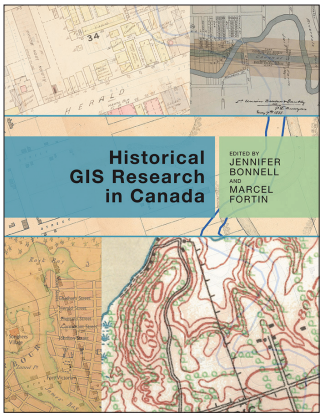

HISTORICAL GIS RESEARCH IN CANADA
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Reinventing the Map Library: The Don Valley Historical Mapping Project

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In June 1888, Toronto City Engineer Charles Sproatt stood up to his knees in the muck of the former river channel. Things were not going as planned. The deadline to complete the Don River Improvement Project was fast approaching, and everywhere around him, so much still to be done. The Mayor and Council were losing patience. At every turn, it seemed, more setbacks. Problems with contractors, disputes with landowners, and protracted negotiations with the Canadian Pacific Railway had delayed project progress and sucked up dwindling funds. The previous winter, attempts to use the project as a form of unemployment relief had gone awry when thick frosts slowed the work of cutting into the river banks and resulted in extravagant labour costs. Now, the land itself was revolting. Sproatt's dredges had run up against dense shale deposits on the course of the new river bed north of Queen Street. To remove the shale would consume the remainder of his budget and leave much unfinished; to leave it would be admitting defeat. A river only eight feet deep, rather than the planned twelve, would scuttle plans for a navigable channel north to Gerrard Street, one of the original impetuses for the project. As Sproatt would find in the years to come, costs and time overruns would continue to mount, and the Don River Improvement Project, originally hailed as the fix to turn a languishing district into a thriving industrial hub, would be remembered most of all for its dubious results.[1]

Toronto's Don River has a history of failing to cooperate. Despite the river's small size – just thirty-eight kilometres from its headwaters north of the city to its mouth in the Toronto harbour – it has long carried great capacity for destruction, from seasonal floods to harbour-clogging silt deposits, to the threat of disease outbreak from water-borne pollution. As ship captain (and later harbour master), Hugh Richardson lamented in 1834, the river was a "monster of ingratitude," whose "destructive mouths" threatened to turn the entire harbour into a "marshy delta."[2] Troublesome landscapes tend to attract improvers, and, as a result, the Lower Don River and the area around its mouth have since the 1870s been a landscape subject to rapid and dramatic change. The Don Improvement Project and the associated rail corridor of the 1880s saw the lower river straightened and canalized south of Winchester Street. In the 1910s and 20s, the draining of Ashbridge's Bay Marsh and the creation of the Port Industrial District became one of the largest megaprojects on the continent, converting some 1,200 acres of lacustrine marsh to ship slips and new revenue-generating land for the city.[3] Forty years later, the construction of the Don Valley Parkway along the valley bottom radically altered the river landscape once again, cementing its function as a transportation corridor.

A place subject to so much change has a rich spatial history that makes it especially compelling for mapmakers. And for urban environmental historians, this spatial history presents a great store of evidence with which to address the fundamental questions of our field. How did urban ecosystems, and human relationships with those ecosystems, change over time? What were the effects of these changes upon human health, economic prosperity, class relations, and ecological integrity? How did developments here differ from other parts of the city, and why?

This chapter explores the ways that historical Geographic Information Systems (GIS), or HGIS, can be applied to historians' understanding of the environmental history of Toronto's Don River Valley. It follows the experiences of a small team of researchers (an historian, a map and GIS librarian and a few research assistants) in navigating the complexities of building a historical mapping project using GIS technology. Through the example of the resulting Don River Historical Mapping Project, we discuss the challenges of accessing and working with historical source materials, the uncertainties inherent to historical GIS, and the difficulties of making resources and research findings publicly accessible. Unlike most HGIS projects, which take their origin from a research problem or question and produce specific datasets with which to address that question, this project aimed from the outset to produce a body of data that would be accessible to a broad range of researchers from different disciplines for use in a variety of different projects. While a research project on the Don River Valley was the impetus for the project, the outcomes of the project were in the end much broader, shaped by the mandate of the library to promote its collections and provide open access to data to facilitate research. This chapter, as a result, is as much about the changing role of the academic library as a partner in academic research as it is about mapping the history of the Don Valley.

As noted in the introduction to this volume, Canadian historians, like their counterparts in other parts of the world, have to date

only tentatively explored the possibilities of working with historical GIS. Access to digitized historical data and technical support are among the obstacles that historians face in adopting HGIS methods in their research. Here the academic library has much to offer. More than simply a repository for collections, university libraries have over the past twenty years increasingly stepped into the role of service providers. Particularly in specialized libraries such as map and data libraries, these services go beyond traditional supports such as reference and circulation to encompass teaching, in-depth research consultation, and even partnership in research. Increasingly, library staff are being included in the research process because of their expertise with the source material housed in libraries, with technical issues, and with the process of academic research. As much as historians stand to benefit from digitized historical data, librarians are looking for ways to give little-used paper historical collections a new life as digital data. Digitized and georeferenced to real-world coordinates, the information contained within historical maps can be extracted, collated, queried, and compared to produce new knowledge about the past.

A collaborative endeavour, this paper makes a case for collaboration: fruitful partnerships, we demonstrate, can emerge between historians and academic librarians, not only in finding and accessing data, but also in learning from each other in order to work more effectively with the often unusual problems (and promises) that HGIS research presents to the historian.

INTERPRETING ENVIRONMENTAL CHANGE IN THE LOWER DON VALLEY

Toronto's Don River winds through the most urbanized watershed in Canada. Like many of the rivers on the north shore of Lake Ontario, this small waterway follows a generally southwesterly course as it moves from the porous moraine lands at its headwaters to its outfall in Toronto harbour. Two main branches, the East and West Don, join to form a single stream (the Lower Don River) at the forks about seven kilometres north of Lake Ontario. A third tributary, Taylor-Massey Creek, flows into the forks from the east (Figure 3.1).

The environmental history of the Don River valley is in large part a story of the relationship between the developing city and the river valley at its eastern periphery. This history of the two-hundred-year relationship between a small urban river and what is today Canada's largest city revolves around the idea of the river valley and the city as mutually constitutive – each shaping the development of the other. As the city grew, it radically altered the physical and ecological composition of the valley, denuding slopes, polluting waterways, filling wetlands, and levelling hills. Just as the city transformed the valley, the valley presented certain possibilities and foreclosed others as the city expanded. From the mosquito-infested marsh at its mouth to the occasionally devastating floods it wrought upon valley landowners, to the large quantities of silt and debris it washed into Toronto harbour, the river was an active participant in the city's development.

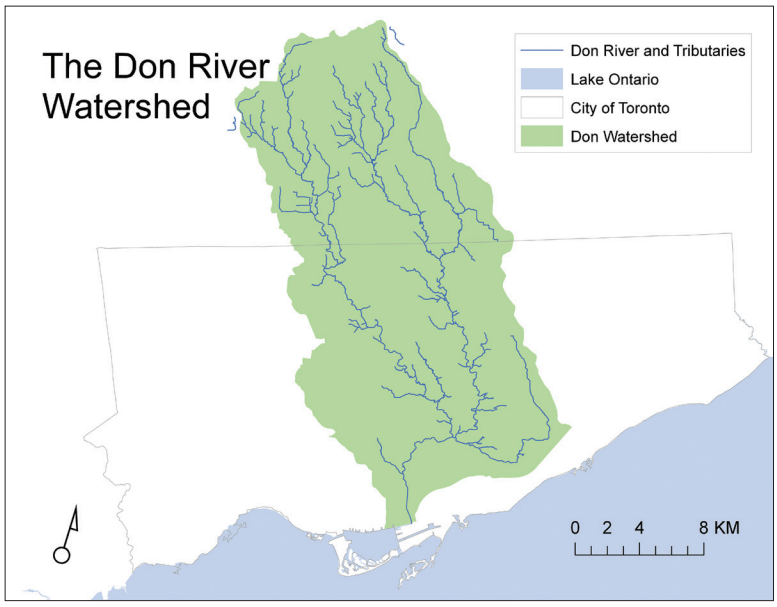


Fig. 3.1. Don River watershed. (Sources: Don Watershed boundary: Toronto Region Conservation Authority 2008; current shoreline: DMTI CanMap Postal Geography FSA Boundaries, v2008; City of Toronto Boundary: City Wards Boundary File, City of Toronto Open Data Catalogue.)

The valley's geography, with its steep ravine walls and wide plateaus, was even more influential, at once a formidable barrier to the eastward expansion of the city and an enabling corridor for transportation and urban growth. Until the completion of the Prince Edward (Bloor Street) Viaduct in 1918, no bridges existed across the wide valley expanse north of Gerrard Street, and travellers were forced to route south to Winchester Street or north to Pottery Road to access communities east of the river. Those bridges that did exist were precarious structures prone to washout during seasonal floods, further constraining access for landholders and industrialists east of the Don. As much as the lower valley posed a barrier to east–west communication, it invited movement north–south. Rail development happened first, in association with the Don River improvement plan of the 1880s and 90s. Seventy years later, the Don Valley Parkway took the valley's corridor function to its full potential, carving six lanes of highway from the Gardiner Expressway near the lake shore to Highway 401 north of the city. Reconfigured as a metropolitan corridor, the valley facilitated suburban development along its length, stimulating the growth of the city.[4]

The river valley has also served as a different kind of corridor, laying a swath of green space through the heart of the city. Through the nineteenth century, its steep, corrugated ravines resisted agricultural and residential development, surviving as pockets of woodland within an increasingly deforested landscape. Parkway construction in the mid-twentieth century capitalized on valley woodlands as an aesthetically pleasing backdrop to the curving ribbon of road, and a site for roadside parkland and recreational areas. In the aftermath of Hurricane Hazel in 1954, valley parklands served a secondary function as development-free drainage corridors. For 1940s-era conservationists and twenty-first-century urban explorers, valley green spaces provided, and continue to provide, a welcome respite from the monotony

of the urban grid, a place to restore body and mind within easy distance of the city core.

Corridors of movement for urban wildlife, producers of oxygen and sinks for carbon, these green spaces also serve important ecological functions. Once feared as a harbour for gangsters and social deviants, today's valley lands are appreciated for their role in "wilding the city."[5] The valley is, however, as it always has been, an ambiguous space, subject to multiple uses and divergent ideas about its future: busy recreational trails expose the ramshackle tents of the homeless; the burble of a blackbird at a restored wetland site challenges the hum of traffic on the parkway; at the river's edge, hardy riparian grasses push through the metal grid of a discarded shopping cart.

The river valley has also claimed an important place in the history of ideas about the city and its future, its landscapes conceived by different groups in different periods as verdant wilderness, picturesque countryside, polluted periphery, predestined industrial district, restorative retreat, vital refuge, dangerous underworld. Over the course of the river's relationship with the city, a series of improvement schemes, from major channel reconstruction to highway construction and parkland acquisition, have mobilized these competing ideas, harnessing the river and its valley as a transformative force in building a prosperous and productive future metropolis. The relative success of these plans, and the effects they had upon valley ecologies, upon individual lives, and upon the life of the city, have served as important catalysts for change in the historical relationship between Toronto residents and the natural environment upon which they depend.

Much of this two-hundred-year history of the relationship between a city and its iconic river valley can be explored using existing sources and historiographical methods. Evidence of the valley's social history, for example, and changing cultural perceptions of valley landscapes, can be gleaned from a close reading of newspaper articles, municipal reports and correspondence, city council minutes, and other sources. A project focussed so fundamentally on landscape and environmental change, however, requires a comprehensive understanding of the area's spatial history. Issues surrounding historical land use are especially difficult to puzzle out. What kinds of land uses did the river valley attract in different locations and periods? How did the river channel change over time, and in which periods were these changes most pronounced? How did the spatial representation of these changes align with contemporary planning documents?

The rich legacy of historical maps, fire insurance plans, engineering drawings, and aerial photographs that document the city's development contains the evidence needed to address these questions. Extracting this evidence to make comparisons across space and time, however, is not an easy task. To begin with, the large number of sources available for the river valley makes conflicting representations inevitable – a challenge common to all forms of historical analysis. The nature of the sources themselves also complicates the process of analysis. Historical maps are drawn at different scales and with varying degrees of accuracy. The large format of many of these sources, furthermore, makes them difficult to work with. Jennifer Bonnell, the historian in this partnership, recalls attempting to document the river's industrial history by photocopying unwieldy fire insurance plans and taping them together to create a giant visual mosaic of building

outlines along the lower river. Tiled together, each paper collage stretched the height of her office walls; each represented just one year in the history of the river.

Fortunately, the challenge of building and interpreting eight-foot map mosaics led Bonnell to seek assistance from staff at the University of Toronto Map and Data Library. There, conversations with map and GIS librarian Marcel Fortin revealed the potential for a collaborative project that would both digitize and pool together existing historical sources for this iconic Toronto landscape and use this information to build something new: a comprehensive geospatial database for the watershed as a whole. For Bonnell, the prospect of such a database removed months of tedious work with paper maps from her analysis and opened up exciting possibilities for historical insight. For the map library, the project provided an opportunity to showcase the rich resources of the university library's map collection and the dramatic interpretive and presentation capabilities of GIS. Seed funding from the Network in Canadian History and Environment (NiCHE) allowed us to hire a research assistant to begin the work of scanning and georeferencing historical maps and building geospatial datasets of the area, and, within a few months, the Don Valley Historical Mapping Project was underway.

Over the next two years, with some additional support from NiCHE and the University of Toronto Map and Data Library, we produced a series of geospatial datasets for Toronto's Don River watershed between the years of 1858 and 1950. In keeping with the core themes in the valley's environmental history and with available source materials, we produced data in four main categories: 1) industrial development in the lower valley from 1858 to 1950; 2) changes to the river channel, tributaries, and the Lake Ontario shoreline near the river mouth from 1858 to 1931; 3) land ownership in the watershed in 1860 and 1878; and 4) historical points of interest throughout the watershed. The project extracted information from a wide range of source materials, including topographical maps, detailed city maps, fire insurance plans and atlases, city directories, county atlases, and planning and conservation reports. Nearly two hundred maps were digitized over the course of the project, most of which have been made available to the public on the project website.[6]

BUILDING THE DON VALLEY HISTORICAL GIS

For librarians, involvement in a project like this engages new strengths in research and technical services and partnerships. But projects like this also draw upon librarians' long-standing expertise in creating and promoting free and open access to information. Sharing and disseminating information flows naturally from their mandate to serve the public. To the academic, the library may not only act as the technical arm of a project but also relieve the burden of personally archiving or disseminating resulting data.

Although GIS has become an obvious choice for historical geographic research, access to historical data sets continues to limit researchers' ability to use and apply the technology. Like most digital collections, for example, the Map and Data Library's digital geospatial data holdings contain thousands of datasets,

but its historical datasets are still few in number. Because of these limitations in the availability of scalable and expandable data for original research, data creation is more often than not a significant component of these projects.

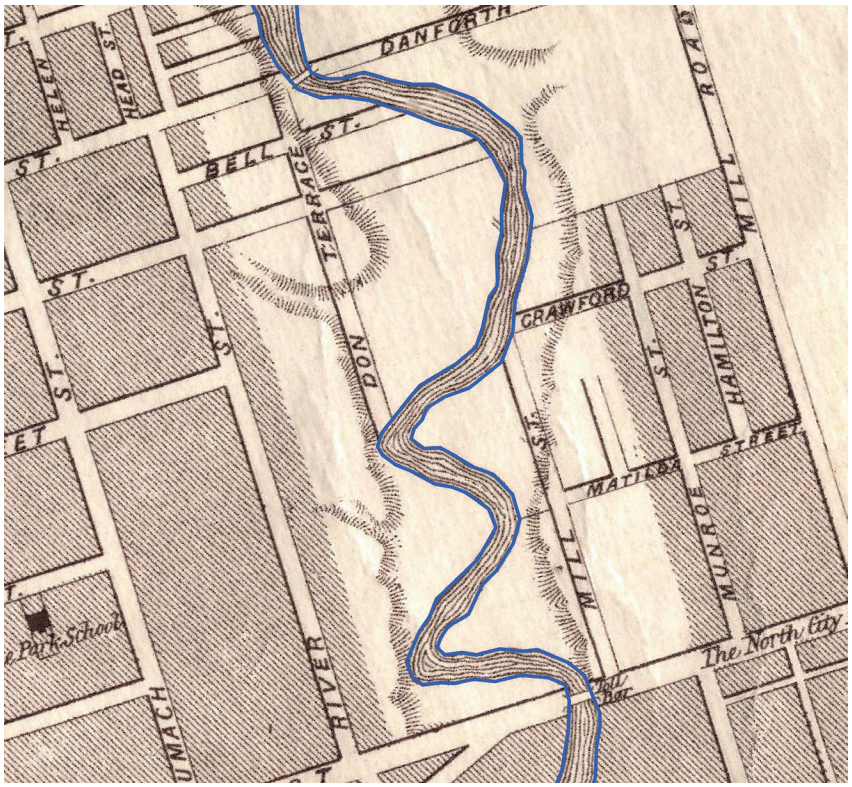
The first step in the creation of any historical dataset is the assembly of historical source materials. Here again, Canadian researchers face access challenges unique to the Canadian regulatory environment. The Don Valley Historical Mapping Project, for example, relied heavily on fire insurance plans and atlases to assemble information on the valley's industrial history. Fire insurance plans are richly detailed documents that provide scaled renderings of street grids, building outlines and construction materials, and other structural land uses (oil tanks, coal and lumber storage, number of boilers, etc.); they were produced for all parts of the old city beginning in the 1880s, and revised frequently. The larger-format and smaller-scale fire insurance atlases also proved valuable in places and periods where the more-detailed fire insurance plans were unavailable or inaccessible. Valuable as these documents are, they are also very difficult to access in digital form. As we discussed in the introduction to this volume, fear of copyright infringement has led many Canadian libraries and archives to restrict and in some cases eliminate the duplication of all fire insurance plans by researchers. These restrictions constrained the breadth and accuracy of our work. In some cases, rather than digital colour reproductions of the plans, we had to make do with black and white microfiche reproductions from the University of Toronto map collection. The legibility of these images posed problems in a few cases. Issues of quality arose in part from the process of reproduction: microfiche scanning is a complex process that involves numerous experiments with resolution, image size, scanner surface placement, and automation. The nature of the source documents themselves also contributed to the quality of these reproductions. Fire insurance plans were often revised incrementally by pasting revised drawings over small portions of the original map. The result in many urban areas are layers of revisions and annotations covering several years. Held to the light, the original notations are often visible beneath the revisions. When photographed for reproduction, the revised areas of these plans are often difficult to decipher.

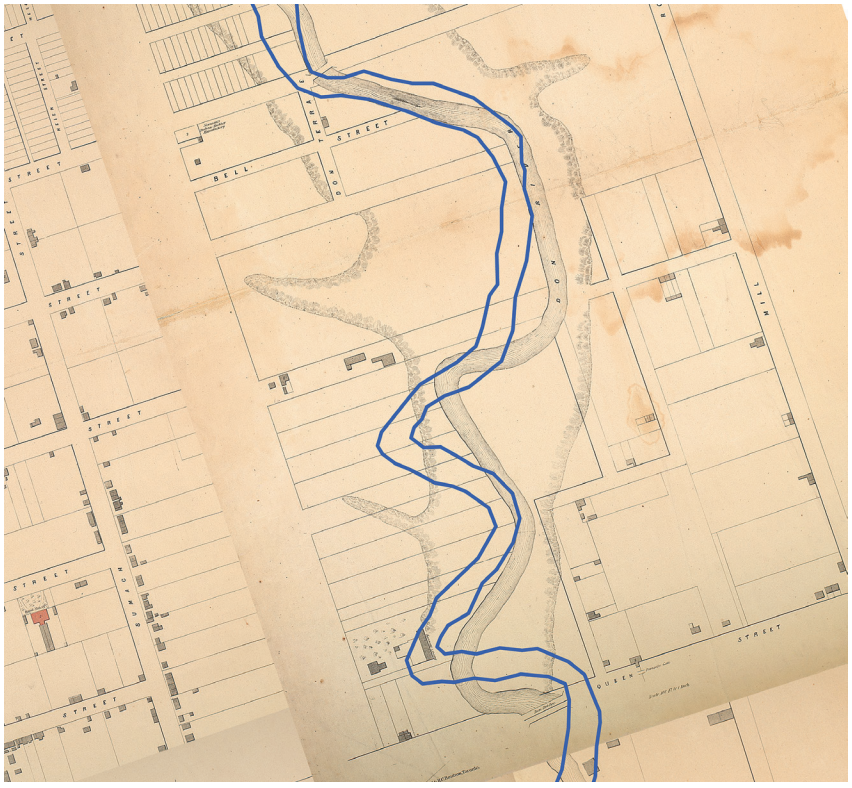
The nature of historical maps and the circumstances in which they were typically created also pose challenges for historical GIS projects. In creating and later interpreting historical datasets such as ours, it is important to bear in mind that the process of mapmaking in nineteenth-century Canada differed markedly from the process today. Maps from this period often took years to create, incorporating the process of surveying the sites, compiling information from each site or building, drawing the maps based on the information accumulated, and printing the final (dated) map. Once published, paper maps were not easily altered, as digitized maps are today, to reflect subsequent changes in landscape features. The potential for error compounded as maps were frequently used to create other maps. Features and information were copied from one map to another, and errors and changes to features were often long to be registered across a generation of maps. Within this context, historical maps and the data they contain are best understood as representing a date-range of several years, rather than the specific year of the map's publication.

Geographic extent is another issue that one must grapple with in working with historical sources. Reflecting the jurisdictional realities of the time in which they were produced, maps often present information in different "containers" than we are familiar with today: municipal boundaries differ; other boundaries, such as watersheds, are not apparent. This can have benefits and disadvantages in HGIS. In mapping changes to the river channel over time, for example, we found that many of our sources (city maps in particular) drew the river only as far as the forks, omitting the upper valleys. Our datasets reflect the sources available to us: many, especially for the nineteenth and early twentieth century, comprise information for the lower river alone. At the same time, the limited coverage of these city maps often resulted in more detailed representations of the river channel. Because the Lower Don formed the eastern boundary of the city for much of the nineteenth century, depictions of the bends and oxbows of its lower reaches are especially detailed on city maps from this period.

Finally, as in all historical accounts, the presence of competing representations of the same place and time adds complexity to the process of interpretation. Historical representations of the river channel are a case in point. Multiple and varying representations of "what was water" and "what was land" made it difficult to delineate the changing course of the river in different periods. Certainly, part of the uncertainty stemmed from the landscape itself: the river, especially in its lower reaches, was a dynamic landscape subject to transformation, not only from year to year, but from season to season. Seasonal meteorological events such as spring snowmelt, summer rainstorms, periods of drought, and ice jams in winter worked to continually alter the land/water interface, as spring freshets submerged marshy wetlands and summer heat waves made previously water-logged channels passable by foot. Mapping valley lands, as a result, was not a simple assignment, and the maps that were produced, even within a short time period of each other, often differed in substantive ways. The individual objectives of mapmakers also influenced the representations they produced. Depending on the surveyor's assignment – to assess the boundaries of the river, for example, or to determine the extent of traversable, marketable land – what constituted "water" and what constituted "land" were represented differently.

The accuracy of our work depended in large part, therefore, on the assessments of early mapmakers. While we could judge the relative "soundness" of the map – for example, whether its features could be georeferenced with current landscape features, such as buildings and street intersections – we could not determine what was the "best" representation of the landscape that the mapmaker had before him. Take for instance the two maps in Figures 3.2 and 3.3. Both are from the late 1850s: the one on the left from 1857, and the one on the right from 1858. Both maps georeferenced relatively well to current features, but both present the course of the river differently. Had the course of the river changed in the space of one year, or was one map a more "accurate" representation of the landscape than the other? We can take a guess at the answer but we cannot know with certainty. Several years can pass between the time a particular place was surveyed and the time the resulting map is printed. Individual maps can also fluctuate in the accuracy of their representations across the landscape: historical and current features may, for example, align





Figs. 3.2 and 3.3. Two representations of the river channel, 1857 and 1858. (Map Sources: Toronto, Canada West, Waterlow & Sons. Lith. London, 1857; Boulton, W.S. Atlas of the City of Toronto and Vicinity, 1858 [courtesy of Toronto Public Library].)

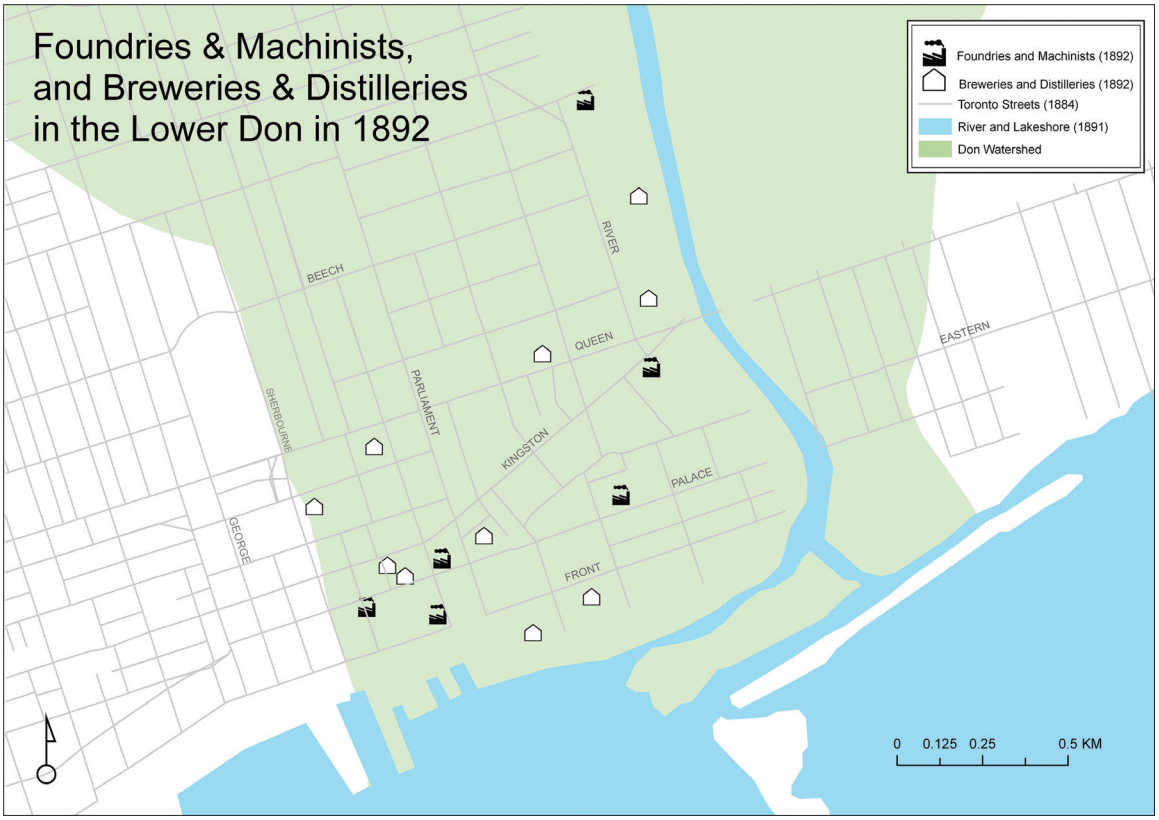


Fig. 3.4. Foundries and machinists, and breweries and distilleries in the Lower Don in 1892. (Sources: Don Valley Historical Mapping Project Database; Don Watershed boundary: Toronto Region Conservation Authority 2008; Toronto Historic Streets, University of Toronto Map and Data Library 2011.)

well in one section of the map, but not as accurately in others. To avoid making unsupportable statements of accuracy about these maps and their resulting data, we elected to include multiple representations in our database. Our data represent, therefore, not a definitive portrayal of the river in a particular year, but instead the information extracted from a certain map printed on a certain date.

In addition to the issues that arose from the nature of our source materials, we also faced decisions around how best to use GIS technology to represent past landscapes. The database we developed for the valley's industrial history is a case in point. The database incorporated industrial sites visible in maps published between 1858 and 1950, identifying for each "point" on the map the industry's address, ownership, industrial category,[7] and the source map and year. Once complete, the database contained the potential to display industries not only by location but by industry type and map year. We could, for example, query the database to show the number of slaughterhouses represented on maps in 1891 or the number and location of breweries along the river in different periods (Fig. 3.4).

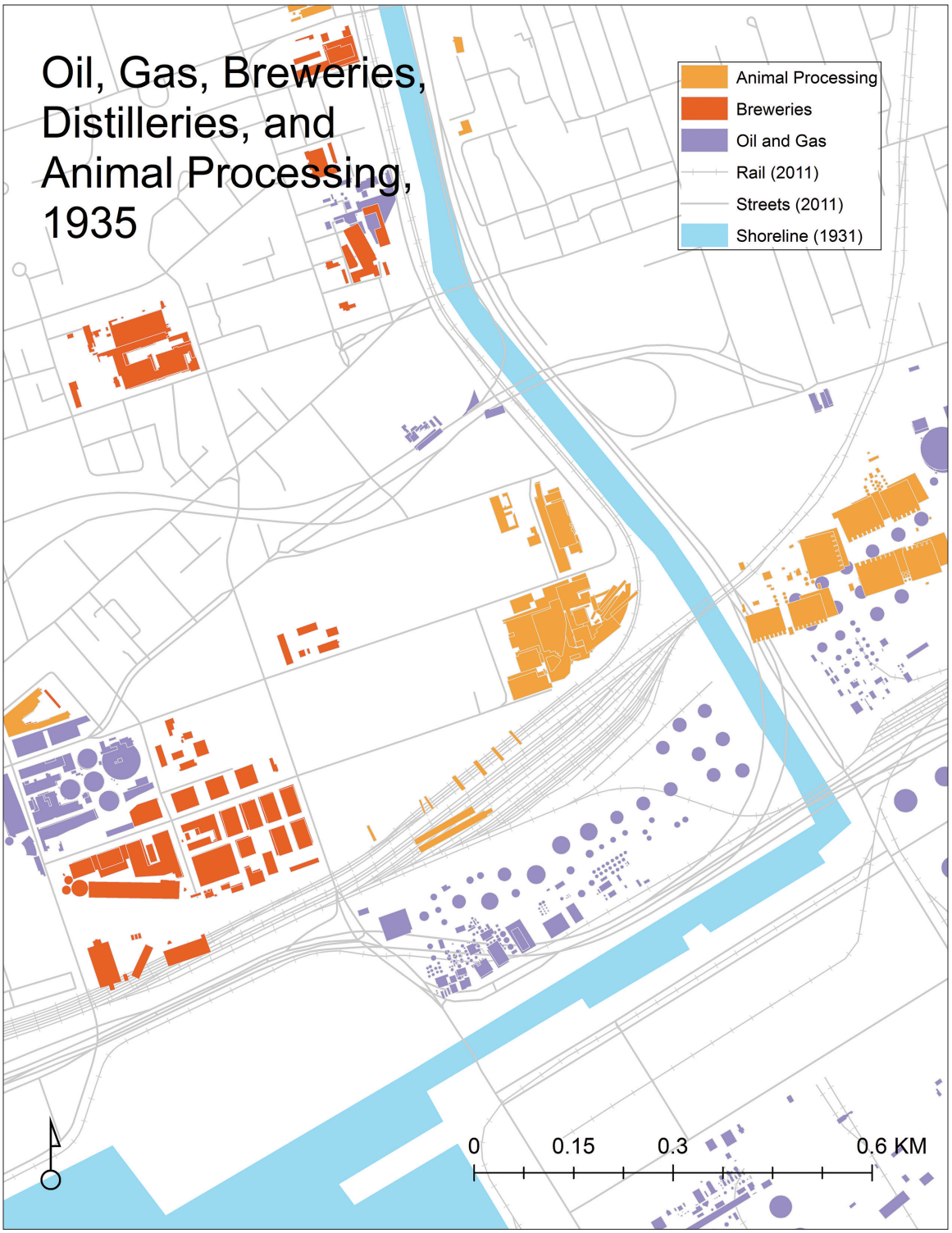


Fig. 3.5. Oil and gas, breweries, and animal processing, 1935. (Roads and Railroads from DMTI Spatial Inc. CanMap RouteLogistics 2011.3.)

While our point layer of industrial sites allowed for the efficient display of a large number of sites in different periods, it failed to take into account the variance in the "footprints" of different establishments. A mammoth site such as the Gooderham & Worts distillery, for example, which occupied several hectares near the river mouth, was represented with the same small point as a small tanning operation upriver. The solution to this problem lay in creating a "polygon" layer that traced the building outlines of industrial establishments. Fire insurance plans and atlases provide rich evidence for this work, in their documentation of surveyed building outlines and lots, and a range of specific information pertaining to industrial operations on these sites such as the volume of toxic liquid contained in tanks or the amount of coal or lumber stockpiled on site. As the example below shows, these industries displayed considerable variability in the size and relative land consumption of establishments. Once built, polygon layers provide a wealth of accessible data for researchers seeking to address a diverse range of research questions. By building polygons of oil tanks, for instance, including information from the fire insurance plans on the capacity of these tanks, models could be built to investigate the potential impact of pollutants on various industrial sites. Patterns of dispersal of hazardous material could also be investigated for specific known toxic sites.

Polygons also proved more appropriate than a simple line layer in mapping the river channel. We began by drawing the course of the river as a line layer for the year 1857. We soon realized, however, that, while easier to build, single lines failed to represent the variable width of the river and its tributaries in a useful way. We could draw lines to depict both shores of the river, but we could not shade these in to depict hydrography. Building the layers as both polygons and lines solved the problem. Displaying the river using polygons, however, brought its own complications. As discrete shapes, polygons are not easily used to represent continuity. Rivers, of course, are naturally connective in function. For the hydrographic data we were building to be useful, we needed to represent the Lake Ontario shoreline east and west of the river mouth. These polygons had to be stretched out into the lake and somewhat unnaturally squared off at the east and west extents of the historical maps they were drawn from.

When the database was complete, our coverage of the lakeshore spanned from Humber Bay in the west end of the city to just past Ashbridge's Bay in the east, with slight variations on this extent for years where maps were not available for the full area covered. The river channel was not the only ecological feature to change in this period. The Lake Ontario shoreline also fluctuated dramatically with dredging and land reclamation activities in the harbour and adjacent marsh. By extending our geographic coverage, we were able to document this changing shoreline along with the changing course of the Don River. In the end, we built the river and lakeshore layers using lines and polygons for nine "snapshots" between the years 1857 and 1931. These dates encompassed dramatic changes in the area surrounding the lower river, including the straightening of the river south of Winchester Street in the 1880s, the construction of Keating Channel in the 1910s, and the reclamation of Ashbridge's Bay to create the Port Industrial District in the 1910s and 20s. River layers also included a number of historical tributary

creeks, many of which were buried or culverted as the city expanded.

WORKING WITH HISTORICAL GIS: NEW AVENUES OF INQUIRY AND NEW INSIGHTS

The Don Valley Historical Mapping Project produced new insights on the environmental history of the river valley. New possibilities for interpretation emerged, not so much from our evidence (the sources we worked with were for the most part already familiar to historians), but from the collating and comparative functions of the method itself. The capacity of GIS technology to extract, group, and display data from diverse sources, to alter the scale of analysis, and to alternately highlight and suppress particular groups of data, allowed for detailed comparison of spatial information within and between selected time periods. Nowhere was this more evident than in the spatial history of the river channel.

In the late nineteenth and early twentieth centuries, a series of improvement plans directed at the lower reaches of the river produced dramatic changes to the course and character of the river channel. Among these was the Don River Improvement Plan, proposed by civic politicians in the 1880s with the goal of producing a sanitary and rational river landscape as a basis for prosperity. The plan, which deepened and straightened the river's serpentine lower reaches, aimed to transform flood-prone and polluted valley lands into a hub for industry and a driver of residential development on adjacent table lands. Unravelling the timing and the extent of the material changes brought about by the 1880s improvements is an important facet of the environmental history of the river valley.

Most prominent among the sources that exist for the 1880s improvement is the 1888 "River Don Straightening Plan" (Fig. 3.6). The document provides a detailed projection of the future envisioned for the Lower Don, depicting the existing course of the river between Winchester and Eastern Streets, the proposed route of the straightened channel, and the lot numbers of properties to be expropriated. It is, nevertheless, a plan for a project that encountered numerous hiccoughs in implementation, both in terms of projected timelines and projected results. What did the river channel actually look like after straightening? What aspects of the project were completed, and what was omitted from the initial plans? How long did the project take? These questions were surprisingly difficult to answer upon reviewing existing source materials. Textual sources, such as newspaper articles and city council minutes, often failed to include precise spatial information. In other cases, accompanying maps had been lost or misplaced. Historical maps and plans presented conflicting information, furthermore, that made it difficult to track what changes had actually occurred on the ground, and when.

GIS technology proved unmatchable in documenting the environmental changes associated with the 1880s improvements. It enabled new insights about the timing of particular project components, and the disconnect that often existed between engineers' plans and timelines and what actually transpired on the ground. The capacity of HGIS to create layers of data for different periods was especially useful in

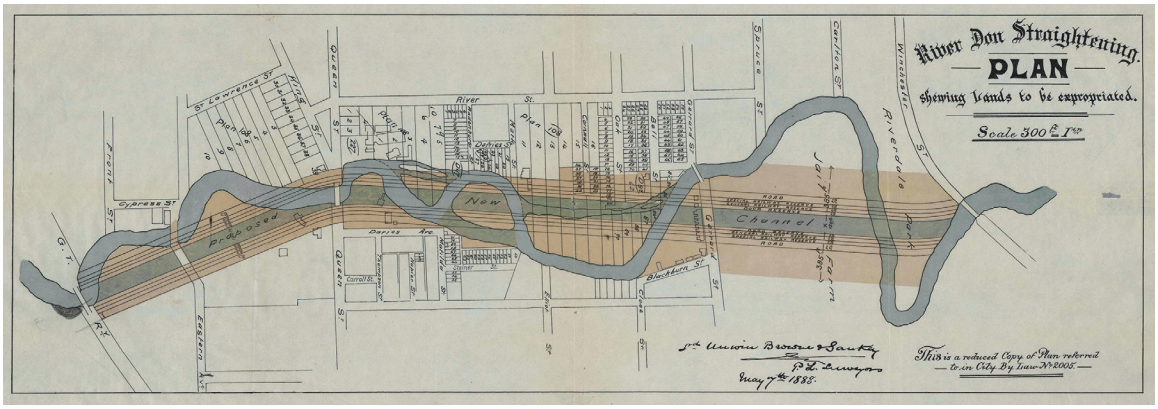


Fig. 3.6. River Don straightening plan. (Unwin, Browne and Sankey, Surveyors. May 7, 1888. City of Toronto Archives, Series 725, File 12.)

interpreting these changes, facilitating as it did the detection of patterns and anomalies over time – something very difficult to achieve in the one-to-one comparison of print or even scanned maps. This increased capacity is evident in Figure 7, which depicts the river's changing course in three different periods. The extent of the lakeshore is also visible in its different stages of reclamation during these periods. Without GIS technology, the overlay of historic data is both more difficult, and it lacks interoperability – the capacity to be used in a variety of software for different purposes – which is crucial for data sharing and reuse.

GIS also created interpretive possibilities in tracking smaller landscape changes unmentioned in the textual sources, and perhaps not readily apparent in a review of paper or digital maps of the period. References to isolated relocations of the river channel in association with the construction of the Don Valley Parkway in the 1950s and 60s, for example, are easily discernible by overlaying polygons of the river channel before and after highway construction and adjusting the scale of the map to view particular reaches of the river.

In other aspects of the project, the capacity to select out certain information for analysis (for example, the locations of oil refineries that established in the lower valley in the early twentieth century) and the ability to adjust the scales of analysis – to zoom out to see the large picture of industrial development in the lower valley, and the concentration of particular types of industries; to zoom in to analyze the outlines of individual buildings and their relationship with the river – provided opportunities for insights into the history of pollution in the river valley and the services the river provided in different places and periods.

A GIS of a river's history is, of course, only as good as the source material upon which it is based. While we would have liked to gain an appreciation, in spatial terms, of historical changes to the condition and character of the river, including depth and flow rates and levels of pollution and sediment, the absence of detailed historical source materials made this impossible. An understanding of the changing sensory experience of the river – its visual appearance, sounds, and smells – was another

Fig. 3.7. River and Lake Ontario shoreline, 1857, 1891, and 1918. (Sources: Don Watershed boundary: Toronto Region Conservation Authority 2008; current shoreline: DMTI CanMap Postal Geography FSA Boundaries, v2008; Historical Roads [1818–1884]: University of Toronto Map and Data Library 2011.)

aspect of the river's past that would remain dependent upon scattered textual references often lacking in spatial specificity.

CONCLUSION

On average, about two hundred people per month visit the Don Valley Historical Mapping web pages (see maps.library.utoronto.ca/dvhmp/). Presentations on the project to local environmental and citizens' advocacy groups such as Lost Rivers and the Task Force to Bring Back the Don have generated substantial interest; these groups aim to incorporate project data and maps into their own planning and public education initiatives for the valley. People have used the data we created in ways we didn't expect. For example, the scanned map images and the Google Earth files, and not the GIS files, have been by far the most popular downloads. Students and the general public, rather than GIS researchers, have been the main beneficiaries of the project, and, consequently, the "web ready" and open format files such as our Google Earth data are downloaded with much greater frequency than the more stringent and difficult-to-use but highly versatile and powerful shapefiles.[8]

By digitizing hundreds of historical maps and producing over fifty features in GIS and Google Earth format, all freely available for download by the public and other researchers, the project accomplished its primary goal of making library resources more accessible. Its results demonstrate the possibilities opened up through collaboration. From the library's perspective, projects such as these showcase what libraries are all about. They justify the acquisition and maintenance of expensive collections and the hiring of skilled and academically inclined personnel that are dedicated to research and services. For the historian on the team, participation in such a project stemmed from the recognition that, despite the time and energy invested to learn HGIS methods, she was unlikely to become proficient enough to produce her own data and maps expediently. An understanding of how GIS works, however, and the particular challenges of HGIS did prove extremely useful in working with the data, and members of the project team, effectively.

The project presents numerous opportunities for expansion. A wider geographic expanse would provide a striking demonstration of the spatial distribution of industry across the city. More lost streams and rivers could be uncovered, bringing Toronto's history alive cartographically and enhancing, at the same time, the appreciation of the map collections at the University of Toronto and other libraries. The project might also be expanded to include other important geospatial features, such as tree cover, topography, elevation change, agricultural development, and transportation and municipal infrastructure development.

Projects such as these can also fuel the development of other projects. They can feed into existing ones, such as the Ontario County Map Project currently underway,[9] and stimulate future projects. A commitment to open access to the data produced by projects such as this one is an essential part of this process. Agreements between institutions to share not only aggregated data but source materials such as archival maps and images is another way forward. Many historical GIS projects fail to get off the ground in part due to the prohibitive cost of acquiring digital map reproductions. A large proportion of the material we work with in urban environmental history is in the public domain but restricted from use because of cost-recovery mechanisms in a number of institutions that restrict reproductions without payment. Making this information accessible to researchers is the first step in enabling new historical knowledge. New relationships and new practices within archives and other collecting institutions are vital to the development of HGIS projects in Canada.

NOTES

1 For a detailed history of the Don River Valley and the various infrastructure projects that have altered the landscape of the river valley over time, see Jennifer L. Bonnell, *Reclaiming the Don: An Environmental History of Toronto's Don River Valley* (Toronto: University of Toronto Press, forthcoming). See also Bonnell, "A Social History of a Changing Environment: The Don River Valley, 1910–1931," in *Reshaping Toronto's Waterfront*, ed. Gene Desfor and Jennefer Laidley (Toronto: University of Toronto Press, 2011), 123–50; Gene Desfor and Jennifer Bonnell, "Socio-ecological

Change in the Nineteenth and Twenty-first Centuries: The Lower Don River," in *Reshaping Toronto's Waterfront*, 305–25; and Bonnell, "An Intimate Understanding of Place: Charles Sauriol and Toronto's Don River Valley, 1927–1989," *Canadian Historical Review* 92, no. 4 (2011): 607–36.

2 H. Richardson, W. Chisholm, and J. G. Chewett, "Report of the Select Committee on the Improvement of the Harbour of York," in *Memorandum with Accompanying Plans and Documents Relative to the Past and Present State of the Harbour of Toronto* (Ottawa: Department of Public Works, 1881), Appendix, pp. 1–3.

3 For an excellent history of the reclamation of Ashbridge's Bay Marsh and the creation of the Port Industrial District, see Gene Desfor, "Planning Urban Waterfront Industrial Districts: Toronto's Ashbridge's Bay, 1889–1910," *Urban History Review* 17, no. 2 (1988): 77–91; and Gene Desfor and Jennefer Laidley, eds., *Reshaping Toronto's Waterfront* (Toronto: University of Toronto Press, 2011).

4 For a good overview of the history of Toronto and its development, see J.M.S. Careless, *Toronto to 1918: An Illustrated History* (Toronto: James Lorimer, 1984); James Lemon, *Toronto since 1918: An Illustrated History* (Toronto: James Lorimer, 1985). Bonnell details the history of the Don Valley Parkway and floodplain acquisition in the valley in *Reclaiming Toronto's Don River Valley*. See also Stephen Bocking, "Constructing Urban Expertise: Professional and Political Authority in Toronto, 1940–1970," *Journal of Urban History* 33, no. 1 (2006): 51–76; Wayne Reeves, "From Acquisition to Restoration: A History of Protecting Toronto's Natural Places," in *Special Places: The Changing Ecosystems of the Toronto Region*, ed. Betty I. Roots, Donald A. Chant, and Conrad E. Heidenreich (Vancouver: UBC Press, 1999), 229–41; Richard W. White, *Urban Infrastructure and Urban Growth in the Toronto Region: 1950s to the 1990s* (Toronto: Neptis Foundation, 2003).

5 On the history of the urban ecology movement in Toronto and the significance of valley green spaces, see Gene Desfor and Roger Keil, "Every River Tells a Story: The Don River (Toronto) and the Los Angeles River (Los Angeles) as Articulating Landscapes," *Journal of Environmental Policy and Planning* 2, no. 1 (2000): 5–23; Gene Desfor and Roger Keil, *Nature and the City: Making Environmental Policy in Toronto and Los Angeles* (Tucson: University of Arizona Press, 2004).

6 Several maps still fall under copyright and cannot be made available as digital copy. Other maps were obtained through licensing, which restricts their availability to the public. The Don Valley Historical Mapping Project can be accessed at maps.library.utoronto.ca/dvhmp/.

7 Although detailed classification codes exist for industries in the present (the North American Industrial Classification System [NAICS] and the Standard Industrial Classifications [SIC] are two examples), they are not easily applied to historical industry types, a number of which no longer exist, or are difficult to distill into a single category in the present. With this in mind, we devised our own classification system based on the industries represented in our source materials, and the themes that emerged from the valley's environmental history. These categories included: saw mills; paper mills; grist mills; breweries, distilleries, and their suppliers; foundries and machinists; oil and gas refineries and paint manufacturers; soap works; textile manufacturers and carding mills; other food production; other light manufacturing; fuel storage; building materials producers and suppliers; agricultural suppliers; general suppliers and warehousing; transportation; utilities and public works; chemical producers and suppliers; printers and lithographers; and animal processing.

8 Not widely known outside the GIS community, shapefiles are the most commonly used GIS format around the world. While the format is proprietary and owned by ESRI, most GIS software packages, including open source software, can read and write this format.

9 The Ontario County Map Project can be accessed at: http://maps.library.utoronto.ca/hgis/countymaps/. The project's goal is to compile land occupancy, cultural and physical information in the form of geospatial data, from nineteenth-century Ontario County Maps. The ongoing collaborative project is a partnership between the University of Toronto, the University of Guelph, Western University, and McGill University.