Reclaiming Geospatial Data and GIS Design for Indigenous-led Telecommunications Policy Advocacy: A Process Discussion of Mapping Broadband Availability in Remote and Northern Regions of Canada

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RECLAIMING GEOSPATIAL DATA AND GIS DESIGN FOR INDIGENOUS-LED TELECOMMUNICATIONS POLICY ADVOCACY

A Process Discussion of Mapping Broadband Availability in Remote and Northern Regions of Canada

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ABSTRACT

Geographic Information Systems (GIS) and geospatial data are important advocacy tools adopted by a range of users, including telecommunications policy advocates. However, without the means to actively deconstruct and reshape such platforms, reclaim the geospatial data they utilize, and generate the visualizations they produce, the increasing adoption of these resources threatens to disempower some community-based user groups. In this article, we argue that the processes used to design such tools for policy advocacy must transparently reflect the socially constructed nature of the GIS systems and the geospatial data visualizations they generate, as well as the values and goals of the specific user groups they are designed to support. We ground this argument in a case study of a regulatory hearing on telecommunications infrastructure and services in Canada, and introduce a freely available online resource that documents our GIS design workflow in more detail.
Keywords: telecommunications policy; geographic information systems (GIS); indigenous peoples; broadband availability; Canadian Radio-Television and Telecommunications Commission (CRTC)

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Introduction

Geospatial data and the platforms that house them can be used as tools for both colonialism and Indigenous resurgence. For centuries, mapping technologies and the data they represent have been used by colonial governments to administer and control Indigenous populations. At the same time, Indigenous peoples have actively worked to secure access to and control over mapping and data resources to support their own self-determined development initiatives. These tensions persist today through digital mapping technologies, the geospatial data they generate, and the social practices involved in their design and use.

While many authors have commented on the risks of digital technology adoption by Indigenous peoples, citing risks to traditional cultural practices or increased susceptibility to forms of colonial exploitation, the history of the appropriation and shaping of technologies by these groups also provides many examples of community-driven innovation.[1] Indigenous peoples, like all societies, engage in the ongoing, recursive process of adoption and modification of technical artifacts and associated social practices, including those used to archive, steward, and manage geospatial data. Land-based Indigenous Knowledge has been curated by generations of traditional knowledge keepers, while the activities of groups such as the First Nations Information Governance Centre provide recent examples of digital data management.[2] In this article, we discuss a case study of Indigenous reappropriation and use of geospatial data and Geographic Information Systems (GIS when referring to the field of study; GIS platforms when referring to software) in an information policy context. We do this by making transparent the workflow and design choices that we used to adapt an open source GIS plat-

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1. Roth; Valaskakis; Perley et al.; Wemigwans.

2. Bruhn; Andersen and Walter.

form to reclaim and re-present existing government statistical datasets on broadband availability during a telecommunications regulatory proceeding in Canada. This illustrates an example of how GIS design and use can support the efforts of Indigenous peoples to secure ownership, control, access, and possession of data resources held by third parties. Building on an argument made by Corbett, Hamilton, and Wright (2016), we suggest that the process as much as the outcomes of GIS design and use are key to these efforts. That is because the process of reclaiming geospatial data allows user groups to build community cohesion, focus attention on matters of importance, and produce informational resources that support their policy proposals.[3] Our discussion of these activities through a grounded case study will help address a concern raised by Lentz (2014) regarding the gaps in our understanding of the learning processes (framed here as data literacy initiatives) undertaken by information policy advocates in their activities:

> We know far too little about how media [and telecommunications] policy change takes place from the perspective of the civil society actors actually engaged in this work. We know much less about how citizen and consumer policy advocates learn how to do media policy advocacy work, or how they pass on their expertise to others. (181)[4]

In this article, we contribute to efforts to address this knowledge gap by providing a discussion of the reasoning behind a geospatial data-driven telecommunications policy advocacy initiative undertaken in Canada by the First Mile Connectivity Consortium (FMCC). We hope this example demonstrates transparency of method in our construction and use of GIS tools and data literacy resources for public policy advocacy. In the future, we hope our process might be taken up, adapted and used by community-based organizations to generate their own GIS design practices and geospatial data visualizations. To this end, more specific information on these elements of our project, including a step-by-step guide that illustrates how community groups can develop theirown broadband mapping projects, is available for free download here: http://firstmile.ca/guide-an-open-source-gis-and-mapping-methodology-for-internet-access/. To support this goal, we also reflect on the design challenges

3. Corbett, Hamilton, and Wright.

4. Lentz.

that we encountered, discussing how they may impact further adoption, adaption, and overall sustainability of our methodology.

We conclude the article by suggesting that the personal relationships, shared understandings, social processes, and technical knowledge established and documented through this project helped further clarify and strengthen the FMCC partnership, as well as contribute to a concrete intervention in telecommunications policy. The FMCC is a national nonprofit association of Indigenous broadband service providers and affiliated researchers that emerged from a 10-year participatory action research project called First Nations Innovation, and is informed by the Assembly of First Nations "e-Community Strategy."[5] A registered national nonprofit, its membership and board of directors consists of staff from First Nations technology organizations serving remote and rural areas in the provinces of B.C., Alberta, Manitoba, Ontario, Quebec, and Atlantic Canada, as well as university-based researchers.

The FMCC members reviewed the research and design activities described in this article, and informed the work of the university-based researchers. Importantly, this relationship was cultivated over a number of years, necessarily involving the slow development of trust, reciprocity, and understanding among the partners. In our opinion, this careful, deliberate approach toward relationship-building is necessary for the kind of engaged research and policy advocacy work we describe here, particularly when partners are spread over geographic areas and come from different organizational, cultural, and political backgrounds.

Applying GIS and Geospatial Data in Public Policy Advocacy: Challenges and Opportunities

Contemporary policy-making is increasingly data-driven, particularly from geospatial data, but several challenges arise from this activity. The interpretation and application of geospatial data by policy makers in their decision-making can be used to administer and control marginalized populations, expand surveillance activities, and extend systemic inequalities.[6] While the use of GIS platforms and the information they organize and

5. Judy Whiteduck.

6. St. Martin, and Wing.

deliver can support community-driven initiatives, such as by documenting patterns of spatial inequity, critical GIS scholars note that it can also support the concentration of corporate, governmental, and military power—including through the ongoing colonization and appropriation of Indigenous lands and resources.[7]

Reliance on geospatial data and maps for public policy decision-making also faces epistemological critiques, including its ability to misrepresent and oversimplify complex spatial phenomena both inadvertently and deliberately.[8] Although descriptions of GIS as a Geographic Information "Science" capture the complexity and sophistication of the field, they also suggest a presumed ability of such geospatial research outputs to reveal universal truths. In the mid- to late 1990s, critical geographers described this framing of GIS as a resurgence of "quantitative elitism"; a return to positivist modes of inquiry and representation.[9] But as Wainwright and Bryan warn, "Cartography always involves flattening, simplification, abstraction, and representation" (p.155). While geospatial data-driven analysis can be a powerful public policy tool, it also represents a "chosen field of vision, a political statement grounded within the world, rather than a scientific statement reigning above it."[10] Chrisman (2005) similarly critiques GIS for its tendency to reify the data visualizations that it produces—that is to make them appear truthful, objective, universal, and therefore "real."[11] It can be easy for GIS specialists to produce false or inaccurate impressions of public policy issues through their manipulation of data visualizations. This is an increasing problem in an era of "fake news" and contending visions of social reality presented to public policy decision-makers who must sort through such evidence under short timelines.

Access to and availability of the data sets used by GIS specialists to produce geospatial data visualizations are also uneven, and major changes in the methods and variables utilized by statistical agencies can enable or constrain attempts to collect and standardize socioeconomic information between data sets. At times, robust and accurate data are simply unavailable. For example, the decision of the former federal

7. Thatcher et al.
8. Fraley; Monmonier.
9. Schuurman, *Progress in Human Geography*.
10. Fraley.
11. Chrisman.

government in Canada to retire the long-form census and replace it with a voluntary survey, as well as the discontinuance of certain statistical tables in that census, pose challenges in locating, and interpreting certain data pertaining to some years. The geographic uniformity of available statistical data is a related challenge. Census tracks are often revised on a near-annual basis, while some communities previously included in Statistics Canada (StatsCan) data may be aggregated into larger units or may no longer be included in statistical surveys. For example, a September 18, 2015 article published in *Maclean's* magazine described one-fifth of Canada's communities as "statistical dead zones" and refers to a "systematic erosion of government records far deeper than most realize, with the data and data-gathering capability we do have severely compromised as a result."[12]

Well-documented criticisms of the logistical complexities and costs of generating geospatial data visualizations and analyses through GIS also exist. GIS operations, platforms, and data management practices can create a steep technical learning curve for non-GIS specialists.[13] Particularly in an age of information abundance, under-resourced groups face increasingly complex challenges in collecting, assessing, and sorting information through geospatial analysis.[14]

These varied challenges clearly point to problems with the use of GIS platforms in policy development, including for community groups that may lack the resources available to well-financed government or corporate entities. However, GIS platforms can also be powerful resources for such under-resourced groups. Such tools can enable them to collect, code, organize, reorganize, present, and represent a range of cultural, environmental, and other types of data through spatial analysis.[15] In recognition of the utility of this approach, since the 1990s a host of mapping methodologies, resources, and platforms have merged geospatial data and GIS technologies to support marginalized groups in their efforts to inform public policy decisions.[16] Such activities are seen, for example, in attempts by GIS specialists to partner with communities to utilize these tools.[17] In recent years, participatory approaches to GIS and public par-

12. Kingston.
13. Hao, Brown, and Harding.
14. Fisher, and Myers.
15. Bailey, and Grossardt; Dobson.
16. Schuurman, *Canadian Geographer*.
17. Sieber; Zube.

ticipatory GIS platforms (PPGIS platforms) have emerged as attempts to provide an easy-to-use means for under-resourced community groups to produce, analyze, and present spatially organized knowledge through customized software platforms.[18] Most recently, popular Web 2.0 tools such as Google Maps and CARTO have provided a user-friendly means to layer and format geospatial data to produce increasingly complex online analyses and visualizations. Such projects aim to better inform community groups of the utility and potential of geospatial data, as well as aid them in contributing to the formation of public policy.[19] Online GIS platforms are making it simple for anyone to do this work, and open source platforms are making it more accessible for user groups who may have technical knowledge in GIS, but lack the financial resources to buy commercial software licenses.

These projects range from focused efforts to create customizable data-entry and visualization platforms that illustrate the interests, aptitudes, and needs of a specific community, to proposals for the broad reenvisioning of the Canadian government's geomatic infrastructure to make it more available to a broader variety of user groups.[20] Examples of such projects in Canada include the BC community mapping network,[21] the Aboriginal Mapping Network Initiative,[22] and the Participatory GIS Training Kit.[23] Other examples of Indigenous mapping can be drawn from countries such as New Zealand.[24]

There is no doubt that efforts to democratize the use of GIS platforms are beneficial to under-resourced community groups. However, such GIS-supported public policy initiatives tend to focus on the production of outputs (visualizations, infographics, maps, etc.), rather than on interrogating the social processes involved in collecting, processing, aggregating, and visualizing of geospatial data sets presented through GIS systems.[25] Many examples of the use of GIS systems to generate "counter," "community," "alternative," or "Indigenous" maps exist—but when adopted uncritically by user groups, the data and design process behind such efforts can have unintended outcomes. In one study,

18. Peng.
19. Bailey, and Grossardt.
20. Lenihan.
21. See: http://cmnbc.ca.
22. See: http://nativemaps.org.
23. See: http://pgis-tk-en.cta.int.
24. Harmsworth.
25. Bhargava, and D'Ignazio; Pfeffer et al.

Wainwright and Bryan (2009) describe how cartographic-legal strategies that use GIS visualizations aim to correct the injustices of the colonial past by extending property rights to Indigenous peoples—albeit in ways that may undermine deeper cultural recognition of Indigenous approaches to land ownership and usage rights.[26] Wainwright and Bryan (2009) further caution against an analysis of maps as self-evident representations of either national territory or Indigenous property, arguing that although (re)mapping space is a precondition for securing legal recognition for Indigenous land rights, it nonetheless does so by reinforcing Western conceptions of individual property ownership—an understanding counter to some Indigenous approaches to land stewardship (153–54).

To address this tension, some critical GIS researchers focus attention on GIS systems as socially constructed sets of practices and technical resources that can be actively shaped and reshaped by user groups. Countering understandings of GIS as a single, monolithic platform, these approaches use the insights of Science and Technology Studies to foreground the contexts that GIS users are embedded in—and the ways that they can shape (and reshape) such systems to better reflect those contexts.[27] As St. Martin and Wing (2007) argue, this works to "negate the notion that GIS is a single thing, linearly progressing, inherently expanding, and universally applicable," and instead frames it as a diverse and malleable set of social practices and understandings that are undergoing continuous negotiation and experimentation.[28] Such attempts to "re-claim" GIS design practices by diverse user groups provide examples of how such systems can be deployed in ways that better reflect their situated understandings of the world.

However, this kind of reclamation of GIS platform design practices requires a certain technical skill set that may result in what Wainwright and Bryan (2009) term "differential empowerment." In their discussion of Indigenous GIS mapping initiatives, they write:

> Not everyone can be equally involved in the work of map-making, building lawsuits, negotiating with state officials, and so forth. In spite of the use of 'participatory methods' to produce the maps described here, however, we have been repeatedly struck by the inability of

26. Wainwright, and Bryan.

27. Mackenzie, and Wajcman; Pinch, and Bijker.

28. St. Martin, and Wing, 245.

> many who participated in the process itself to read the maps in the ways that judges, lawyers, and geographers do. To the extent that villagers are able to read the maps (putting aside the question of access), peoples' authority to participate in making and reading the maps is often strikingly uneven.[29]

We recognize the excellent work that has been done to map the various facets of "digital divides."[30] Researchers have applied geographic analyses to study the effects and outcomes of policy initiatives aimed at addressing digital access divides.[31] This work extends to research that examines digital divides in Canada.[32] However, our focus in this article is not on these important efforts, but rather on the challenges that community-based organizations may face in doing this work themselves. We are interested in the supports and barriers that may affect the ability of local groups to directly engage in efforts to map and analyze digital divides—not only through collecting and visualizing locally-produced data, but also in reclaiming and re-presenting data about their experiences that is often held in centralized or metropolitan organizations.

Applying this focus to our analysis, we caution that despite its seeming success, the "democratization" of GIS and geospatial data may in fact generate new methods of exclusion, and present new technological and societal barriers for community organizations and their members.[33] This observation raises the need for a transparent approach to geospatial data literacy that includes the capacity building that takes place when community groups are actively involved in developing and redeveloping their own GIS tools and associated geospatial data. As St. Martin and Wing (2007) put it, such an approach involves "the work of innovators who choose to rethink and alter what is possible with GIS."[34] In the next section, we describe a design process aimed at reshaping GIS design and reclaiming geospatial data to better meet the needs of an Indigenous user group engaged in telecommunications policy advocacy. Our goal in this project is to raise questions and points of consideration for community groups, policy-makers, and researchers working in this space.

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29. Wainwright, and Bryan, 161–62.
30. van Dijk Johannes.
31. See for example: Alizadeh, and Shearer; Grubesic; Mossberger, Tolbert, and Stansbury.
32. See for example: Fiser; Sawada et al.
33. Byrne, and Pickard.
34. St. Martin, and Wing, 243.

Reclaiming Geospatial Data and GIS Design to Support Indigenous Advocacy in Telecommunications Regulatory Proceedings: The Case of the FMCC

Around the world, the development and regulation of telecommunications systems continues to be shaped by state institutions. As Flew and Waisbord (2015) write, the emergence of national policy and regulatory frameworks reflect the complexity and contradiction of the actors involved in such work.[35] Diverse organizations can shape the formation of formal policy structures during certain "critical junctures" or moments of reform, provided the right enabling conditions are in place.[36]

In Canada, one such juncture arguably emerged in the context of the deployment of broadband infrastructure in geographically rural, remote, northern, and Indigenous regions, where the federal government is establishing regulatory and policy mechanisms to encourage development. However, these frameworks sometimes fail to take into consideration the interests and needs of all service providers operating in these areas.[37] Specifically, while private sector telecommunications companies have an important role to play in deploying infrastructure and services, attempts to address broadband availability challenges in Canada are not limited to their efforts; people living in unserved and underserved communities have also been engaged in building and operating their own digital infrastructures and services. Indigenous peoples in particular have a long history of setting up organizations to build, manage, and sustain the broadband systems networking their territories.[38] Desire for increased autonomy in the administration and delivery of these systems—along with self-determination more broadly—has been a primary driver of the development of community-based telecommunications infrastructure, services, and applications by these groups.

In discussions of telecommunications policy and regulation, the term "First Mile" frames such community-driven initiatives as an alternative to the "last mile" link from service providers to subscribers.[39] The First Mile concept provides language that its proponents use as shorthand to illustrate

35. Flew, and Waisbord.

36. McChesney.

37. Gurstein; Jayakar; MacDonald, Longford, and Clement; Paisley, and Richardson.

38. See for example: Carpenter; Fiser, and Clement; McMahon, Hudson, and Fabian, *The Shifting Terrain: Public Policy Advocacy in Canada*; Tim Whiteduck et al.

39. Paisley, and Richardson; Strover.

their position that policy and regulatory frameworks should be designed and implemented in ways that enable communities to build, own, and operate their own telecommunications infrastructures and services.

Over the past decade, the FMCC has emerged as a vehicle for Indigenous technology organizations operating in remote and Northern regions to advocate for First Mile-oriented policy and funding support to address digital divides.[40] The organization's approach to these interventions is a continuation of previous efforts by Indigenous groups to assert control over broadcasting and telecommunications systems.[41] Its work is also inspired by the longstanding efforts of Indigenous peoples in Canada to retain ownership, control, access, and possession (OCAP) of data about their lives and societies that are typically collected, organized, interpreted, and disseminated by third-party organizations such as government agencies.[42] Canada's history of settler-colonialism contains many contemporary and past examples of how various forms of Indigenous data have been extracted and used by external authorities to manage such populations, sometimes against their will and knowledge.[43] In response, Indigenous peoples have consistently advocated for more control over the data and information that pertains to their communities and institutions, and have developed tools to support community-based data and information management.

An opportunity to propose reforms to telecommunications policy and regulation to better reflect these principles arose in 2015–2016, when Canada's national telecommunications regulator held a series of public hearings on whether broadband should be considered a "basic service" made available to everyone in the country. In Canada, telecommunications regulatory proceedings, like court cases, involve the presentation of multiple arguments put forward by a variety of stakeholders including telecommunications companies, public and consumer advocacy groups, government agencies, and private citizens. Organized as a quasi-judicial body, the CRTC adjudicates between the arguments and evidence put forward by these interveners.[44] To referee this process, the Commission starts a proceeding by releasing an announcement establishing the terms of inquiry and setting out the specific questions to be considered. The Commission

40. McMahon, Hudson, and Fabian.
41. Alia; Perley et al.; Tim Whiteduck et al. 2012.
42. Schnarch; Andersen, and Walter.
43. Smith.
44. Shepherd, Taylor, and Middleton.

invites interveners to comment on these issues; information that is not relevant to answering these questions can be deemed inadmissible.

But despite these efforts to police the contours of debate, regulatory hearings typically generate an abundance of information and data that Commissioners and their staff must sort through and determine the validity of during time-limited deliberations. As well, the presentation of arguments and associated evidence by interveners is shaped by a number of factors, including their varying levels of technical expertise and financial resources.[45] Due to knowledge and technical barriers, some data sets presented in this forum are only accessible to specialists specially trained in their usage—most of whom work for well-financed corporate entities. This can disadvantage under-resourced groups, including public and consumer advocacy organizations, who as a result may lack equitable opportunities to contribute to regulatory and policy decision-making processes that affect the lives of their constituents. For example, limited data describing local contexts are often extracted and interpreted by experts situated far from the lived realities of community members, providing an inaccurate representation of on-the-ground conditions. Such a situation can result in the formation of binding public policy decisions that fail to address the conditions faced by people living in these communities.

Such tensions arose in 2015, during national consultations held by the CRTC to update the definition of the "basic service objective"[46] for telecommunications, as well as define the regulatory environment to support the delivery of those services to all Canadians.[47] The public hearings associated with this proceeding allowed interested parties to file a series of written and oral interventions that present arguments and evidence to inform the Commission's decision-making. In the case of the hearings considered in this article, robust data on existing availability and affordability in the northern and remote regions of the country is lacking.[48] Federal agencies including StatsCan and the CRTC have acknowledged that much of what we know about current broadband availability is made available on a limited basis through private parties

45. McMahon, Hudson, and Fabian, *Journal of Information Policy*.

46. Telecom Regulatory Policy CRTC 2011-291 defines the "basic service objective" as a combination of services as follows: "individual line local Touch-Tone service; access to low-speed Internet at local rates; access to the long distance network and to operator/directory assistance services; enhanced calling features, including access to emergency services, voice message relay service, and privacy protection features; and a copy of the current local telephone directory."

47. Canadian Radio-Television and Telecommunications Commission (CRTC).

48. Ibid.

(such as telecommunications companies) or determined by educated guesses based on available information.

Given this uncertainty about the actual costs and availability of broadband infrastructure and services, one goal of the CRTC hearings was to determine the boundaries of unserved and underserved geographic regions under consideration. A related goal was to use these boundaries to determine the availability of telecommunications (broadband) services in those regions. As presented in the Notice of Consultation leading the proceedings:

> The Commission will examine how these telecommunications services are used by Canadians, and what prices Canadians should be expected to pay for these services.
>
> The Commission will also examine the availability of telecommunications services to determine which areas in Canada are underserved or unserved. The Commission will consider what its role should be in ensuring the availability of basic telecommunications services, particularly in rural and remote regions of Canada.[49]

To address these and other questions, during the proceedings interveners presented geospatial data sets and map visualizations as evidence of current levels of broadband availability. A range of diverse interest groups presented arguments and evidence regarding the scale and nature of Canada's "digital divide." Many of these interventions were based on limited publicly available data and uncertain geographic boundaries concerning broadband availability in Canada's northern and remote regions. For example, the limited publicly available data currently available through StatsCan on remote and Indigenous communities is in a difficult-to-use format, particularly when self-defined geographic and service provision boundaries of Indigenous organizations are taken into account.

Telecommunications providers provided coverage maps to the Commission, but these maps were typically redacted from the public record for competitive reasons, and also lacked the granularity of data illustrative of available broadband in small or isolated communities. Early stage crowd-sourced data generated and managed by third-party organizations such as M-Lab[50] and the Canadian Internet Registration

49. Ibid., para 32–33.

50. Measurement Lab.

Authority (CIRA) was submitted during the proceedings by Professor Fenwick McKelvey from Concordia University.[51] However, since these monitoring activities were only very recently launched, at that time they did not provide adequate data from many remote and Northern regions of the country.

These contending geospatial data sources about broadband accessibility came into tension with one another during the proceedings, as Commissioners were confronted with conflicting evidence that broadband availability and affordability either was, or was not, a problem in northern and remote regions of Canada. The FMCC was one intervener in the ensuing debate. In the following section, we document the FMCC's efforts to design and utilize GIS tools to reclaim publicly available geospatial data currently held by government statistical agencies and create spatial illustrations from it. Rather than rely on existing visualizations presented by third-party groups such as government agencies or commercial telecommunications providers, or present visualizations based on the very limited data available from remote and Northern regions, we decided to develop and present an operational workflow methodology that the FMCC (and others) can add to and improve as more accurate data become available. This process allowed us to collect, analyze, and visualize publicly available broadband availability data in a way that matched the geographic boundaries validated by our specific community of interest, the FMCC member organizations (First Nations technology organizations that provide digital telecommunications services to communities in their regions). In developing this process, we documented a series of steps that other under-resourced community groups can use to reclaim and visualize geospatial data to meet their needs. Our submission of this design process to the Commission thus aimed to present an alternative visualization of broadband availability data that drew attention to the socially constructed nature of maps generated through GIS platforms.

The following section introduces the GIS workflow that we developed. As described, this design process involved first defining a geographic community of interest, and then collecting, formatting, and spatially encoding available statistical data through map visualizations. For more details, download the full report at: http://firstmile.ca/guide-an-open-source-gis-and-mapping-methodology-for-internet-access/.

51. See https://cira.ca/cira-internet-performance-test-0.

Case Study: A Workflow Design Process to Reclaim Broadband Availability Data about Canada's Indigenous Regions

The accessibility of geospatial data and GIS, both from a computational and a financial perspective, has broadened the capacity of non-GIS specialists to use these resources. That said, several barriers to performing geospatial analysis persist. In this context, our design process (outlined in more detail in our online guide) provides a methodological approach and exposes some of the potential limitations and challenges of performing spatial analysis using Open Canada geospatial data. In our opinion, and building upon some of the factors presented by Sieber (2006),[52] notable barriers to performing this type of analysis include the following:

- Lack of robust data that accurately represents the realities of Internet access in remote and rural Indigenous communities in Canada.
- Familiarization with the Open Source software ecology takes time and requires some preexisting knowledge of statistical programs and web data extraction techniques.
- Data repositories often use different formats and collection procedures, and vary in terms of relative quality and/or commensurability.
- The technical knowledge required for GIS analyses (as well as the licenses needed for proprietary versions of GIS) have traditionally impeded researchers in many fields from adopting these tools.
- Particularly for web applications, a reliable broadband Internet connection is needed for data collection and interactive visualizations.
- Ethical reservations exist concerning the creation, control, and applications of sensitive information.

With these challenges in mind, we created an approachable workflow that user groups can use to perform statistical data collection, parsing, analysis, and geographical presentation using both a fully featured Open Source GIS platform, QGIS, as well as a web-based spatial analysis platform, CARTO (previously CartoDB). These approaches are aimed at different types of users, and can help provide different data products depending on the familiarity of the user with GIS software. Our guide is therefore organized by platform, with conceptual workflow suggestions for more experienced users and step-by-step instructions for less experienced users. Considerations when using each tool are briefly explored and both options are presented with reference

52. Sieber.

to their strengths and limitations. Both data analysis options demand different steps but essentially perform the same data handling and presentation processes, which are summarized here in the following three steps:

1. Building a geographic definition for the community of interest
2. Collecting and formatting statistical data sets
3. Joining spatial and statistical data

The work necessary for Step 1 to manipulate and generate spatial data requires the use of a dedicated GIS platform, while Step 2 can be performed using any modern web browser (e.g., Safari, Edge, Firefox, Chrome/Chromium) and standard spreadsheet software (e.g., Microsoft Office, LibreOffice). The approach for Step 3 is dependent on the software platform being used (QGIS or CARTO); the steps used in both platforms are explained in sequence in the online guide.

Step 1: Building a Geographic Definition for the Community of Interest

First, we identified the geographically defined community of interest to represent the FMCC constituency. The regions we represented were largely within the Canada Revenue Agency definition of "Northern" and "Intermediate" areas. These areas are identified as such for their higher cost of living due to their remoteness, and are largely underserved or unserved by high-speed telecommunication infrastructures, as defined by the CRTC. Unfortunately, this geographic region is seldom represented in maps—even though its spatial boundaries are clearly defined in legal texts such as the *Income Tax Act of Canada*.[53] As such, we needed to manually delineate the boundaries and create this region using a GIS platform. As noted by Wainwright and Bryan, "Maps contribute in many ways to the production of community, in particular through drawing lines delineating relationships between people and places" (p.162).[54] In the context of the CRTC proceedings, this step also helped address the questions asked by the Commission regarding the appropriate geographic boundaries to determine the availability of broadband in northern, rural, and remote communities. As noted in the Commission's *Telecom Notice of Consultation CRTC 2015–134*: "The Commission will also examine the availability of telecommunications services to determine which areas in Canada are underserved or unserved."[55]

53. Justice Laws of the Government of Canada.
54. Wainwright, and Bryan.
55. CRTC, para 33.

In our GIS design workflow, developing this geographic definition involved collecting Canadian census data sets for several different levels of government and building a vector (Shapefile) to represent the CRA's Northern and Intermediate zones as the geographic regions under consideration.[56] Translating the CRA's boundaries as displayed in the legal texts defining them involved a GIS technique called "digitizing," where data is created by specifying coordinates into a GIS used to create points or vertices of a line or shape. This process is useful for converting spatial information into spatial data, typically the act of tracing the shapes and symbols of historical maps and digitizing its data. While tutorials are available for the most common forms of digitizing (tracing), the process we performed involved creating a geographic shape from its known vertices. The end result of this process yielded a Shapefile with two regions that could then be used to identify regions considered to be in the unserved and underserved areas of Canada, as CRA determined them to be.

This process was informed by existing research on northern regions of Canada,[57] as well as through input from the FMCC's member organizations and the First Nations communities that they represent. In Canada, northern Indigenous communities are located in three territories (Yukon, Northwest Territories, and Nunavut) and in the northernmost regions of the provinces. These small, dispersed communities do not have a common defined geographic community of interest. In fact, they are jurisdictionally separated by various provincial, territorial, and Indigenous borders, which makes it difficult to generate a common definition with regards to shared geographically oriented challenges, such as bridging broadband availability divides.

To build a collective voice to represent their shared challenges and perspective to policy makers such as the CRTC, in 2013 several Indigenous organizations that provide technology services in these regions founded the FMCC. While respective of differences and diversity of its individual member organizations, the FMCC is an incorporated national nonprofit association that aims to provide a unified voice in areas of common concern, including building a geographic definition to address broadband availability in the regions in which its member organizations operate in. Figure 1 illustrates the geographic regions that encompass the FMCC's community of interest (illustrated in blue and teal). We created it through

56. Statistics Canada.

57. Fiser, 2010.

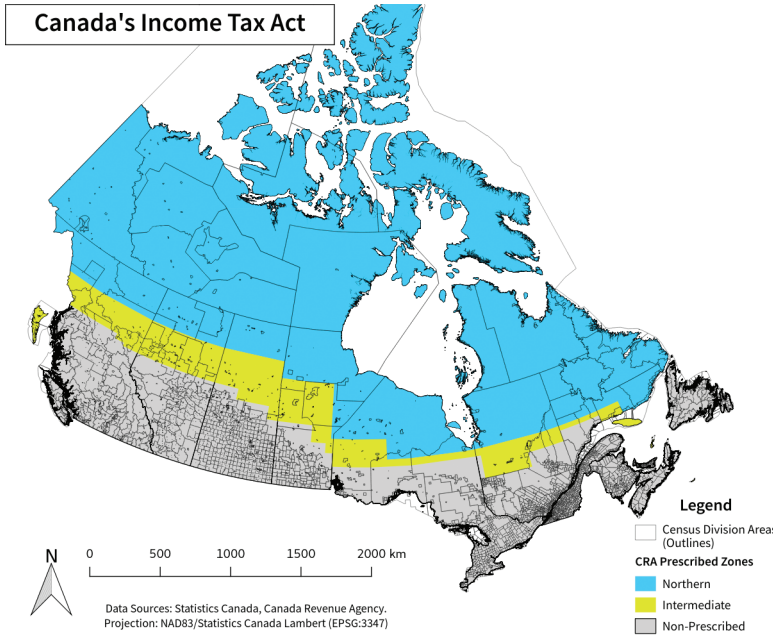

FIGURE 1 Canadian Census Division Areas overlaying FMCC Community of Interest (Northern and Intermediate Regions).

an intersection of existing data sets developed by government agencies and geographic boundaries translated from the *Income Tax Act of Canada*.[58]

Our work in this area should be periodically reviewed and verified by the Indigenous people living in these regions, including the FMCC member organizations. While we attempted to use multiple sources in our mapping requirements, our process also reflects the need for close partnerships between technical designers and involved communities—including through the FMCC, which is one vehicle to help ensure that any GIS-developed maps used in public policy activities in fact reflect their lived experiences.

Step 2: Collecting and Formatting Statistical Data Sets

Second, we collected and formatted quantitative data from a variety of publicly available statistical sources to illustrate broadband availability from federal, provincial, territorial, Indigenous and non-governmental organizations. The data sources that we reviewed to collect indicators for our purposes are summarized as follows:

58. Statistics Canada; Justice Laws of the Government of Canada.

TABLE 1 Statistical Bureaus and Relevant Socioeconomic Data/Information

Statistical Bureau	Geographic Scope/Area of Interest
Statistics Canada (CANSIM, Census, National Household Survey)	Canada, Provinces/Territories, Census Divisions/Municipalities, Census Dissemination Areas/Blocks, Health Regions, Economic Regions
Aboriginal Affairs and Northern Development Canada (Community Well-Being Index)	Census Divisions/Municipalities, Aboriginal Communities
Government of Newfoundland and Labrador	NFLD, Municipalities, Nunatsiavut Communities
Government of Nunavut	Nunavut, Municipalities, Inuit Communities
Government of the Northwest Territories	NWT, Municipalities, Inuvialuit Communities
Nunivaat	Nunavik Communities (Quebec)

Examining this data more closely, we learned that much of the available data sets are presented for large regional geographic areas such as provinces, territories, and at the national level. Depending on the area or subject of interest for the specific analysis, the geographic scale of interest (national, regional, municipal, or local) will affect the data availability, appropriate methods, and reliability/certainty of the results.

For our research purposes, in many cases the data that best illustrated issues that may be of interest to communities (e.g., Household Spending on ICT; Total Current Consumption; Employment and Education rates) were only available in a format aggregated at the provincial/territorial level, or were presented in a nonmachine-readable format. This required us to perform manual data entry. The aggregated nature of statistical information and the long hours needed to enter and render data for useful GIS analysis at smaller scales can raise logistical and resource challenges in attempts to produce effective and/or community-relevant visualizations.

This work also involved navigating challenges that stem from both data abundance and data scarcity. GIS analysis can be a useful tool to simplify, curate, manage, and visualize data. However, in an age of information abundance, it is difficult to sort through and find data sets that are both accurate and reflect the requirements of user communities. At the same time, the availability of statistical data sets is impacted by government policy. Many challenges arose in our attempts to collect and standardize socioeconomic

data from census and intercensal years, due to major changes in the methods and variables utilized by statistical agencies. For example, the decision of the former federal government of Canada to retire the long-form census and replace it with a voluntary survey, as well as the discontinuance of some pertinent tables of data on socioeconomic variables and digital technologies, posed challenges in locating and interpreting data pertaining to previous years.[59] This clearly limits the data and knowledge resources available to community groups—even in cases of public statistics.

Our examination of these multiple data sets highlighted another lesson: as with the use of maps, the use of statistical data should be problematized with reference to its limitations. The information needs to be accurate, timely, and approachable. Formatting raw data to usable geospatial data is a long and involved process, and if GIS specialists are not clear on this process, they might inadvertently generate less useful or misleading visualizations and information. Therefore, shortcomings in the collection, formatting, and presentation of data (and the workarounds that parties use to address them) must be made as transparent as possible. This allows audiences to critically assess the informational resources presented in cases where a party is utilizing data sets for a defined purpose, such as mapping them onto a geographic region to support a policy proposal or regulatory intervention.

Along with challenges that stem from the general unavailability of scalable statistical data sets and discontinued statistical tables, we needed to ensure that the data that we collected could be formatted and presented on the maps we created. GIS objects can represent any kind of geographic data that can be represented spatially and—in the case of manual data entry—data that share similar identifications can easily be misattributed. A lot of processing work was required to ensure that each geographic location was accurate and acted as a single entry point we could use to visualize the data. These processes require some experience in data formatting and geospatial data management: potentially another barrier to nonspecialized users. Further complicating these matters, for some geographic units, occasional (and in some cases, annual) revisions to geographic boundaries, and names by government statistical agencies presented challenges in comparing data sets across time.

Step 3: Joining Spatial and Statistical Data

The third step in our process involved joining our formatted statistical data sets with the spatial boundaries representing our geographic com-

59. Kingston.

munity of interest. This allowed us to measure and track inequities in broadband availability by generating visuals that layer aggregated data from statistical agencies onto maps we created of our northern communities of interest. Once we established this geospatial data formatting and visualization process, it became relatively simple to add data to produce other maps—recognizing that different types of data call for different methods of processing and presentation. We considered, for example: dynamically layering and representing many different fields of data for individual geographic objects; animating changes over time (torque mapping); and hosting interactive, modifiable, and sharable maps on the FMCC website.

One notable challenge in performing this task was found in the lack of unique identifiers joining the geographical nature of statistical information to the available geographic shapes. In the case of smaller agencies, this is understandable; however, the lack of ease in joining geographically-organized statistical data to their respective shapes can translate to a time-intensive process. The work of research groups such as the Computing in Humanities and Social Science (CHASS) data centre (http://dc.chass.utoronto.ca/index.html) currently delivers statistical products with unique Geo-identifers for use with StatsCan Shapefiles, but this remains only accessible to Canadian Universities for research and academic purposes. Access to resources such as these could benefit not only university-associated researchers, but also support the efforts undertaken by community-based advocacy groups such as the FMCC.

We are now exploring the use of free and affordable online GIS platforms to simplify the technical expertise needed to work with socioeconomic and geospatial data held by third-party organizations. Easy-to-use interfaces, such as those seen in CARTO and Google Maps provide more approachable platforms for nonspecialists. A helpful categorization system presented by Bhargava and D'Ignazio (2015) examines some of these data management tools according to their learn-ability and flexibility.[60] However, these platforms also have potential drawbacks such as a lack of privacy settings or the presence of soft paywalls limiting the amount of data or user connections per month. Nonetheless, given the success experienced by FMCC—notably the warm reception to its mapping efforts by its member organizations, and the subsequent decision of the CRTC that followed the proceedings described in this article—we feel that there is value in the continued application and evolution of these kinds of GIS tools to contribute to efforts to involve community-based organizations in information policy development.

60. Bhargava and D'Ignazio.

Conclusion: Building Sustainability in Geospatial Data Analysis for Community-Driven Policy Advocacy

The project that we describe in this article benefited from sustained, critical treatment of the GIS technologies used, available data sets, the regulatory framework enabling intervention, the specific community of interest involved in the intervention, and the social and design practices that fused these elements together in a policy advocacy strategy linked to a major public proceeding about telecommunications in Canada. In documenting our process and rationale, we aimed to expose the design choices inherent in our development and use of GIS tools and geospatial data for this purpose. In this way, we sought to frame GIS as a socially constructed artifact and set of social practices that can be taken up and reshaped by user groups at various stages of design and use—not only at the end point of data visualization. We hope that this process may be useful for a diverse array of community-based user groups interested in reclaiming geospatial data generated by third-party sources, and "remixing" or representing it in ways that meet their needs.

However, ensuring that under-resourced community groups can take on this kind of project requires appropriate digital literacy tools and practices. In their review of qualitative research on the adoption and use of GIS platforms by under-resourced groups, Byrne and Pickard found:

> [T]echnical literacy precludes many people from utilizing these tools. Thus, a dichotomy exists between perceived democratization through increased numbers of participants and initiatives, and of increased methods of exclusion . . . [This] can result in the democratization of GIS and geospatial data limited to a mostly already technically literate demographic. (1518)[61]

GIS and cartography are time-consuming skills to learn, particularly given the technical complexity of many GIS platforms. Efforts are further limited by technical considerations such as available processing power, data storage, and tools to support data analysis, such as statistical software or data-handling algorithms. To address this challenge, we focused our efforts on developing and documenting an accessible methodology that can act as an explanatory bridge between GIS specialists and community-based user groups.

61. Bryne and Pickard.

Tygel and Kirsch discuss how data literacy involves connecting the thematic interests of community-based user groups to the formatting and visualization of data in outputs such as statistics, graphics, and tables.[62] Here, we tried to adopt their approach by documenting the design choices considered by the FMCC user group in their policy advocacy strategy, which evolved from constructing a geographic community of interest, to building standardized data sets to illustrate socioeconomic and broadband performance indicators, to combining these elements into more complex maps. In doing this, we sought to produce inclusive, relevant, and adaptable data literacy tools in partnership with the community-based user groups seeking to use them.[63] We agree with Tygel and Kirsch, who stress that data literacy must start from the lived reality of involved user groups, and extend out from there.[64] Critical data literacy initiatives thus necessarily involve partnerships between technical GIS specialists and involved community-based user groups to identify ways that data articulates with concrete aspects of their lives.

This highlights the need to involve community-based user groups in the collection, interpretation, and presentation of both data and GIS platforms. In particular, for policy advocacy activities involving geographically remote communities, a key challenge is the distance—both physical and disciplinary—between involved communities and GIS designers working to interpret their needs and understandings from afar. Along with a lack of exposure to their lived realities, it is very difficult to build a customized workflow for such user groups unless the designer is working directly with them on an ongoing basis.

This challenge of distance extends to the collection and manipulation of geospatial data for policy development. We stressed above the necessity of more valid, accurate data on broadband availability in Northern and remote regions, and recognize the work being done by parties such as the CRTC and CIRA in this area. We also point readers to efforts undertaken in other countries such as Australia to map digital divides experienced by Indigenous populations.[65] However, such efforts will take time, and in the meantime, we point to the need to build sustained partnerships and information-sharing relationships between researchers and policy-makers located in metropolitan centers, and the residents and organizations situated in rural, remote, Northern, and Indigenous communities.

62. Tygel and Kirsch.
63. Bhargava, and D'Ignazio.
64. Tygel and Kirsch.
65. Dobson, Jackson, and Gengatharen.

As a final point, Tygel and Kirsch stress that appropriate data literacy involves the systemization of process: beyond simply merging data and generating information about an issue, it is the exercise of theorizing and deeply analyzing an experience.[66] With this suggestion in mind, we present this article, and the accompanying online report, as an early stage effort in systematizing our work for the benefit of under-resourced community-based user groups interested in reclaiming geospatial data and GIS platforms for their community development and policy advocacy efforts.

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66. Ibid.

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