership as an environmental geoscientist in the Association of Professional Geoscientists of Ontario (APGO), allowing for practical use of their PGeo designation. Ontario's legislation under the Professional Geoscientists Act, 2000, requires registration with the APGO for anyone wishing to practice geoscience in Ontario.

In addition to majors in geography (BA), environmental governance (BA), and environment and resource management (BScEnv), the Department of Geography continues to offer a BSc minor in Geographic Information Systems and Environmental Analysis. This popular option attracts students from a range of disciplines who recognize the applicability of spatial analytical techniques to numerous research areas in the natural and social sciences.

More information about all geography programs at the University of Guelph can be found at *www.uoguelph.ca/geography/*.

Janet E. Mersey, Associate Chair
Department of Geography
University of Guelph

University of Northern British Columbia (UNBC)

Natural Resources and Environmental Studies (NRES)

Geomatics courses at UNBC are offered by the geography program, but are taken in an interdisciplinary environment, within the Faculty of Natural Resources and Environmental Studies (NRES), which oversees the graduate programs, and includes biology, forestry, environmental planning, sciences and engineering, geography and outdoor recreation and tourism programs. Our introductory cartography course is often taken by students from up to 20 or more different programs. The GIS course is also taken by students located remotely in some of our satellite campuses up to 500 km away. Parks form a teaching and research focus in many areas, given the vast hinterland of northern British Columbia, which contains many substantial parks and management areas, especially the Muskwa-Kechika in the northern Rocky Mountains.

Several students choose to complete the GIS minor each year, which combines a selection of geomatics and computer science courses, both from geography/NRES and computer science backgrounds. Coursework in GIS and remote sensing is focused on data processing and final output options. Lab exercises incorporate the forested lands surrounding the campus, with an extensive network of official and unofficial trails, which provide access for fieldwork and a framework for analysis and mapping. Multiple copies of the new campus trail map have been mounted at strategic locations during 2015, and will also be available online. Mapping and GIS teaching datasets include nearby research forests and stations, in addition to the city of Prince George and regional and provincial parks.

Research applications involving cartography include ecosystem and wildlife habitat mapping, forest inventory and fires, water resources and watersheds, and first nations mapping applications. Of interest, UNBC has the highest First Nations percentage enrollment in Canadian universities apart from the First Nations University of Canada (Regina). The largest single focus at UNBC is the inventory mapping and change detection of alpine glaciers, and we act as the regional centre for western Canada under the Global Land Ice Measurements from Space (GLIMS) project. Several western glaciers are monitored each spring and late summer —at the start and end of ablation season —for snow depth and ice elevation in order to assess glacier mass balance. The recent acquisition of a LiDAR system greatly expands our scope of operation and mapping opportunities in both glaciological and forestry applications.

Roger Wheate, GIS coordinator
University of Northern British Columbia
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University of Toronto: Departments of Geography at St. George, Scarborough and Mississauga

The department has an active agenda in GIS-related matters; in our undergraduate program, in graduate and faculty research, and in our GIS and Cartography Office. The graduate department has a single program that operates over the three university campuses (St. George, Scarborough and Mississauga), while each of the three campuses has a distinct undergraduate program. In the GIS minor at the undergraduate level, each campus offers a series of second- and third-year courses in GIS for geographic analysis, mapping, and remote sensing. These lead to upper-year courses in advanced GIS techniques, a group GIS research project, and one or more specialized courses. These courses are all available to non-specialized undergraduate students as well. The Mississauga campus (UTM) also offers a major in Geographic Information Science, with courses aimed at transportation systems analysis, land resource analysis, spatial modelling and statistics, as well as a course on communication with maps.

Graduate and faculty research using GIS has ranged far and wide, for example, the Remote Sensing, Modelling and GIS Lab at St. George (spatially explicit carbon and water cycle modelling), the Transportation and Environmental Change Lab at UTM (spatial structure of cities and regions, and the sustainability of human activities). Recent new hires in GIS have expanded our capacity at our Scarborough campus (UTSC) to determine how land use and transportation systems affect social and economic outcomes of urban areas; and in the areas of health, transportation and food supply, related research at our St. George location.

The department also houses the GIS and Cartography Office, which undertakes GIS and mapping work for researchers within and outside the department, designing and publishing maps to illustrate their results, in print or interactive web formats. Recent projects illustrating the diversity of this work include: web-mapping collaborations with the Records of Early English Drama project, the Drama Centre and the U of T Library; numerous mapping projects for publications in conjunction with the Chair of Ukrainian studies; the Canadian Century Research Infrastructure project; and a forthcoming project developing a portal for historical GIS research in Canada. The Office also publishes a Technical Paper series documenting project-based GIS work, and has created and currently maintains GIS data collections, including the Neptis Foundation Geospatial Data Collection on Urban Issues.

Byron Moldofsky
Manager, GIS and Cartography Office
Department of Geography
and Planning
University of Toronto

University of Victoria, Department of Geography

The Department of Geography at the University of Victoria is home to a wide variety of GIS teaching and research programs. Undergraduate students have three degree options that emphasize GIS.

- **Geomatics Concentration**: Geography undergraduate majors have an opportunity to concentrate their courses in topics related to GIS, remote sensing, surveying, cartography, and spatial analysis. A geography degree concentrated in skills development helps students become job ready at graduation.
- **Geomatics Degree (Joint with Computer Science)**: Combine geographic techniques with skills from computer science to become a geomatics developer. The joint geography/computer science degree appeals to technical students interested in applications. Through the Geomatics degree, students become customizers of geographic technology with powerful skills in computer programming, software development, spatial data management and analysis using GIS.
- **Minor in Geographic Information Technology**: Any UVic undergraduate degree can be combined with a minor in Geographic Information Technology. The minor includes courses in GIS and is ideal for students looking to add marketable skills in geomatics to applied knowledge in a discipline.

The Department of Geography is a leader in geomatics research and graduate student training. The Coastal and Oceans Resources Analysis Laboratory (CORAL), led by Dr. Rosaline Canessa, uses GIS to study marine protected areas and integrated coastal management, including developing techniques for management and assessment of MPAs. The Hyperspectral and LiDAR Research Group and Remote Sensing Laboratory, led by Dr. Olaf Niemann, partners with Terra Remote Sensing to operate a twin-engine Piper Navajo with an imaging spectrometer, LiDAR, and dual-digital camera sensory. The Spatial Collaboration and Visualization Lab is jointly led by Drs. Rosaline Canessa and Peter Keller, and research emphasizes the development, implementation, and evaluation of spatial technologies to support coastal planning in group settings. The Spatial Pattern Analysis and Research (SPAR) Lab, led by Dr. Trisalyn Nelson, conducts research to develop and apply spatial and spatial-temporal analysis methods. Current research emphasizes wildlife and grizzly bear movement, cycling safety (Bike-Maps.org), and species distribution modelling.

The Spatial Sciences Research Lab (SSRL), led by Dr. Peter Keller, is project-based research group that uses GIS-spatial decision support systems and education for a broad range of applications, from tourism to population health. The SPECTRAL Lab, led by Dr. Maycira Costa, explores and develops research methodologies for interpretation of rapidly advancing remote sensing technologies and imagery exploring themes, ranging from biogeophysical processes in ocean waters and wetlands, to light attenuation in coastal and riverine waters. In addition, Dr. Randall Scharien's Research Group exploits innovative satellite earth observation data, such as polarimetric synthetic aperture radar (polSAR) and constellation mission data, in order to map critical biogeophysical components of the atmosphere-ice-ocean interface.

Trisalyn Nelson
Director of Geomatics
Lansdowne Research Chair in
Spatial Sciences
Department of Geography
University of Victoria

University of Winnipeg: Department of Geography

The Department of Geography at the University of Winnipeg offers three-year, four-year and Honours Bachelor of Arts and Bachelor of Science degrees in geography. This reflects the diversity of expertise that exists within the department.

The University of Winnipeg has aggressively pursued consolidation, expansion and realignment of its geomatics program through a number of initiatives. With the recent hiring of two new faculty members (September 2010, June 2011), the Department of Geography is revamping and streamlining its offerings in geomatics, offering logical stepped course progressions in geostatistics, cartography, remote sensing and GIS.

Upper-level courses focus on specialized training in various geomatics areas (e.g., radar and hyperspectral remote sensing) as well as project-based courses, in which teams of students undertake geomatics projects for external clients. Field-based activities and courses have been developed, in areas such as research methods and data collection protocols to supplement our classroom- and laboratory-based instruction.

The University of Winnipeg has an articulation agreement with Red River College. Through this articulation agreement, the Advanced Diploma in GIS that is available through Red River College, has been integrated into the four-year BA and BSc streams offered by the University of Winnipeg's Department of Geography. In essence, this joint program offers students the opportunity to graduate with a four-year University of Winnipeg BA or BSc degree in addition to the one-year Red River Advanced Diploma within a span of four years rather than the usual five years.

The geomatics offerings at the University of Winnipeg also benefit from a long-standing site license agreement with ESRI, whereby the full suite of ESRI products are available through a campus-wide research and teaching site license. This allows us to offer training using the latest generation of state-of-the-art GIS software. We also hold a site license for Idrisi and have a 25-seat license of ENVI, thereby complementing our GIS software with state-of-the-art remote sensing software as well.

Geomatics training at the University of Winnipeg also benefits from the availability of the state-of-the-art Planetary Spectrophotometer Facility associated with the Department of Geography. This federally- and provincially-funded facility houses over $1 million of remote sensing infrastructure, including a variety of field-portable and laboratory imaging, and point spectrometers, offering capabilities ranging from the ultraviolet to the far-infrared. In addition, the department has recently seen the addition of the GeoLEAD Lab (Geospatial Laboratory for Environmental Analysis and Decision Making), which supports faculty and undergraduate student research in geomatics. The lab has dedicated office space, specialized computing, software and GPS units to support the diverse needs of the researchers that use it. More recently the lab added an unmanned aerial vehicle to support field mapping exercises.

The geomatics faculty at the University of Winnipeg is involved in diverse research projects that employ a number of undergraduates every year. Current and recent projects include geological mapping of regions on the moon and Mars, field-based studies of planetary analogue environments, urban-rural fringe mapping in Argentina, coastal vegetation mapping in Churchill, Manitoba, and wetlands mapping in Southern Manitoba, to name but a few.

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Vancouver Island University

Master of Geographic Information System Applications (MGISA) and the Advanced Diploma in GIS Applications (ADGISA)

Vancouver Island University (VIU), located in Nanaimo, British Columbia, is now offering two GIS programs: the Master of Geographic Information System Applications (MGISA) and the Advanced Diploma in GIS Applications (ADGISA). The university's Spatial Data Infrastructure (SDI) program has been adapted to meet local needs, and is currently being taught in Ukraine by local instructors.

MGISA Program

http://www.viu.ca/mgisa

The Master of Geographic Information System Applications (MGISA) program builds on the existing Advanced Diploma in GIS Applications (ADGISA) program, by providing opportunities for students to strengthen their GIS skills, enabling them to compete more effectively and for better positions in the job market.

The program consists of a Stage 1 and a Stage 2, each of 30 credits. Stage 1 involves the same courses as the current Advanced Diploma, and is available both face-to-face and online; the Stage 2 courses will be delivered online, with face-to-face or online supervision, and will include a defense of the research project thesis.

The program offers courses, labs, seminars, and a research project to generate an intellectual environment within which students can enhance their theoretical knowledge and practical skills in the area of geographic information science. It combines a strong academic foundation with professional skills by requiring both academic courses and a thesis research project.

ADGISA Program

http://www.viu.ca/adgisa

The Advanced Diploma in GIS Applications (ADGISA), a post-graduate program in GIS applications, is offered in both face-to-face and online teaching modes. The face-to-face version offers a valuable twist: after an intensive four months of hands-on training in a dedicated classroom setting, students then spend the next four months using GIS as a tool in resolving a real-world geographic or spatial problem of their choice. As a result, a number of local and regional businesses, industrial firms, government agencies, crown corporations and research institutes have provided project opportunities. The student project, which may be paid, has been designed so that students will be fully job-ready upon graduation.

The ADGISA program is also delivered in a fully online format, with all resources, lectures, lab assignments and exams being delivered online. Because everything is delivered online, and designed for access at any time, students can participate from anywhere in the world that has Internet access. This program delivery runs over 16 months, and has been designed for students who are currently in the workforce, or who simply need or want to work from home. Classes are delivered over a longer period, and the practicum has been replaced with three specialty courses in programming, remote sensing and global positioning systems.

The curriculum of both versions of the ADGISA program has been designed to strengthen a student's understanding of basic geographic and cartographic principles, while at the same time providing them with hands-on experience in applying these techniques using the GIS, remote sensing and

DBMS software. Customization and development of GIS and mapping applications are taught using .NET, Python and JavaScript, and desktop, web and mobile SDKs/APIs.

Ukraine SDI Project

http://www.viu.ca/sdi

The Partners for Development Program of the Department of Foreign Affairs, Trade and Development Canada funds selected Canadian universities working on international development projects. VIU and its partners, the Taras Shevchenko National University of Kyiv (NUK), and the National Technical University of Ukraine "Kyiv Polytechnic Institute" (NTUU-KPI) proposed developing and then delivering an educational program to the Ukrainian civil service, to support the country's development of a National Spatial Data Infrastructure (NSDI). The proposal was successful and began November 2012.

One of the long-term goals of the project is to develop a capacity in Ukraine for cadastral land management, particularly for agricultural land. Around 120 students will participate in the training program over the lifespan of the project. These students come from government ministries such as the Ministry of Agrarian Policy and Food. VIU is developing six GIS/SDI-related courses, translating them into Ukrainian, adapting them to the Ukrainian context, piloting them in Ukraine and then supporting the partner universities as they prepare to offer the courses themselves on an ongoing basis.

Six Ukrainian instructors have been working collaboratively with VIU's team of GIS instructors to ensure that we design and deliver a high quality program in Ukraine. Faculty members from other disciplines, including geography, forestry and the Centre for Innovation and Excellence in Learning, have added their expertise to the project. ❑

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