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PRAIRIE PERSPECTIVES: GEOGRAPHICAL ESSAYS

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Preface

Introduction

Each volume of *Prairie Perspectives: Geographical Essays* is published in coordination with the annual meeting and conference of the Prairie Division of the Canadian Association of Geographers (PCAG). The year 2015 marked on the 39th occurrence of the PCAG gathering, which was hosted jointly by the University of Winnipeg and Lakehead University and held in Kenora, Ontario over the 25th to 27th of September. A total of 84 members gathered for a weekend consisting of paper presentations, a poster display, field trips, and PCAG business meetings. The research papers reflected the diverse interests of prairie geographers: three concurrent sessions on borders and regions; geographical techniques and methods; and hydrology were held early on Saturday morning, while another set on culture and environment; geography and society; and climate took place in the late morning.

This was the first year that PCAG was held in Ontario. The decision to gather in Kenora reflected the important role of Lakehead University in the association and gave geographers from the prairie institutions a chance to broaden their perspectives by visiting a region of the Canadian Shield. The choice of Kenora also reflected the longstanding PCAG tradition of gathering annually in smaller towns, celebrating an interest in local culture and seeking out places for geographic inquiry that are 'off the beaten track' from major centres. In accordance with these goals, two field trips were held on Saturday afternoon. Marc Vachon led the cultural geography excursion through the town core to recount Kenora's history, consider the evolution of architectural forms, and explore the development of public space along the Lake of the Woods waterfront. Participants also learned to see the town's place through the lens of territorial disputes between Manitoba and Ontario. The physical geography trip was directed by Nora Casson, who led members to the Experimental Lakes Area (ELA) 35 km southeast of the town site. The ELA is an outdoor research centre consisting of 58 lakes. By manipulating the lakes under controlled conditions, scientists are able to study the effects that human-induced factors such as climate change and nutrient loading have on freshwater ecologies. The ELA was also featured later in the evening at the gala banquet where the association's honorary speaker was Michael Rennie, resident biologist at the site and professor at Lakehead University. Dr. Rennie's talk was warmly received by the audience. It ranged across the history of the ELA and its importance in a number of leading studies, its public role in disseminating scientific research, and its relationship with First Nations' use and land claims in the area. He also reflected on the ELA's recent transition from federal direction through Fisheries and Oceans Canada to new management under the International Institute of Sustainable Development, an independent non-profit organization. Following Dr. Rennie's talk, the association welcomed CAG President Theresa Garvin and thanked her for attending the divisional meeting. The evening concluded with remarks from Derrek Eberts (PCAG President), the annual slide show competition, and an awards ceremony that saw Weldon Hiebert receive the John Welsted Award for Service to Geography in the Western Interior.

Prairie Perspectives

Prairie Perspectives: Geographical Essays is maintained by PCAG and functions as a proceedings of the annual conference as well as an edited, peer-reviewed journal. The articles within are often papers presented at the PCAG meeting but are also drawn from a wide community of scholars including association members, geographers working at prairie institutions, and those not based in the region but working on topics relevant to prairie geography. In this volume the article by Baidoc and Cromwell, both contributions by Lehr and McGregor, and the field trip by Casson et al. were elements of the PCAG 2015 meeting in Kenora. The article by Beattie and the two field trips by Wiseman and McGinn arose out of the 2014 meeting at Elkhorn Lodge in Riding Mountain National Park, hosted by Brandon University.

Volume 18 groups articles into three thematic sections. The first set reflects geographic techniques and research methods. We open with Brian McGregor and John C. Lehr's article, which problematizes past analyses of the 'frontier' concept often used to understand European settlement of the North American west. The authors charge that the convention of using census and postal information to map the geography of settlement leads to inaccuracies, since these records do not necessarily reflect the reality of who was living on the western frontier. Instead, McGregor and Lehr find school district formation a more realistic measurement of established settlement. They employ a GIS model of the movement and evolution of prairie settlement, building a series of maps to illustrate how schools track the transformation of western Canada. Next, Aaron J. Kingsbury's article also describes a project that combines GIS and schools, this time to identify locations meeting classroom placement requirements for P-12 teacher education candidates at Mayville State University (MSU) in North Dakota. Because of the rural location of the university and the demographic homogeneity in many of the surrounding towns, MSU administrators found it difficult to identify placement locations that would expose teacher candidates to ethnic diversity in the classroom. Kingsbury describes how a GIS-based spatial decision support system was able to improve the placement process for the candidates. In the following article, Gina Sylvestre is likewise concerned with the use of research methods to meet institutional and social needs. She describes a project directed by the City of Winnipeg to create *Surefoot*, a bulletin designed to raise awareness and communicate changing winter sidewalk walking conditions to city residents. Sylvestre argues that a geographic mobilities paradigm brings to light new questions about the experience of friction and walking in winter environments. She also examines the ultimate discontinuation of the *Surefoot* program, concluding that hierarchies of mobility exist between car travel

and pedestrianism that impact policy decisions. The next article describes the application of geographical tools to commercial silviculture. In this two-part study, authors Ashley Greenley, Mandy MacRae, William Paton, and Dion Wiseman worked with an industry partner to assess opportunities for commercial production of red osier dogwood (*Cornus sericea*) in Brandon, Manitoba. Interest in this particular plant comes from its neutraceutical derivatives, which may provide considerable benefits to human and animal health. In their article, the authors first describe a study to understand and meet the considerable difficulties of propagating red osier dogwood in nursery conditions. The second part describes how a GIS model was developed to locate optimal propagation sites by considering a variety of overlapping concerns including soil suitability, distance to markets, and labour supply.

The next set of articles showcases how a range of questions may be addressed using methods in physical geography. Though the research reported on is drawn from study sites ranging across Canada, a connecting thread between the three articles is their illustration of anthropogenic impacts on the natural environment. This group is led off by Robert Baidoc and Adam R. Cornwell, who describe their efforts to determine the future probability of forest fires in the eastern boreal forest region of Canada. Their analysis relied on factors affecting moisture content in fine debris found at the forest floor: higher temperatures will dry the material, increasing its ignition potential, whereas precipitation will have the opposite effect. Using these indicators, Baidoc and Cornwell model a future climate change scenario, determining that the probability of fire will increase significantly as climate change continues toward the end of the twenty-first century. The next study, by Melody Caron, David Lobb, Jim Miller, Kui Liu, and Phillip Owens, takes place in Alberta in the Lower Little Bow River (LLBR) watershed. Here, sediments in the river are a growing concern. Silt and soils in the water cause a variety of problems: they transport pollutants, can negatively affect river ecology, and damage the irrigation pumps used by farmers. Controlling the influx of sediments is thus a main concern of conservation and management in the LLBR. In their article, Caron et al. explain how it was possible to use the presence of radionuclide cesium-137 as a means of 'fingerprinting' the origin of sediment found in the river. They found that surface erosion sources like agricultural fields are far less impactful on the river than subsurface sources, such as irrigation return flow channels and cuts into streambanks feeding the river. The third physical geography paper returns to the central prairies to an agricultural research facility in Brandon, Manitoba. Here, Brandice Hollier, Christopher Malcom, and Melanie Dubois report on a study of the effects of agricultural land use on small mammal populations. Their results speak directly to diminishing biodiversity – in comparisons between cropped and natural areas, the study found heavy agricultural land use corresponded with the diminished variety of small mammal species.

The final set of articles concern human and cultural geography. Beckey Hamilton begins with an article on French and Belgian farming settlements in southwestern Saskatchewan. Her question is straightforward: did settlers from these communities always choose the best possible land when they arrived in the Canadian west? To answer this, Hamilton merges nineteenth-century accounts of pioneers with Canada Land Inventory (CLI) maps compiled in the mid-twentieth century. She examines the influence of cultural factors found in letters and archives, such as prior European origins, attitudes toward landscape, and religious structures against the information in the CLI maps, including the capability of soils for agriculture, the availability of wood, and the proximity of water. A second article by Lehr and McGregor follows, again on the historical geography of prairie settlement. In this case the authors provide a study of prairie place names, also known as 'toponymy.' They recognize that the story of how a place gets its name is a demonstration of history and heritage, but argue that toponyms also reflect power and politics, human-environment relationships, and illustrate social evolution over time. Offering a wealth of examples, the authors show how some prairie place-names reveal the influence of Indigenous cultures, some were employed as symbols of corporate power, and how some enabled immigrant communities to either preserve their traditions or weave themselves into dominant settler society. The final research article moves forward in time to examine a moment in prairie history when new uses of the rural landscape were being promoted. Hillary Beattie offers a case study of the Manitoba Bureau of Travel and Publicity's efforts to make the province's natural environment attractive to American campers and sport anglers during the 1950s. Here she finds a consistent message to would-be tourists that a return to nature could regenerate people stressed by modern industrial life. Beattie claims these 'anti-modern' beliefs about the healing power of nature were actually a means by which the modern world was transposed to the wilderness: the same gender and social codes of the city and the workplace were written into experiences of camping and fishing. The historical geography of tourism in Manitoba, she suggests, reflects a broader pattern of antimodernism across North America.

Many of the articles in this collection make important contributions to geographical knowledge or reveal new ways to study human-environment relationships. The volume as a whole demonstrates both the broad interests of PCAG members and the strength of the regional association over its 40-year history.

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Prairie Perspectives: Geographical Essays
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The agricultural settlement of the Canadian prairies 1870–1930: Using GIS to interpret a dynamic process

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Mapping the spread of agricultural settlement across the western Canadian prairies using conventional data sources presents some serious difficulties. Land alienation data, other than records of homestead entry, does not always reflect actual occupation of the land and census data offers only snapshots of population density at widely spaced intervals. At the time of settlement, the establishment and location of schools was determined by demographic and spatial criteria enshrined in territorial and provincial legislation. It is argued that using the date of school formation offers the best available measure of land occupancy and the emergence of community institutions. Using this data, the spread of settlement across the Canadian prairies was mapped. The advance of the settlement frontier can be depicted on an annual basis and compared to the progress of railway construction. GIS offers an opportunity to overlay other socio-economic and physical data to enable evaluation of the principal factors bearing on the process and pattern of settlement.

Keywords: school districts, frontier, settlement, GIS, computer mapping

Introduction

In 1890, the United States Census Bureau declared the frontier of settlement closed in the United States. This, of course, did not mean that there were no more lands available for settlement but that there was no longer a clear line of settlement that marked the edge of European occupation. Some three years later Frederick Jackson Turner, clearly influenced by the ideology embodied in the Census Bureau's statement, presented a paper in which he argued that the frontier was a dominant force shaping the nature of United States society and the characteristics of its people (Turner 1894, 79–112). Turner postulated the existence of several frontiers in American history that cumulatively shaped the nature of the nation. He was frustratingly vague on his definition of frontier but it is clear that both the Bureau and Turner saw the frontier as a wave of European occupation that, with the exception of the California frontier, rolled from east to west.

For years Turner's hypothesis shaped American historiography and even influenced the way in which Canadians approached their own frontiers of settlement. Although the frontier thesis was never embraced as wholeheartedly in Canada, Turner's ideas nevertheless resonated in Mackintosh and Joerg's eight-volume *Canadian Frontiers of Settlement* series, published in the 1930s, which, among other issues, dealt with the mining, forestry, and agricultural frontiers. More recently, in a sweeping global study of European agricultural frontiers, Weaver (2003, 18) shied away from defining frontiers in quantitative terms, preferring to consider them as "areas where the colonizer's re-

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gime of property rights had not been firmly installed but where newcomers were already marking out places in anticipation of that condition."

Just as Turner never actually mapped the movement of the US frontier, preferring to describe the process only in general terms, Canadian scholars were seemingly content to accept Turner's and the Census Bureau's rather crude notion of the frontier being a line that is "the outer edge of the wave [of settlement] the meeting point of savagery and civilization" (Turner 1894, 81). The question of what exactly constituted the frontier, whether it was a geographic area or a process, and how and when it moved was never addressed satisfactorily (Billington 1967, 3–24). The Census Bureau used a simplistic and arbitrary measure of population density to determine the position of the settlement frontier in the United States, marking its location as where the population density was at least two but less than six people per square mile. Higher densities lay behind the frontier, lower ones beyond it. This is a deceptively simple way to determine where the frontier lies and, by implication, when an area is deemed to be settled. It has numerous shortcomings. No rationale accompanies the choice of two or six persons per square mile. An administrative decision to move the parameters to, for example, at least four but less than 12 people per square mile could conceivably move the frontier some distance. Even 12 people in a square mile might constitute only one or two households with a tenuous tie to the land. Nevertheless, this measure was used 100 years later to determine the geographical spread of European settlement on the Canadian prairies (Carlyle et al. 1997, Plate 17).

Other approaches to determining the limits of agricultural settlement include using records of land alienation. In Canada's Prairie provinces most of the land was vested in the Crown, which was anxious to see its resources exploited as quickly and efficiently as possible. To encourage the building of railways, vast tracts, more than 25,000,000 acres, were set aside to compensate railway companies for building lines in British Columbia, Ontario and across the prairies (Martin 1973, 46). Over one-twentieth of the land was reserved to compensate the Hudson's Bay Company for ceding its rights over Rupertsland to the British Government. Two sections of every 36 square mile township were retained to fund the building and operation of schools. Most of the remaining lands were opened to homestead settlement. Exceptions were made when lands were assigned as Indian Reserves or set aside to compensate the Métis. Later, forest reserves were created and some lands held for settlement by specific ethnic groups such as Mennonites, Icelanders, and Doukhobors. Much of the land selected by railway companies remained unsold and unsettled as they waited to put their land on the market until early homesteaders had improved surrounding lands and driven up prices. Land awarded to Métis families in scrip was often sold to speculators and remained unsettled for years afterwards (Martin 1973, 21). While records of homestead entries provide a wealth of information about the settlement history of homestead lands, including the date of first entry, date of patent or cancellation, date of re-entry and so forth, homestead lands only constituted a fraction of all lands open to settlement across the prairies. The sheer detail and scale of this information tends to swamp the researcher with a plethora of data which are unfortunately geographically incomplete. Clearly any attempt to use records of land alienation to determine settlement history is fraught with difficulty.

Perhaps the most reliable and complete set of quantitative data regarding the settlement of the Canadian prairies is provided by the Census of Canada, which conducted detailed population inventories in all the provinces and territories on a decennial basis and, beginning in 1906, at five-year intervals. Since the settlement of the Canadian prairies largely took place within a span of some 40 years (1880 to 1920), it was a rapid process with major changes occurring within the span of three or four years. While census records provide accurate and detailed information on population numbers in each area they only afford a series of snapshots, at best, at five-year intervals. Therefore, census data cannot capture the rapidity with which agricultural settlement advanced across the Canadian prairies, nor does it offer any way to assess the strength of community connections. The objectives of this paper are twofold: to demonstrate the application of GIS technology in mapping historical geography, and to provide a series of maps that shows the geographical progress of European land occupation in the Canadian prairies from 1870 through the first two decades of the twentieth century.

School district formation and the passing of the frontier

An issue that compounds the difficulty of mapping the location of the frontier is that there is no one agreed-upon definition of frontier, apart from the arbitrary one chosen by the US Census Bureau. We share Weaver's (2003) view that the position of a settlement frontier cannot be determined by population density alone, although population densities are a contributory factor in creating frontier conditions. The frontier is best seen as an area where social processes are unfolding, where institutions are being formed (whether transplanted from outside the region or generated from within is immaterial), where social and economic ties with the heartland are present, no matter how tenuous, and where the rule of law is newly present. Frontier conditions no longer exist when a district boasts non-indigenous social and cultural institutions, and has effective links with the organs of regional and national government. Weaver (2008, 27) thought similarly, arguing the frontier was a place where the state had not yet installed its apparatus for allocating property rights. The presence of agricultural settlers is, of course, required to mark the limits of an agricultural frontier. A sparse population of more than two non-indigenous people per square mile seems appropriate to mark the limits of European settlement. This numeric value reflects the fact that the catchment area of a school district was at most 20 sections (20 square miles) not all of which would necessarily be open to settlement. With a minimum population of 10 pupils of school age (5 to 15 years) there would be an adult population of at least 20 people. Assuming a small number of children under five years and some above

school age, the presence of a school would suggest a minimum population of 35 to 40 in the catchment area, likely higher than two people per square mile.

An effective way to determine when these conditions are met is to track the formation of school districts which may be used as a surrogate to determine when the frontier of settlement has passed. In Manitoba and the then North-Western Territories (after 1905 Alberta and Saskatchewan), the formation of school districts was strictly governed by legislation that specified the size of school district catchment areas and the number of school-age children necessary for the creation of a new school district. Although there were some minor differences between the three Prairie Provinces, the legal conditions for the establishment of a school were basically the same. A community could petition for the creation of a new school district when there were ten children of school age living within a three-mile radius. Most did so, seeing a school as a symbol of progress and education as the pathway to social development (Kaye 1964, 319–347). No school district was supposed to serve more than 20 sections (20 square miles) although exceptions were made if natural barriers precluded some students attending schools that were geographically closer.

The formation of a school district signaled the emergence of an area from the disorganized conditions of frontier life, the attainment of a degree of social stability and the embrace of extra-regional governance. It also meant the area had been surveyed and officially declared open for settlement. Provincial and territorial boards of education exercised control over the education process, ensuring uniformity. In Manitoba, the process was administered from Winnipeg, in Alberta and Saskatchewan from Edmonton and Regina respectively. Provincially-appointed school inspectors ensured the approved curriculum was followed, school buildings met provincial codes, attendance was recorded, and teachers were competent. School trustees were elected from within the local community and their members were subject to provincial or territorial codes of conduct. School boards were empowered to issue debentures, raise taxes, and apply for grants from the Provincial and Territorial Governments for the maintenance of school grounds and buildings, and the payment of teachers. If a school district failed in its fiduciary responsibilities, it could be replaced by a provincial trustee who would manage its affairs until such time as the Province deemed the district ready to resume its responsibilities.

Some other common institutions whose presence in the landscape reflects the passing of the frontier include post offices, court houses, and community clubs (Alwin 1974, 183–186; Myers 1990, 218–227; Winsberg 1993, 189–199), while Warkentin (1965, 85–166) used gross postal revenues to create a picture of economic development in western Canada in 1866. Post offices were established when mail traffic was deemed sufficient to warrant the establishment of a position as postmaster–usually in a house or store. In Canada, as in the United States, these positions were often subject to political patronage so their presence and geographic placement did not always reflect true need. Furthermore, as political fortunes ebbed and flowed so could the location of post offices (Winsberg 1993, 191). The presence of a court house, while demonstrating the firm hold of government in an area, was likely to be only encountered in a longer-settled area where frontier conditions had long ceased to exist. Schools, on the other hand, were more than vehicles for education of children. They embodied social values and qualities. The various departments of education saw them as community centres, "around which community life revolves," as one Manitoba school inspector put it (Herriot 1918, 85). In nascent prairie communities, teachers were expected to take a role in the development of cultural (and patriotic) community activities, organizing school concerts and generally elevating the cultural tastes of the people. Forming a school district, building a schoolhouse and the arrival of a new teacher was a signal of progress to settlers in pioneer communities. Teachers working in "foreign" non-English-speaking settlements were regarded by department of education officials as agents of enlightenment and assimilation, inculcating British Imperial values and the Protestant ethic into new Canadian communities (Lehr 2011, 135–137).

Schools had a transformative function as they were a vehicle whereby single young women were injected into communities where there was a serious gender imbalance. Star Mound School District in south-central Manitoba, for example, was formed in 1888. Until it closed in 1962 it had hired 44 teachers. Only two were male, the rest, with one exception, were unmarried females (Star Mound School n.d.). Few taught for more than one year, the majority resigning because they married a local bachelor and, until 1947, married women were not generally allowed to be teachers. A report to the Legislative Council of Alberta remarked that "any teacher could marry in almost any district, if she would [sic]" (Molenkamp 1998, 40). At a time when most teachers in rural schools were women, this was a real problem for school trustees: "The country being overrun with bachelors, no [school district] can hope to keep a girl [teacher] more than a few months, and in many cases, but a few weeks when she is married and away" (McIntosh 1992, 39). Bachelors in rural communities were often the most enthusiastic proponents of education, knowing a school would bring in a steady supply of educated brides. After marriage these former teachers served to establish and maintain cultural institutions within the district, thereby placing it firmly behind the frontier. No other institution had such a profound effect upon community development. The formation of a school district thus clearly signaled integration into the socio-economic fabric of the nation.

GIS technology and mapping

Geographical information systems (GIS) are technologically recent but conceptually old. Before the advent of computer technology geographers wishing to depict the diffusion of an innovation or spread of an idea had to depict data on a series of map overlays. Manually plotting data on a succession of overlays was time-consuming and tedious work. Changing time intervals at which data were depicted was a forbidding task while adding and subtracting various layers of data—such as vegetation zones, soil zones, drainage patterns, roads, railways, buildings,

and so forth—was labour-intensive and extremely time consuming. In the 1980s, geographers first became able to digitize information and, using GIS software, could sort, rank, add or delete data at will. Not only did this accelerate the map production process but it afforded a degree of complexity and geo-spatial accuracy that was simply not attainable using conventional cartographic methodologies.

In a previous study, using the aid of GIS technology the authors constructed detailed maps showing land alienation in southeastern Manitoba by quarter section, year of entry, and/or year of patent, and show it at time intervals of their choice (Lehr and McGregor 2008). Here the spread of agricultural settlement was limited to a far smaller geographic area. As such it presented fewer problems in data acquisition, management and verification.

Mapping the frontier of settlement using the date of formation of school districts as a surrogate for a plethora of often inconsistent and otherwise immeasurable data is not without its problems. School district boundaries were seldom static but were adjusted as in-fill settlement continued and populations expanded. Occasionally schools changed their locations within the district. When a district was formed, classes may initially have been held in a room in a homesteader's dwelling. Erecting a purpose-built schoolhouse might involve relocation to a different quarter or section. Nevertheless, such moves were always within the bounds of the school district, seldom more than a mile or two, and, like changes to school district boundaries, were essentially minor.

Of greater concern is the reliability of data about the dates of school district formation and the precise location of the school. School formation files in each province gave school locations by section, township and range, and in many instances, by quarter section. However, on occasion, the location given was quite vague, specifying only the township and range. In such cases, for the sake of uniformity, it was assumed the school was located on the SE quarter of Section 29, which was always reserved as school land. A small number of schools were located within the bounds of river lot surveys, particularly in Manitoba along the Red and Assiniboine Rivers. The precise position of the majority of these schools was determined by consulting Cummin's Rural Directory maps of the period. In a few cases when these maps failed to reveal the location of a school within a lot and since the legal description of a school's location gave no indication of the school's position within a specific river lot, some assumptions had to be made. As river lots are long and narrow and run back from the river for a maximum of two miles, and since roads tended to parallel the river at some distance from the river frontage, schools were assumed to be one mile back from the river, in the centre of the narrow lot.

Until 1905, the area that now constitutes Saskatchewan and Alberta was a part of the North-Western Territories. After the creation of Saskatchewan and Alberta, school records were held in their respective provinces but records of school districts formed before 1905 often appeared in the records of both provinces. These duplicate records had to be identified and eliminated.

A further complication occurred when school districts, for various reasons, chose to rename themselves. This occurred often when, after submitting their district name for approval by the provincial department of education, it was discovered the name was already used by another school district. During the First World War many school districts, in areas populated by former citizens of the Central Powers, chose to change their names in order to demonstrate their patriotism and downplay their ties to Germany and Austria-Hungary (Lehr and McGregor 2015, 117–119). In Manitoba, for example, Bukowina School District became Lord Roberts School District, Slowo became Strand, and Svoboda became Beckett (Archives of Manitoba, School Formation Files G-6-4-8 School Districts).

School formation records in the Manitoba, Saskatchewan, and Alberta archives were used to create an Excel spreadsheet containing variables such as school district number, school name, opening date, closing date, and location. The vast majority of the schools were located on land surveyed with the township and range system. Both the Manitoba and Saskatchewan governments make ArcGIS shape files of quarter section centre points available on-line. The concatenate function in Excel was used to construct an identification code (id code) for each record (from the range, township, section, quarter section and meridian) that matched the format of the id code in the government files. This allowed the school information to be joined to the quarter section centre points in ArcGIS. As free quarter section shape files were not available for Alberta, an on-line application was used to convert the township, section, and range locations into geographic coordinates.

Using the protocols outlined above, the locations, names, dates of formation, and some dates of closure were obtained for 11,397 school districts established in the provinces of Manitoba, Saskatchewan, and Alberta from 1870 onwards. Locations were plotted on a detailed base map that depicted vegetation zones and topography. As railway lines were completed their routes were added showing the relationship between access to railway transportation, the formation of school districts, and by implication, the occupation of land. Changes in political boundaries were also recorded on the base maps.

The geography of agricultural settlement 1870 to 1920

European agricultural settlement in western Canada began in 1812 with the arrival of the Selkirk Settlers near present-day Winnipeg. Europeans and their mixed blood progeny had been present on the prairies for decades but in one way or another all were tied to the fur trade. They were hunters, traders, or freighters. If they were involved in agriculture, it was in a peripheral way and essentially alien to their principal means of livelihood. Indeed, agriculture was seen as antithetical to the interests of the fur trade, and the Hudson's Bay Company only acceded to Lord Selkirk's request to establish an agricultural settlement at Red River in the belief that such a settlement would serve as a supply base for the Company thereby lessening the need to import food-

stuffs from Britain and providing a home for retired company servants and their Indian or Métis wives (Friesen 1984, 71–72).

Evidence of European (and Métis) settlement was first seen in their dwellings that straggled along the Red and Assiniboine Rivers on the river lots surveyed by Miles MacDonnell. The social glue that held these nascent communities together was religion: Roman Catholic among the Francophone settlers and Anglican among the Scottish. The first schools in both societies were established by these churches. Their establishment revealed the progressive occupation of land along the Red and Assiniboine Rivers remaining entirely within the postage stamp incarnation of the Province of Manitoba until 1878. At Morley (in present-day Alberta) a solitary school was established by Methodist missionaries in 1871 to serve their proselytizing interests among the Aboriginal population (Figure 1). This outlier had little to do with European land occupation.

For several years after the prairies were open for European settlement the region saw little immigration. Its remoteness, intervening opportunities in the United States, lack of access to world markets, and a global depression deterred many agriculturalists from contemplating a move to the region. Even after the development of an all-Canadian route in 1883 the region did not see extensive immigration. Until the accession of a Liberal government in 1896, efforts to attract immigrants from Europe, the United States, and central and eastern Canada were largely unsuccessful.

Occupation of the prairies by European agriculturalists was initially delayed by several issues that had to be resolved by the federal government. Indigenous peoples had lived on and used the land for millennia. Mostly hunting and gathering societies, their territories were established by patterns of use, which were denigrated by the Europeans who believed entitlement to land was effected through improvement, in this case arable farming (Weaver 2003, 27). A series of treaties between Indigenous peoples and the British Crown confined them to a series of relatively small reserves scattered across the prairies, altering their way of life, denying them the ability to provide for themselves, and eroding their social structures (Friesen 1999; Talbot 2009; Savage 2012).

The conclusion of treaties and the occupation of the land was achieved in a relatively orderly fashion, due in large measure to the catastrophe that had struck the Indigenous people of the US Great Plains following the building of the transcontinental railway lines in the 1860s and facilitation of the commercial slaughter of the buffalo for hides (Weaver 2003, 251). The extirpation of the buffalo, the principal food source of the plains tribes, forced them into reliance on governmental aid doled out on the reserves set aside for them by the treaties, creating a landscape that appeared empty to European eyes. The mechanistic Dominion Lands survey also facilitated the orderly occupation of land. Squatting beyond the limits of the survey was relatively rare on the Canadian prairies because the Dominion Lands Branch surveyed and opened land to settlement to forestall administrative chaos. Where squatting did occur, it was often by settlers attempting to remain near their kin or fellow countrymen. There was no equivalent of the "sooners" of the United States Oklahoma Territory in Canada.

Patterns of settlement across the prairies reveal the importance of environmental appraisal and various forms of communication. Pioneers chose their land carefully, using criteria that embraced their social and economic concerns and physical environmental needs (Lehr 1985, 207–219; 1996, 98–108; Lewis 2004, 105–134). In an era before the arrival of the railway, the invention of barbed wire, or the wind-powered water pump, access to wood, water, and meadow were crucial need. A river lot running back from the Red or Assiniboine gave a cross section through the resource base, while the watercourse itself provided an essential transportation route. Early settlement by Métis and Europeans who arrived prior to the railway thus followed the rivers in Manitoba (Figure 2). Later, in the mid-1880s, when the pressure of arriving European settlers caused the Métis to move west in an attempt to retain their distinctive way of life, they had the same needs and so replicated their pattern of riparian settlement in Saskatchewan and Alberta, along parts of the North Saskatchewan River.

Until the arrival of the railway in St. Boniface in 1878 and the completion of the Canadian Pacific Railway's (CPR) transcontinental line across the prairies in 1883, land selection was driven by environmental considerations and, away from the rivers and the long lot surveys, by the geographical advance of the Dominion Lands Survey. Most settlers gravitated to the aspen parkland belt where the land was already surveyed and where wood, water, and meadow were most abundant (Figure 3). They were encouraged by the government's belief that the lands most likely to be settled were the "Willow Prairie" of Palliser and Hind. The "true prairie" was considered unsuitable for colonization because of its light soils and lack of timber (Wier 1960–61, 58). Mennonites from the Russian steppes who settled on the open prairie west of the Red River in the late 1870s were a rare exception to this viewpoint. These settlers had the experience, social organization, and adaptive strategies that freed them from dependence on timber, permitting them to move out on to the treeless grasslands where some of the best land in western Canada was to be found. Even these settlers never moved too far from a ready supply of building timber along the Manitoba escarpment (Epp 1974, 218–223). Figure 3 shows that other settlers who ventured out on to the prairies remained closely tied to the timber found in the river valleys and the well-timbered high ground of the Brandon Hills and the Turtle Mountain areas (Tyman 1972, 37).

Railways came to exert a crucial influence on the progress of prairie settlement but the first track was not laid in western Canada until 1875 when construction commenced on a line from Emerson to St. Boniface. Completed in December 1878, it linked St. Boniface with US rail lines at St. Vincent, Minnesota, and gave all-rail access to Minneapolis (Nicholson 2000, 2). This became the principal route used by Anglo-Canadian settlers from Ontario who entered the West before the CPR completed its line to Winnipeg across Ontario in 1882 (Nicholson 2000, 2). It also meant the Canadian government was hamstrung in its attempts to recruit settlers to come to the prairies from Europe and even

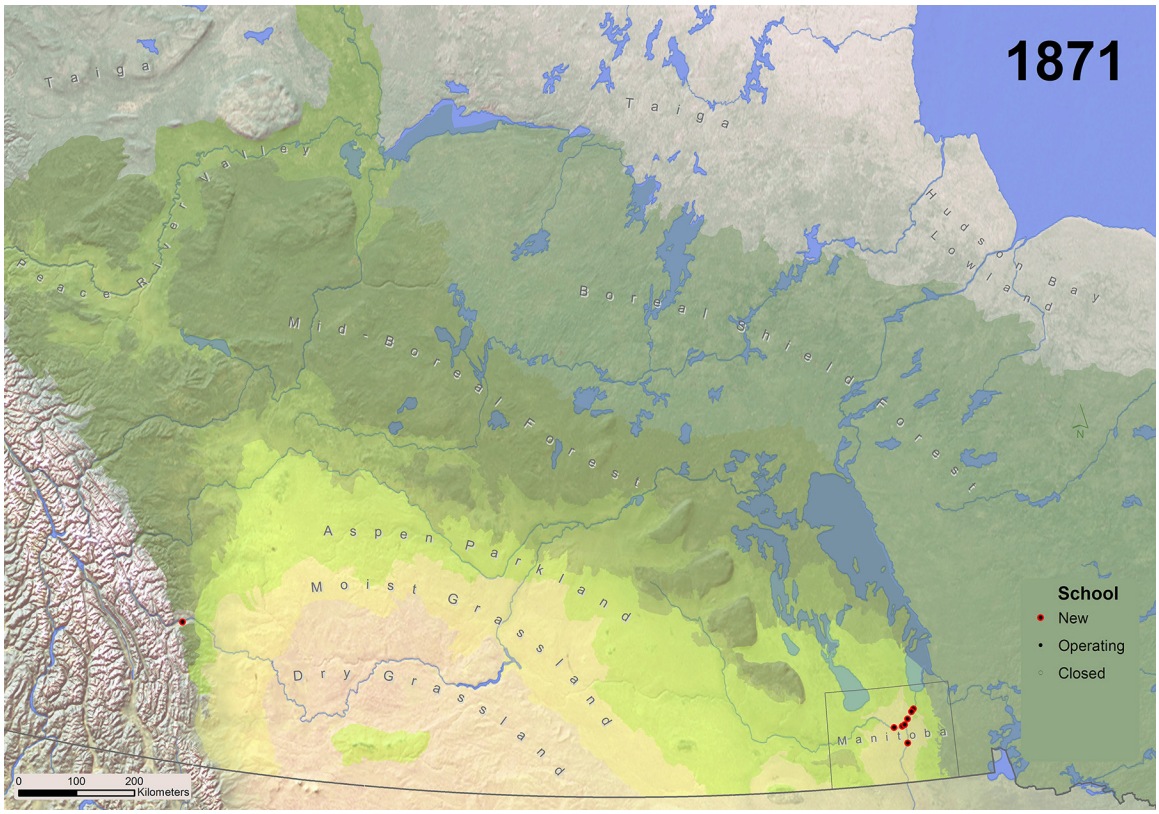


Figure 1
School districts in Manitoba and the North-Western Territories in 1871

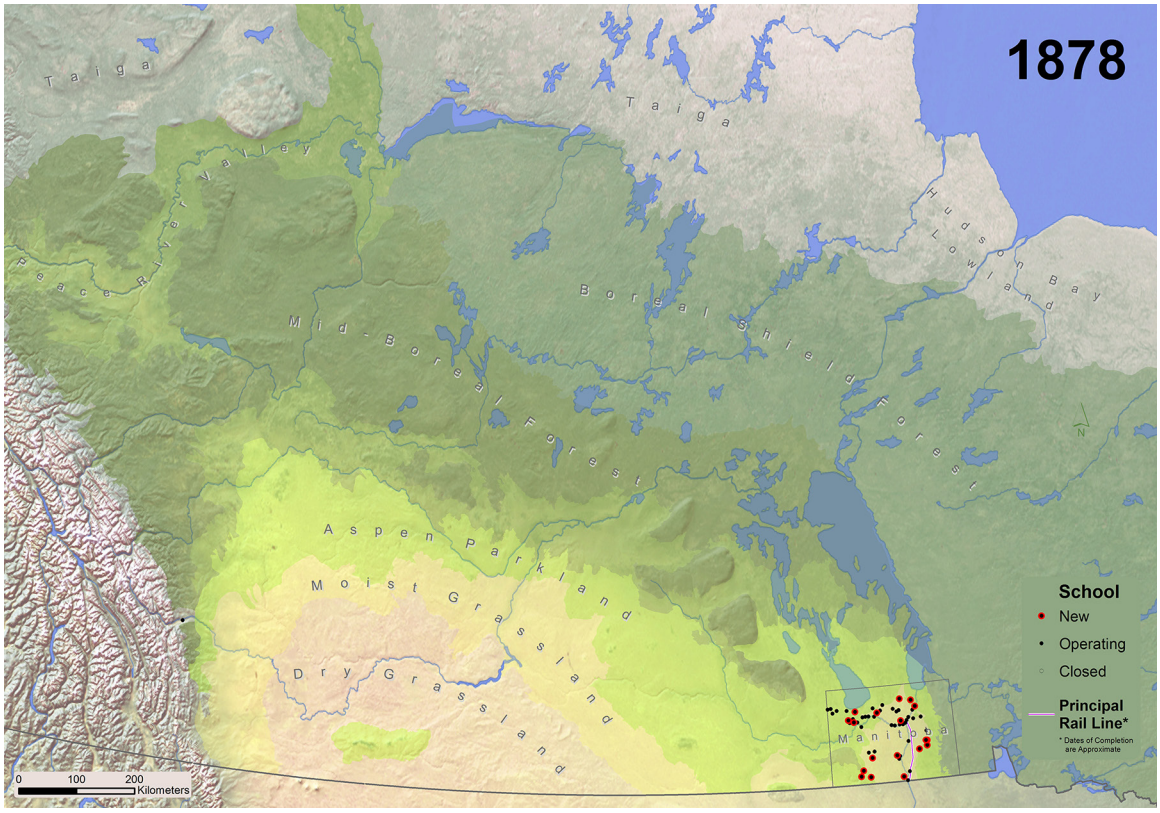


Figure 2
School districts in Manitoba and the North-Western Territories in 1878

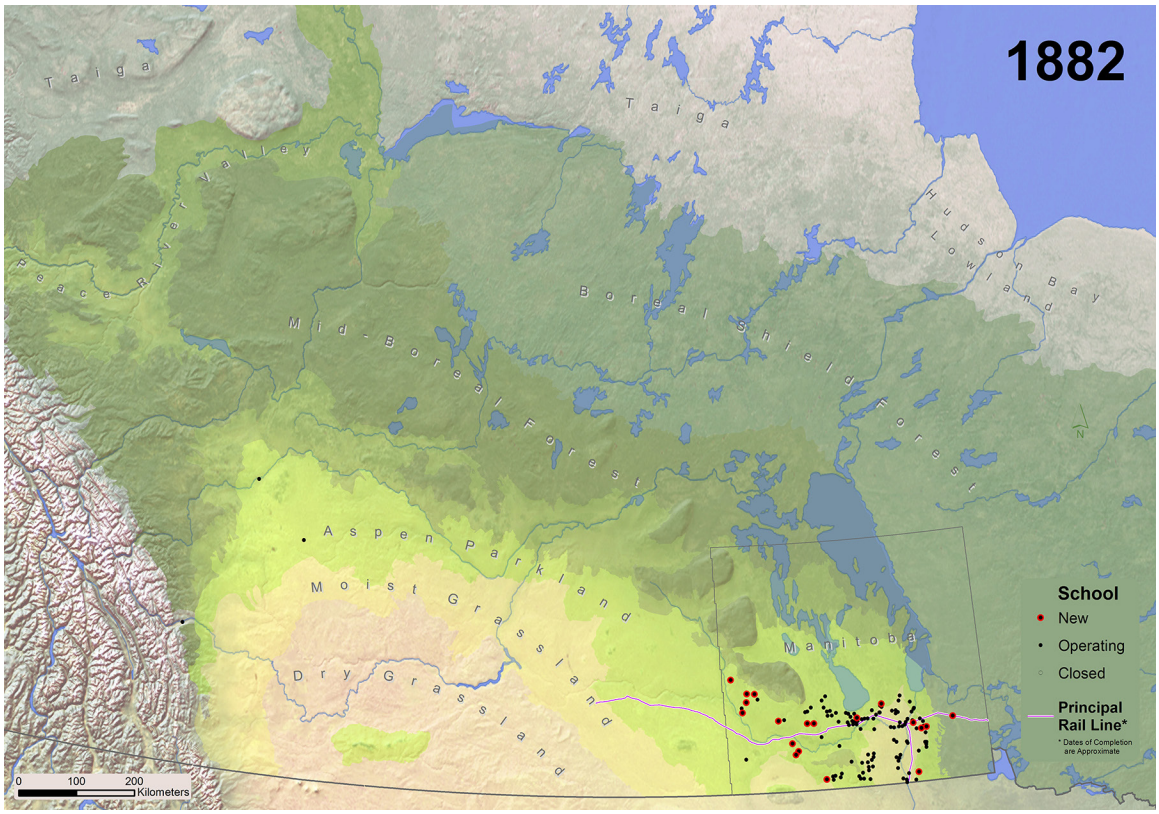


Figure 3
School districts in Manitoba and the North-Western Territories in 1882

Ontario and eastern Canada because it lacked a viable all-Canadian route. Presented with intervening—and better—opportunities for settlement in the United States while en route to the Canadian prairies, many decided to settle in the United States where good land was still available and where access to markets was far better. By 1881, the CPR had completed its track from Winnipeg as far as Brandon. Late in the same year trains were running regularly to Regina and, by September 1883, to Calgary, although the first trans-Canada passenger train did not arrive in Winnipeg until July 2nd 1886 (Innis 1923, 140–141; Moore, 1975, 12; Butterfield 1984, 3).

The CPR was initially planned to proceed from Selkirk, north of Winnipeg, crossing the prairies following the aspen parkland belt and taking the Yellowhead Pass through the Rocky Mountains. This route changed when Winnipeg interests succeeded in persuading the railway to cross the Red River near the confluence of the Red and Assiniboine Rivers. At about the same time, broader political considerations, principally concern about US territorial ambitions, caused the railway to opt in favour of a more southerly route running far closer to the US border and crossing the Rockies through Kicking Horse Pass (Innis 1923, 19). This route passed through the drylands of Palliser's Triangle, an area that held little appeal for most intending settlers, but served as a visible bulwark against encroachment of settlers from the US (Regehr 1976, 25). The process of settlement revealed by the formation of school divisions suggests railways led settlement in the dryland belt but followed settlement in the more humid aspen parkland (Figure 4).

From the outset the pattern of settlement was thus determined by environmental and transportation considerations. Settlers were not attracted to the dryland prairie and only ventured into that environmental zone when able to cling to the lifeline of the railway. Even though access to the aspen parkland belt was logistically more difficult, at least until the turn of the century, most settlers were prepared to trade off difficulty of access against the promise of a wider and more satisfactory resource base of wood, water, and meadow. Of course, access was not totally dependent on railways. Colonization trails facilitated access until the arrival of railways rendered them redundant (Regehr 1976, 25). For example, Ukrainian settlers arrived in both the Star area of Alberta and in Manitoba's Interlake via colonization trails several years before the railway's arrival (Kaye 1964, 348; Lehr and McDowell 2011, 18–23).

Until 1878, virtually all schools in the prairies lay within Manitoba's "postage stamp" boundaries, suggesting the agricultural frontier had not proceeded beyond that point (Figure 2). Access to the CPR mainline slowly pulled settlement westwards in the 1880s. Branch lines were built north from Regina to Saskatoon and Prince Albert in 1889. Given the paucity of settlement in the northern reaches of the parkland belt at the time of their construction it is probable the railway company's principal aim was to gain access to the timber resources in the Prince

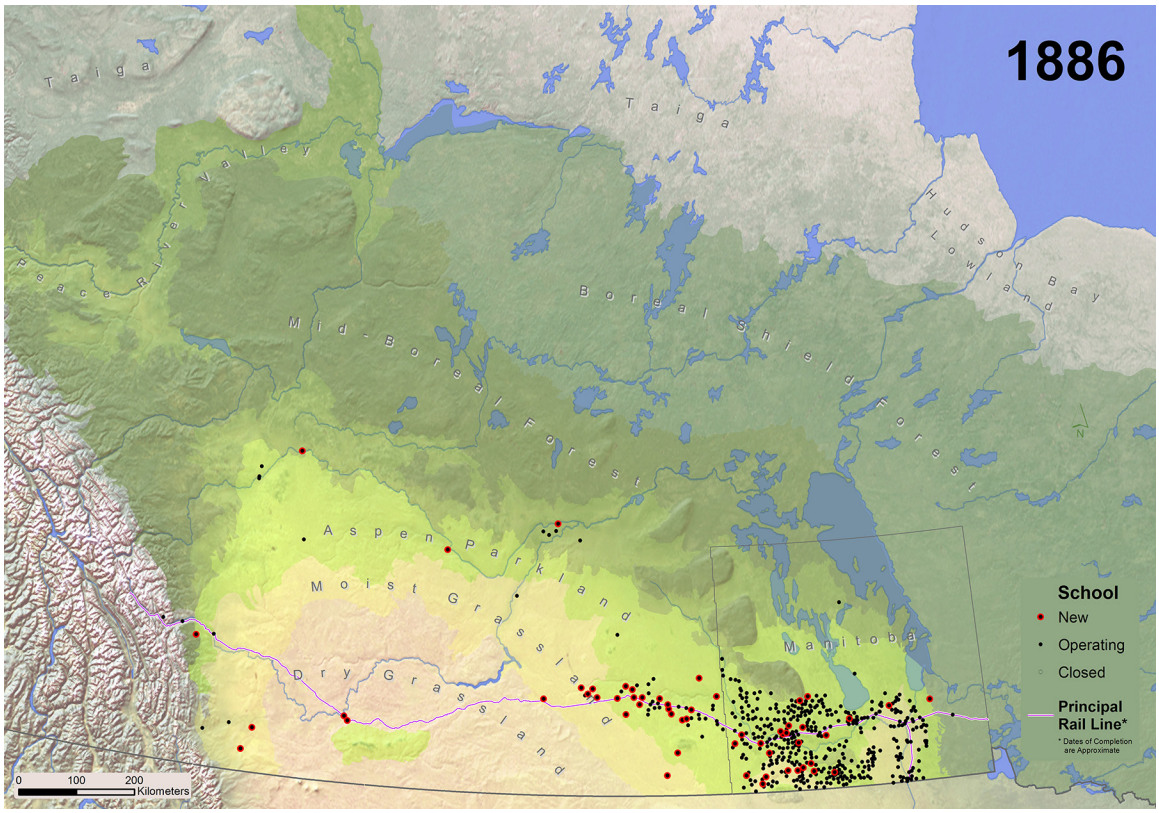


Figure 4
School districts in Manitoba and the North-Western Territories in 1886

Albert vicinity and simultaneously attract agricultural settlers who could constitute the labour force necessary to extract the resource. However, the district was not then surveyed and it was not until some six years later, with some considerable effort, that the Dominion government managed to induce Ukrainian settlers to occupy the only recently-surveyed heavily timbered and swampy territory (Lamont, Speers). In contrast, the line built northwards from Calgary to Strathcona (Edmonton) in 1891 resulted in a rapid burst of settlement in the parkland where the survey preceded settlement (Figure 5).

Except for these lines, there were few branch lines built west of the Manitoba border before the turn of the century. In Manitoba, the picture was quite different (Warkentin and Ruggles 1970, 412). Branch lines radiated out from Winnipeg giving relatively easy access to available lands in the parkland and humid prairie, thereby encouraging settlement and creating a dense network of railways in southern Manitoba by the early 1900s (Figure 6). Easy access to homestead land and greater facility to ship grain helped to funnel settlement into Manitoba at the expense of more distant and difficult opportunities to the west.

As the Canadian west developed, US grain shipment companies sought to capture part of western Canada's burgeoning grain shipments. Several lines were built northwards from the US to this end. Although it was not their intention to do so, these lines, most notably the Soo Line from Minneapolis to Moose Jaw, had a dramatic effect on prairie settlement. Within a few years of its completion in 1893, settlements developed along the Soo line, which for some years marked the edge of agricultural settlement bordering the drylands of southwestern Saskatchewan (Figure 7). In 1895, settlement on the southern prairies still clung to the lifeline of the CPR penetrating in a discontinuous fashion westwards only as far as Moose Jaw. In north-central Saskatchewan, settlers had pushed further west via colonization trails, always keeping to the security of the parkland belt. An apparent anomaly was the presence of a node of settlement in southwestern Alberta on land that was previously unable to support a dense agricultural population. This is explained by two factors: the railway's demand for coal and the Mormon Church's need for land for its land-hungry members (Magrath 1937, 53–57; Knight 1941, 56).

In most of North America railways and coal mining had a symbiotic relationship. By the latter half of the 19th century coal had become the principal domestic and industrial fuel over most of North America and mines relied on railways to transport their product. In western Canada, however, railways themselves were the biggest consumers of coal, so the railways founded the coal mines: coal did not create the railway (Den Otter 1984, 193–194). The CPR's decision to pursue a southern route shifted the focus of economic development on the prairies to southern Alberta and resulted in a surge of settlement in southeast Alberta tied to resource extraction and agriculture based on irrigated sugar beet production (Figure 8). Settlement of the tree-

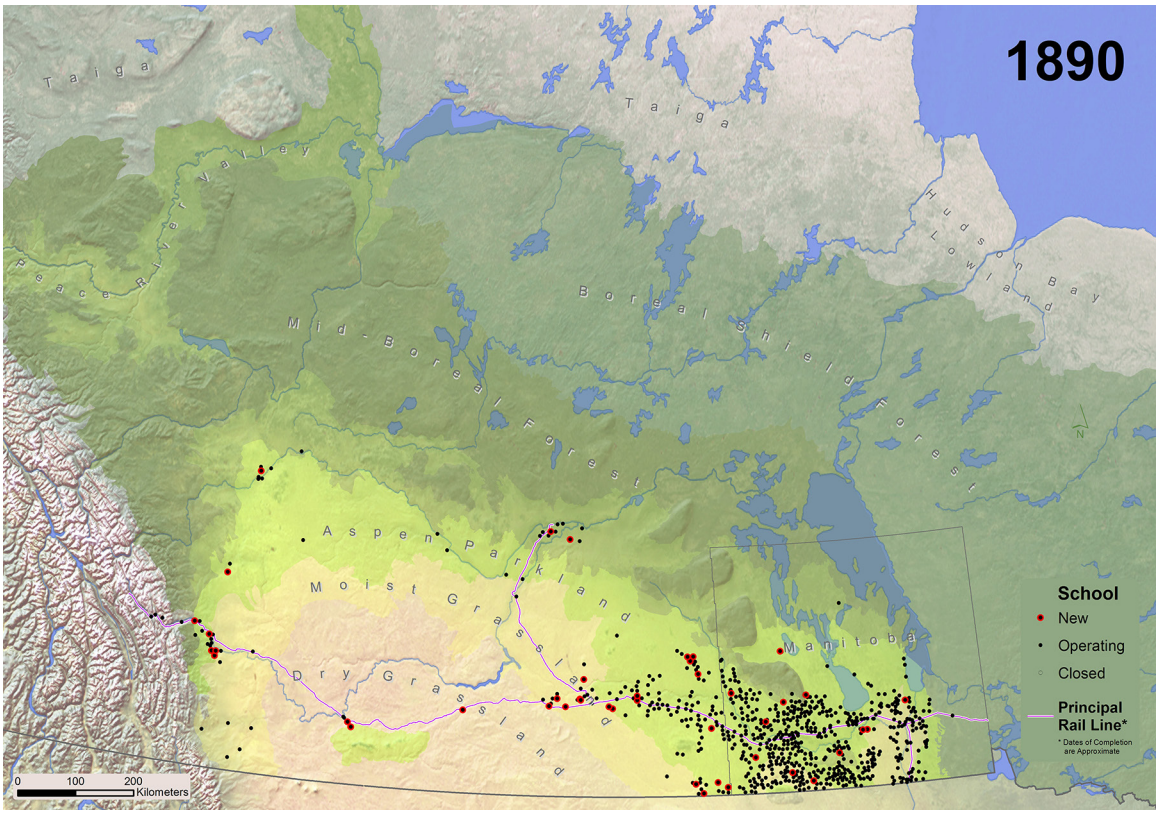


Figure 5
School districts in Manitoba and the North-Western Territories in 1890

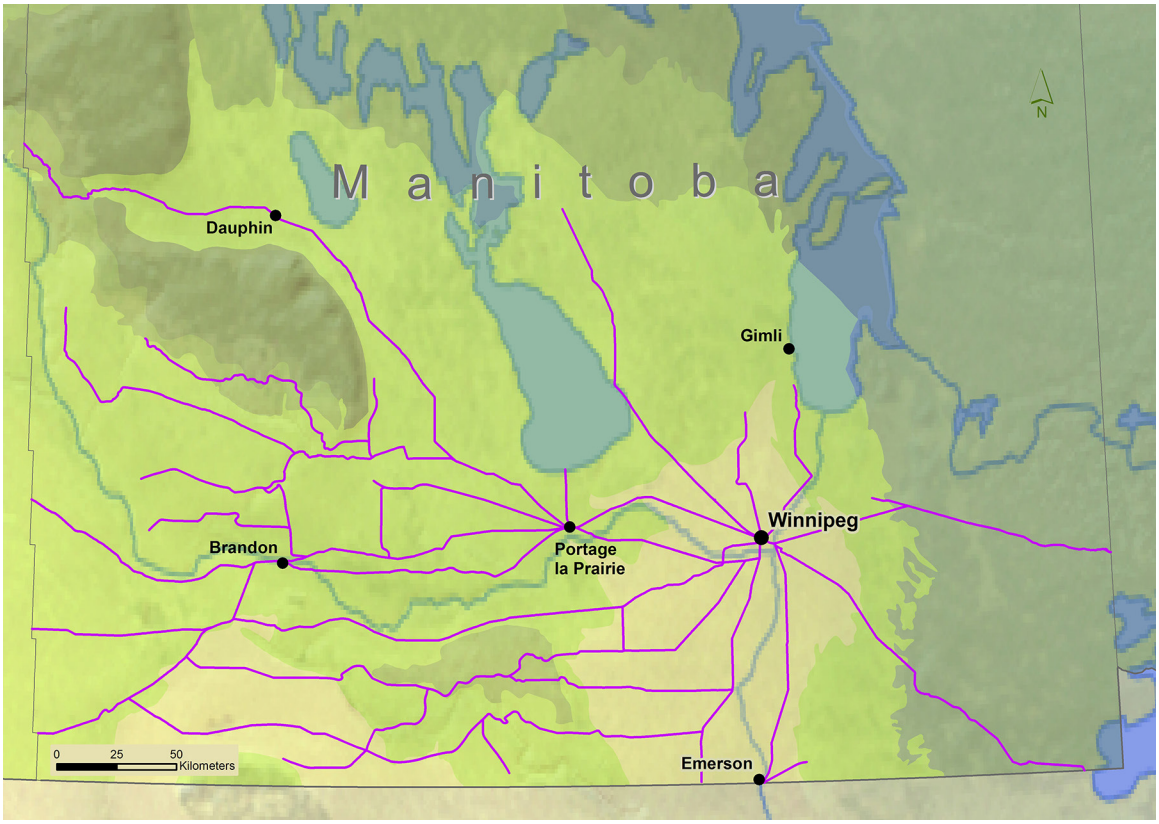


Figure 6
Railways in Manitoba in 1905

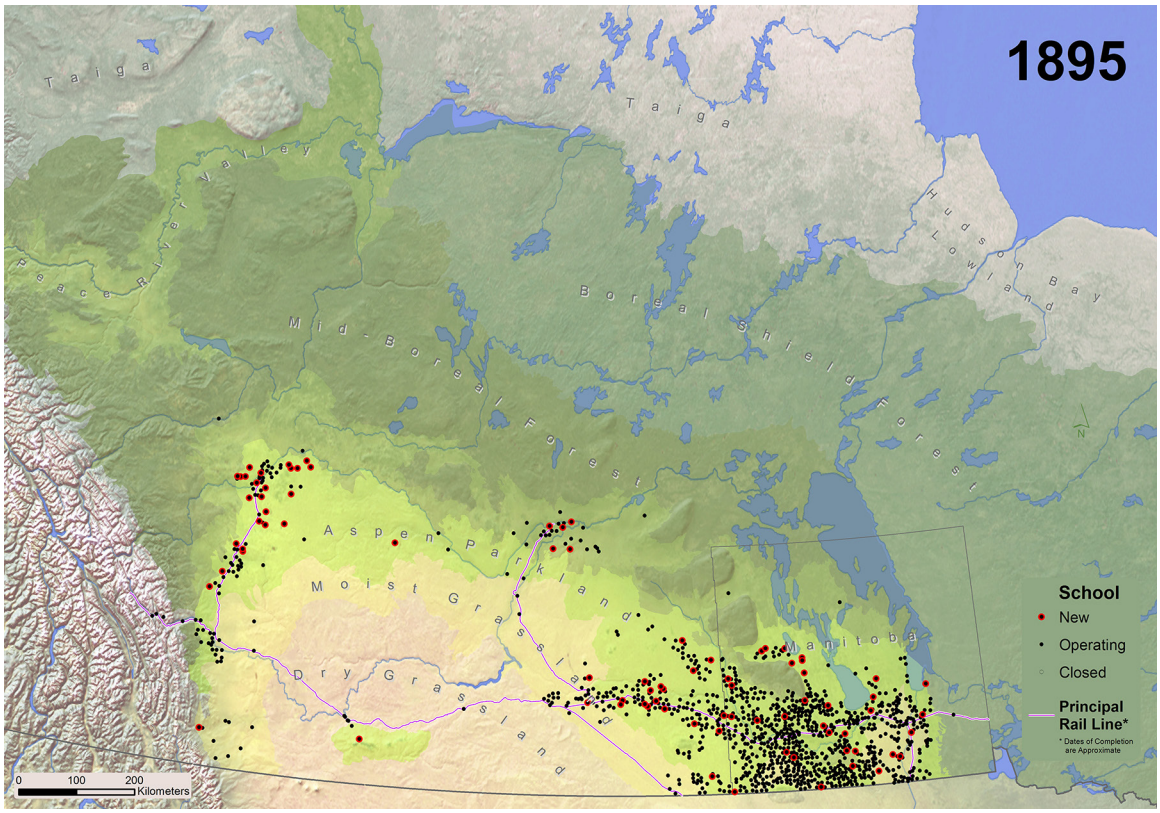


Figure 7
School districts in Manitoba and the North-Western Territories in 1895

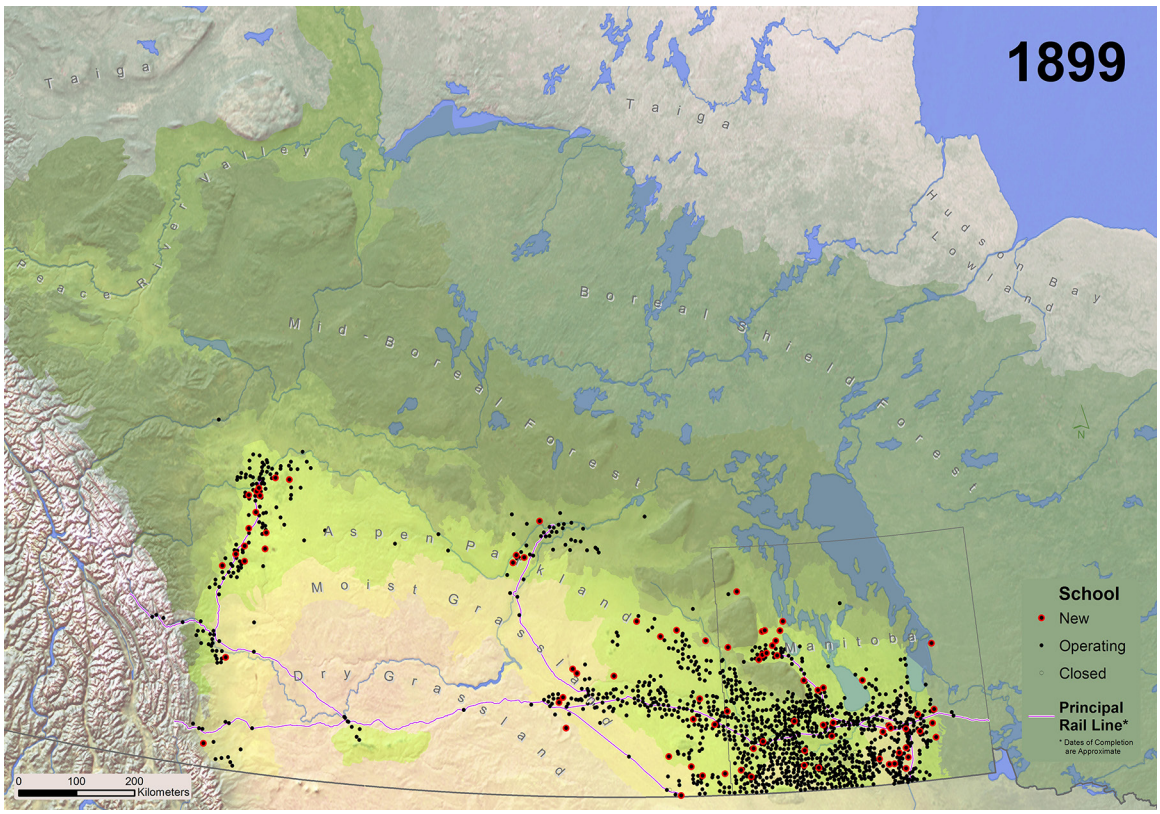


Figure 8
School districts in Manitoba and the North-Western Territories in 1899

less semi-arid lands of southwestern Alberta was unappealing to almost all prospective immigrants, most of whom had little interest in the back-breaking and capital-intensive project of irrigated agriculture. The settlement of this area was facilitated by the coalescing of interests of two massive institutions: the Alberta Coal and Railway Company and the Utah-based Church of Jesus Christ of Latter-Day Saints. The church provided the labour by directing its members to participate as a fulfillment of their church mission. The capital was provided by the railway company (Knight 1941). The usual economics of prairie agricultural settlement were absent.

In the late 1890s, the line between Calgary and Edmonton facilitated the growth of settlements in the Red Deer area and around Edmonton. Figure 9 shows that by 1905 occupation of the aspen parkland was well underway with areas adjacent to Calgary, Edmonton, and Saskatoon being the principal centres. These all enjoyed the advantage of rail connections and an environment conducive to settlement by individuals without strong reserves of capital.

Even the drylands of southwestern Saskatchewan and southeastern Alberta, which had been mostly shunned by European settlers, began to be settled after 1907 (Jones 2000, 9–15). In the 1880s, the thinking of Sir John A. MacDonald's government was the drylands were not suitable for arable farming and should be reserved for ranching. It introduced a "gilded grazing lease" policy that allowed leases of up to 100,000 acres for 21 years, enabling the creation of huge cattle conglomerates. Pressure from prospective homesteaders led the government to oblige ranchers to allow homesteading on their leased lands in 1892, which in turn led to conflict over water rights. Frank Oliver, Minister of the Interior, (1905–1911) championed homesteader's rights and soon after taking office facilitated "the monumental blunder of western settlement: occupation of the dryland prairie" (Jones 2000, 21). By 1912, these areas were receiving increasing numbers of settlers (Figure 10). By 1919, the process of settlement of these marginal lands was virtually complete and shortly thereafter drought began to force a retreat (McManus 2011) (Figure 11).

Settlement continued along the northern margins where forest met the prairie and began to push into Alberta's Peace River District. While this region was virtually unexploited in 1907, this changed rapidly within a few years and by 1913 the establishment of several schools attested to the emergence of settler communities. The Peace River District was clearly the new–and last frontier of settlement. In 1919, settlement was well advanced throughout the prairies, extending even into the marginal drylands of the short grass prairie (Figure 12) and had taken a tenuous hold in the Peace River District.

Conclusion

Settlement of the prairies did not cease in 1920; it sputtered onward across the northern margins. Settlers, many of them the off-spring of early pioneers, took homesteads within existing districts, while others headed for open land at higher latitudes. The Peace River District remained the last active frontier of agricultural settlement. By 1920, almost all of the remaining unsettled areas can be identified as too sandy, too rugged and wooded, or too poorly drained to successfully sustain an agriculturally-based community. Figures 11 and 12 clearly show some of these areas. In Manitoba, the outline of the Dominion Timber Reserve that in 1930 became Riding Mountain National Park is clear, as is that of Turtle Mountain and Spruce Woods Provincial Parks (which were also former Dominion Timber Reserves). In the centre of Spruce Woods Provincial Park two schools in the valley of the Assiniboine River reveal the presence of agricultural settlement in an area otherwise too sandy for arable farming. Straddling the boundary of Alberta and Saskatchewan, the Cypress Hills also remained unsettled, too high and rugged to sustain settlement based on farming.

The late appearance of schools south of Winnipeg and west of the Red River brings attention to the impact of poor drainage on land settlement. Until the end of the first decade of the last century, poor drainage was perhaps a more significant deterrent to agricultural progress than indifferent soil quality. Many wet areas were first occupied during dry years so settlement was already established when their marshy qualities became apparent (Bower 2011, 19–26). In other instances, settlers chose to overlook the environmental drawbacks of settling wet areas when they could achieve their social objectives (Lehr 2011, 47). Consequently, wet areas are generally more difficult to identify from the distribution of schools. The more extensive wet lands of the open prairie were brought under the plough only when drained, which required massive injections of capital that lay beyond the grasp of most prospective settlers, so some parts of what is now regarded as Manitoba's most productive land, such as Lowe Farm, were settled comparatively late.

After 1920, the process of settlement continued, although it was less an expansion of the frontier than adjustment to changing environmental conditions. During the "dirty thirties," for example, an estimated 45,000 people from the drought-stricken areas of Saskatchewan migrated to the northern margins eking out a living by cutting cordwood, hunting, and subsistence farming, as had Ukrainian settlers in Manitoba's bush country some decades earlier (Massie 2010, 178–181; Massie 2012, 32).

The pattern and process of formation of school districts mirrored that of agricultural settlement, providing a clear indication of the rapidity by which the prairies were settled by European immigrants. Patterns otherwise not clearly discernable become more evident when data are plotted at intervals of one year as opposed to five or ten years. The variation in the relationship between settlement, environment, and communications over both time and space cannot be determined through depiction of the movement of the agricultural frontier alone. When used in conjunction with other records and set within the pertinent social, political, and economic literature, maps such as those presented here can add another dimension to an understanding of a complex and dynamic process.

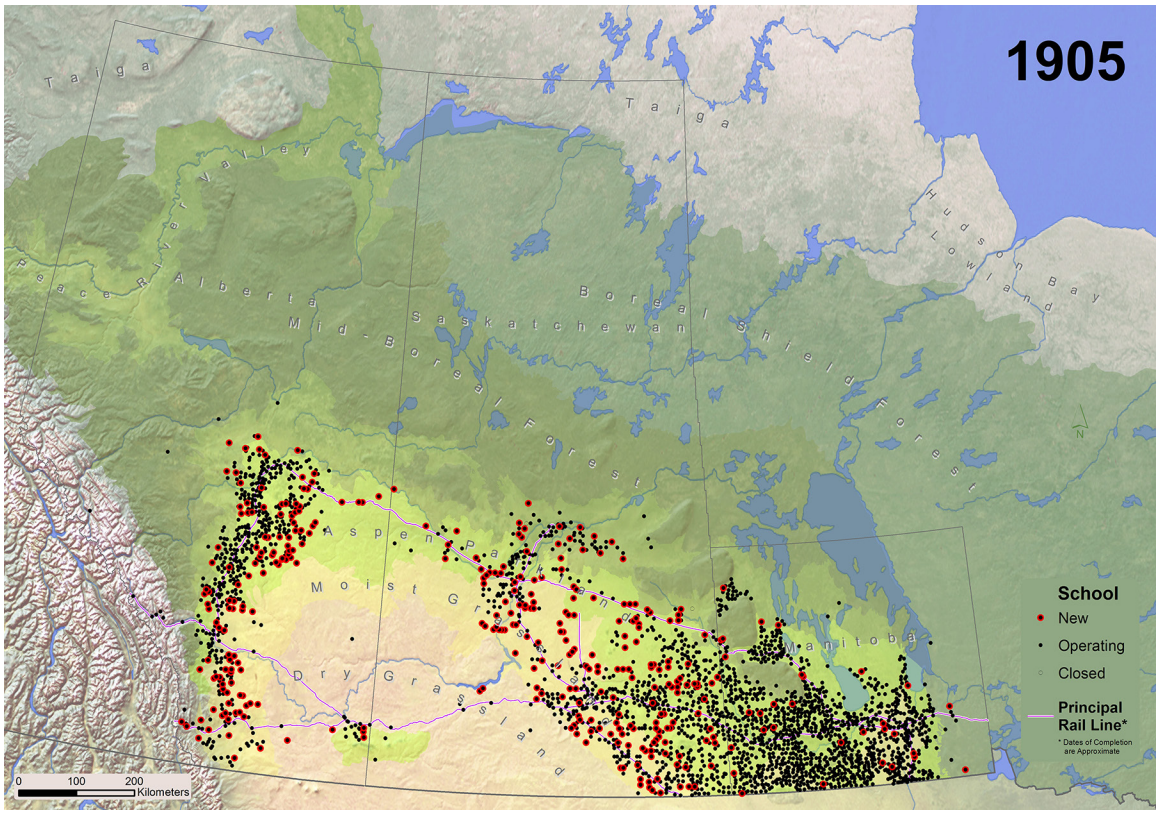


Figure 9
School districts in Manitoba, Saskatchewan and Alberta in 1905

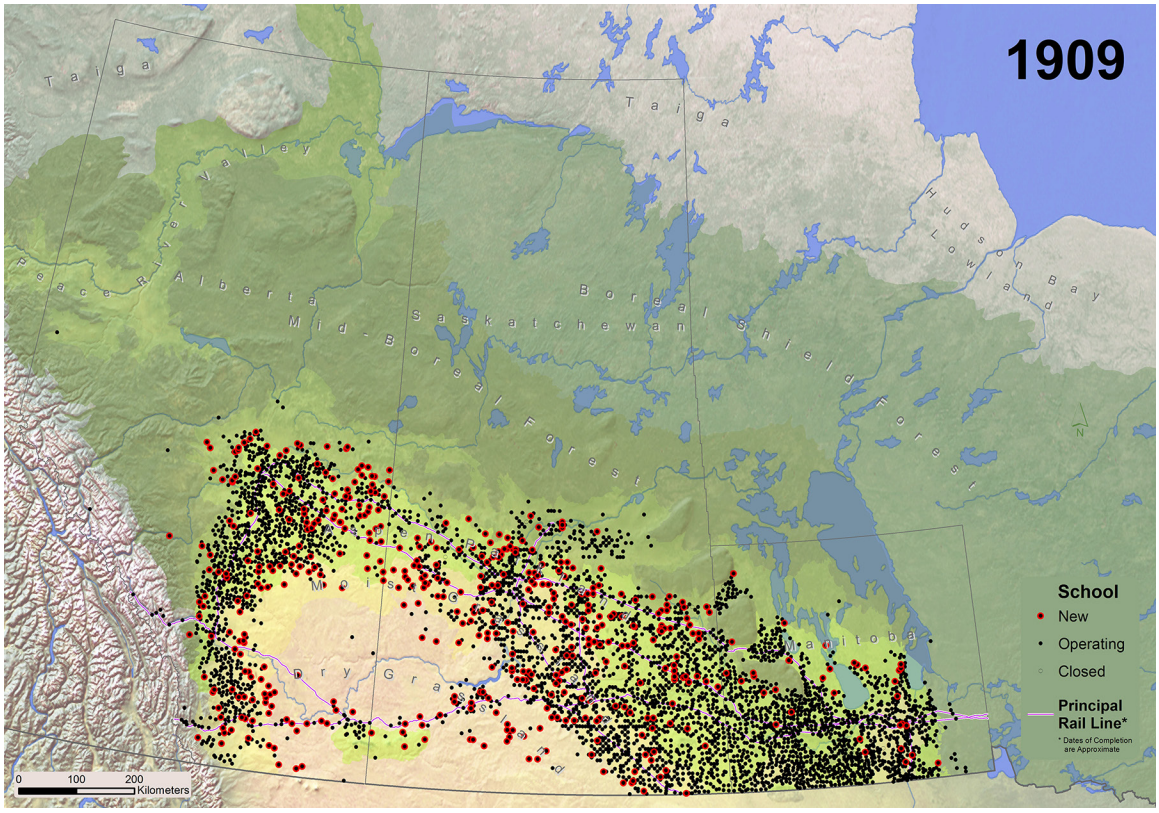


Figure 10
School districts in Manitoba, Saskatchewan, and Alberta in 1909

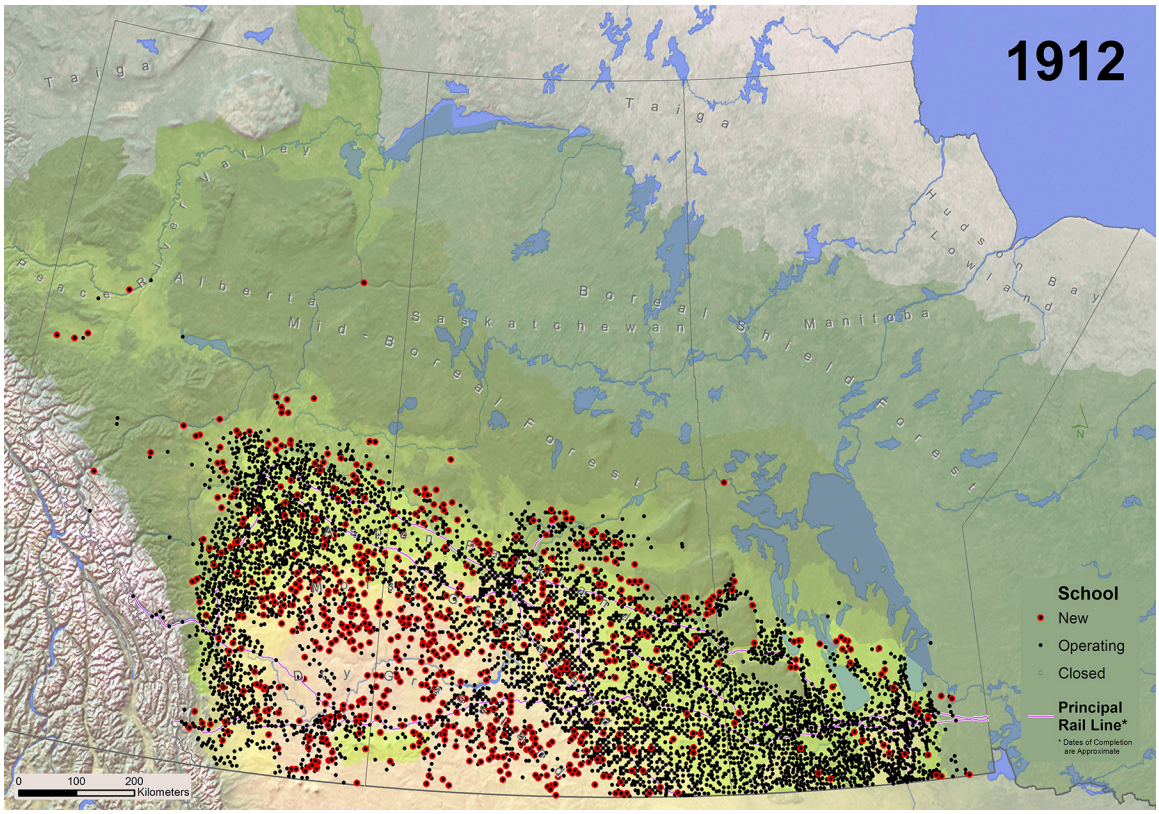


Figure 11
School districts in Manitoba, Saskatchewan, and Alberta in 1912

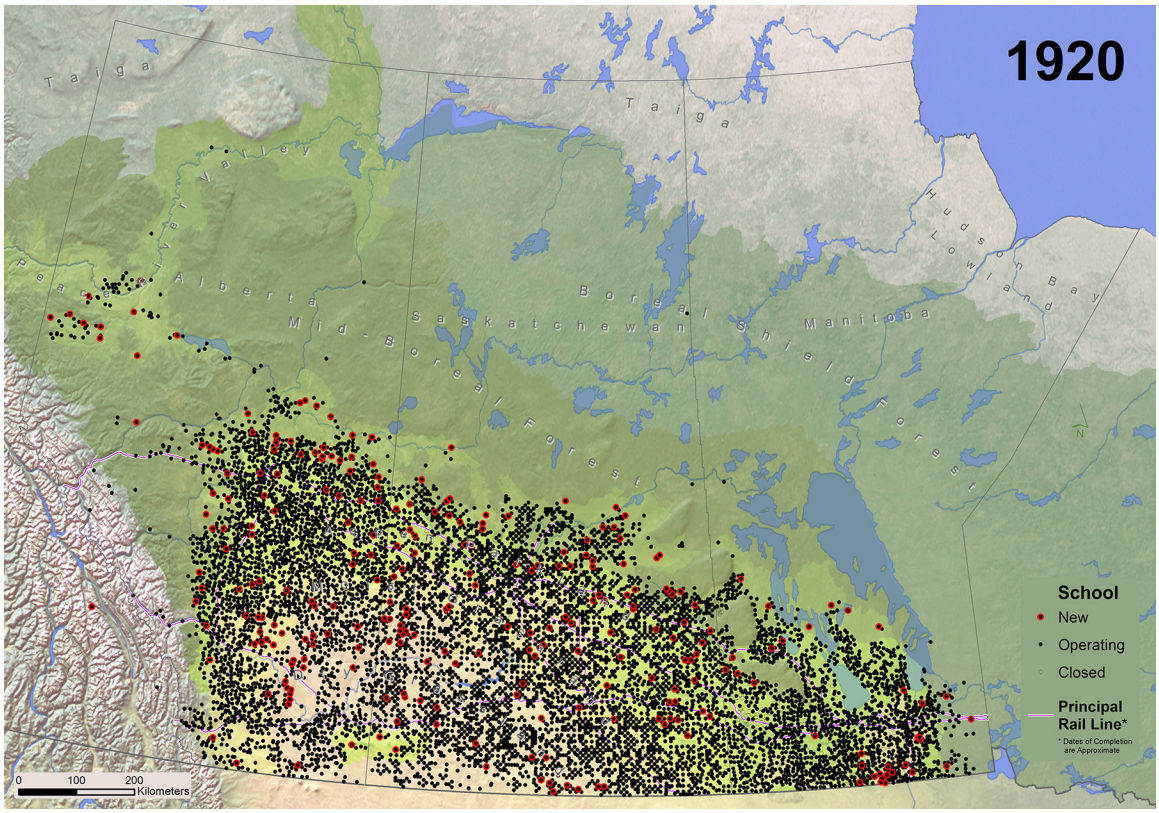


Figure 12
School districts in Manitoba, Saskatchewan, and Alberta 1920

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Prairie Perspectives: Geographical Essays
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Identifying diversity in rural schools on the Upper Great Plains, USA: GIS modeling to optimally place P-12 teacher education candidates

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As primary and secondary student populations in North American schools become increasingly diverse, university teacher education programs must adapt by building cultural responsiveness in the next generation of primary through grade 12 (P-12) teachers. Sometimes considerable restructuring and even institution-wide change becomes critical in these processes. Recently, a small university in rural North Dakota, USA faced challenges ensuring its students had clinical experiences that provided opportunities to interact with diverse P-12 students, peers, and instructors. One component of these challenges included limited exposure to diverse students during the clinical experience teaching sessions of the university's teacher education candidates. Since the population near the university is overwhelmingly white, P-12 schools with the highest percentages of students with diverse backgrounds needed to be identified as places where teacher education candidates could learn their profession. This article draws from the field of GIScience to produce a GIS-based spatial decision support system (SDSS) to help identify locations where teacher education candidates can experience opportunities to differentiate instruction for diverse learners. In so doing, it provides a unique approach to identifying diverse learning communities given the limitations of the university's surrounding demographic.

Keywords: GIS, SDSS, diversity in P-12 teaching, North Dakota, rural communities

Introduction

Established in 1889, Mayville State University (MSU) is located in Mayville, North Dakota, a small town of about 1,858 residents (United States Census 2010). With a current enrollment of less than 500 full-time, on-campus students it is the smallest university in the North Dakota University System. The strategic plan of MSU has long centred on the training and certification of primary through grade 12 (P-12) teachers. Recently, this training has been overseen by the National Council for Accreditation of Teacher Education (NCATE), which acts as the accrediting body for educator preparation at MSU.[2] In 2014, MSU faced challenges ensuring teacher candidates had clinical experiences that provided opportunities to support their work with diverse P-12 students, peers, and instructors which was a measured component of NCATE accreditation Standard 4: Diversity (NCATE 2008; NCATE 2014).

The problem faced by MSU was that each teacher education candidate had to complete a number of observation and clinical experience teaching sessions in state accredited schools. In these sessions, teacher education candidates are required to interact with and teach diverse P-12 students to ensure they are better prepared to serve an increasingly diverse P-12 student population. MSU's problem was providing the clinical sessions for its

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teacher candidates as local school districts did not appear to contain enough non-white students to make these immersive experiences with 'diversity' possible.

The NCATE accreditation document (2014) defined "diversity" as: "Differences among groups of people and individuals based on ethnicity, race, socioeconomic status, gender, exceptionalities, language, religion, sexual orientation, and geographical area." As such, MSU teacher education candidates were receiving only limited exposure to diverse students during these clinical experience teaching sessions. To meet the requirements of NCATE, P-12 schools with higher percentages of students with diverse backgrounds needed to be specifically identified so MSU teacher education candidates could implement teaching strategies for diverse learners in diverse classrooms. This article describes a project where GIS was employed to optimally place P-12 teacher candidates by identifying diversity on the Upper Great Plains. By incorporating interactive mapping and data analysis software from the field of GIScience, a GIS-based spatial decision support system (SDSS) was introduced to assist in the process of determining where to best place teacher education candidates. A review of the project shows that SDSS provided innovative approach to identifying diversity using open access data and publically available software.

Literature Review

The project that is the basis of this study was undertaken between 2014 and 2016, when the Educator Preparation Program of MSU was preparing for an NCATE focus visit on Standard 4: Diversity. As such, this SDSS served as part of a more comprehensive campus-wide initiative to diversify MSU that included a broad suite of changes such as the hiring of a diversity coordinator, constructing an interdisciplinary diversity task force, making overarching changes to recruitment policies, developing scholarship and waiver programs specifically for diverse teacher education candidates, creating partnership agreements with colleges with significant numbers of diverse faculty and students, organizing educational travel experiences for students to develop a greater awareness of cultural diversity, keeping more detailed and systematic records of the interactions of candidates with diversity, and completely redrafting the university strategic plan. While this represented principled changes, putting 'diversity' into practice at the ground level proved challenging because of the limited ability of students to travel far distances. The Educator Preparation Program needed to place teacher education candidates nearby and still expose them to the required diversity.

The scope of recent literature on diversity in P-12 teacher education covers a broad series of topics. These include questions such as what the most effective teacher preparation for diversity is (Garibaldi 1992; McCain-Reid 1995; Gay and Kirkland 2003), studies of rural preservice teachers' perceptions of diversity (Wenger and Dinsmore 2005), the analysis of ignorance of and resistance to diversity (Garrett and Segall 2013), studies of the needs of diverse students the complexities of interactions with diversity (Cornbleth 2008; Sleeter 2008; Miller and Mikulec 2014), how to build diversity into teacher education programs (Barnett and Ceasar 2009; Kerr and Dils 2011), all against the background of debates over the very semantics and meaning of 'diversity' (Muffoletto 1995; Chorcran-Smith 2004; Turner-Vorbeck 2013). Despite these broad areas under study, much of this literature does not adequately account for the local realities of many places in rural North America, specifically the lack of ethnic diversity present within the thousands of small towns and sparsely populated communities across the Upper Great Plains. This article contributes to the literature on preparing rural pre-service teachers for diversity in P-12 education by spatially illustrating the complex geographical issues facing many rural universities as they work toward balancing the progressive national changes in teacher accreditation with the specific needs of their local communities. In this case, the efforts of MSU to maintain commitment to exposing students to diversity needed to be balanced against the homogenous ethnic character of the rural neighbouring plains communities and the limited mobility of the teacher candidates. This example illustrates that the limitations of the North Dakotan socio-cultural landscape matter.

To assist MSU with providing educational experiences for its students, a geographic information systems (GIS) was employed. Essentially, GIS allow users to collect, manipulate, analyze, and then visualize data spatially in order to solve geographic problems. As part of this process, users may also choose to employ a SDSS to aid their decision making. A SDSS expands the conventional process of geographic data visualization by allowing the user to interactively model or predict numerous outcomes based on defined or selected parameters. As a result, its use has expanded rapidly over the last three decades as a tool for determining site suitability and it has been put to use across a diverse field of applications. Examples that employ GIS-based SDSS range from identifying optimal sites for agricultural production (Jones et al. 2004), to the precision management of tree crops (Peeters et al. 2012), to limiting industrial pollution (Rayed 2012). Indeed, out-of-the-box SDSS apps are now available in cases with more accessible data (c.f. Stauder 2014). Most importantly, when designing a SDSS users can evaluate factors based on selected parameters unique to each case.

Methodology

MSU's face-to-face teacher education candidates tend to originate in the small communities along the Red River of the North in eastern North Dakota and western Minnesota, where many of them return to work in schools after graduation. This catchment includes Griggs, Steele, Traill, Nelson, Grand Forks, and Cass counties in North Dakota, and Norman and the more rural schools in Clay and Polk counties in Minnesota. As shown in Figure 1, the percentage of diversity of the population in these counties hovers between 1 and 10%, a rate significantly lower than the United States national average of around 28% (United States Census 2010). P-12 schools in Grand Forks County and

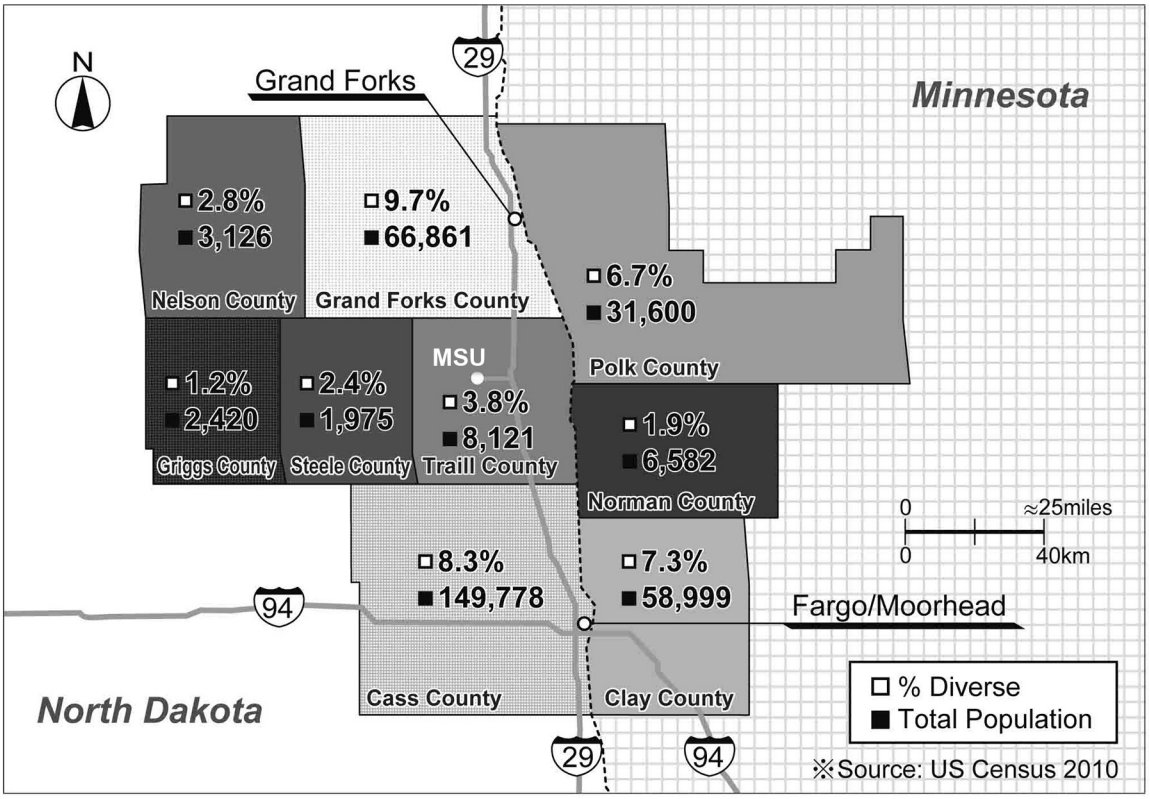


Figure 1
Percent diverse within and total population of counties near MSU

Cass County, situated in the more diverse urban communities of Grand Forks and Fargo, typically draw the majority of their teacher education candidates from the local and larger research universities. For teacher education candidates from MSU, this leaves P-12 schools in Steele, Traill, and Norman counties, among the least populated and least diverse counties in the region. These counties are very sparsely populated and overwhelmingly white, a combination reflected in the ethnic composition of their P-12 student populations. Moreover, continued out-migration from the communities surrounding the campus further exacerbates the issue. This dynamic leads to greater challenges for an educator preparation program in finding diverse placement sites for teacher education candidates and limits the experiential learning that candidates receive.

In efforts to overcome this challenge, an SDSS was based on the following data layers and operationalized in ArcGIS 10.2, a standard GIS for working with maps and geographic information.[3] First, the shapefiles "USA Major Roads" and "US States" were downloaded from ArcGIS.com and clipped to North Dakota and Minnesota. These two files comprised the basemap layers for this project. Next, North Dakota and Minnesota P-12 school location point data was downloaded (c.f. MN DPI 2015; NDGIS 2012). Next, locations of higher education in North Dakota were downloaded (NDGIS 2002) and MSU was clipped from these institutions. Through this procedure an interactive map of North Dakota and Minnesota with roads, P-12 schools, and the relative location of MSU was created.

The states of North Dakota and Minnesota require that teacher education candidates conduct their clinical experience teaching sessions in the grade level category of their eventual licensure. As a result, MSU students must be placed in target schools that can accommodate their primary or secondary education specialization. To make this distinction within the SDSS, grade level data of schools were obtained from the North Dakota and Minnesota Departments of Education (MN DPI 2015; ND DPI 2015). Throughout the study data was divided, evaluated, displayed, and then critically interpreted separately based on primary or secondary specialization.

Alongside grade level data, social information was incorporated into the SDSS. NCATE (2014) had a specific definition of diversity listing "ethnicity, race, socioeconomic status, gender, exceptionalities, language, religion, sexual orientation, and geographical area" as integral components. As such, schools with higher numbers of each of these components were targeted and data sources for each category identified. While data for religion and sexual orientation were not available and were not included in the SDSS, many other quantifiers of diversity were. Using the most currently available data from North Dakota and Minnesota (ND DPI 2015; MN DPI 2015), total numbers of students at target schools by race and social-economic status were entered into Microsoft Excel and then later joined to the downloaded P-12

school location data.[4] A set of choices were made in translating the data into categories: P-12 students identified as bi/multi-racial were considered "diverse," as were students whose primary home language was not English. Social-economic status was determined by the numbers or percentages of students receiving free or reduced meals. The Excel sheet was also conditioned by the level detail of state census. For example, data distinguishing students by exceptionality and primary home language were not publically available on the school level for North Dakota, but were for Minnesota.

Factoring distances between MSU and target P-12 schools into the SDSS was also crucial for education candidates with limited budgets, time, or ability to secure short-term housing. Schools located closer to MSU campus meant students could remain in the university dormitories or their current place of residence, while those geographically distant may require obtaining short-term accommodation nearer to the host school or longer commutes, a matter that is especially problematic in winter months where travel is hazardous. The distances to primary and secondary schools that had previously hosted MSU students was therefore an essential component of the study, and were calculated using ArcGIS Network Analyst.

In consultation with the chair and faculty in the Department of Education & Psychology at MSU, each of the above "grade level," "distance," and multiple "diversity" layers were reclassified and assigned points based on their perceived importance to the accreditation agency and student experiential needs. These variable layers, sub-classifications, and assigned values are listed in Table 1. It is vital to note that although NCATE's published definition of "diversity" made no obvious quantitative value distinction between types of diversity across identity groups (Gollnick 2011; NCATE 2014), significant variances did exist in specific cases. Racial diversity was the most crucial element in that definition in terms of the NCATE focus visit. As Table 1 shows, schools with higher percentages of students of diverse ethnic backgrounds were given greater weight than those with higher numbers of students from lower socio-economic backgrounds.

Upon completion of the SDSS, the following point value ranges were matched to a suitability ranking for each school. As shown in Table 2, schools whose scores ranged from 70 to 100 in the SDSS were rated as optimal, those between 51 and 69 as acceptable, and those less than 50 as unacceptable.

Table 1
Variable layers and point value classifications

Variable Layer	Sub-Classification	Assigned Value (points)
Grade Level	P-6	Restricted or permitted
	6-12	Restricted or permitted
Distance from MSU (miles)	1-39 miles	50
	40-59	30
	60-74	20
	>74	10
Race (% diverse)	50-100	100
	25-49	60
	10-24	20
	1-9	5
	0	0
Free Lunch (% of students)	50-100	40
	25-49	30
	10-24	10
	1-9	5
	0	0
Reduced Cost Lunch (% of students)	50-100	20
	20-49	10
	1-19	5
	0	0
Exceptionality (%) MN only	>6	20
	1-5	10
	0	0
Language Diversity (%) MN only	>9	30
	1-8	20
	0	0
Total Possible North Dakota		210
Total Possible Minnesota		260
Final Point Range Accumulated in SDSS= (Earned points/total possible)*100		

Results

Of the near 100 schools that MSU education candidates have conducted their clinical experience teaching sessions at in the last three years, only five proved to be "optimal" and four proved "acceptable" in terms of potential exposure to diversity.[5] Over 90% of schools where MSU teacher education candidates are placed were classified by the model as "unacceptable" locations in relation to the diversity necessary to support optimal clinical experience teaching sessions. As detailed in Table 3, the results of primary schools provided more options than secondary, with two optimal locations in both North Dakota and Minnesota.

When compared with the primary schools, the results of the SDSS for secondary education proved more problematic. Table 4 shows that only one school in North Dakota and one in Minnesota ranked as "optimal."

Despite proximity to MSU, the vast majority of both local primary and secondary schools were scored "unacceptable" in terms of diversity by the SDSS. The locations of "optimal" and

Table 2
Ranking and point value ranges in the SDSS

Suitability Ranking	Point Range accumulated in the SDSS
Optimal	70-100
Acceptable	51-69
Unacceptable	<50

Table 3
Primary education SDSS results

School Name	SDSS Points (%)	City, State	Ranking
Minnewaukan Public Schools	71	Minnewaukan, ND	Optimal
Minto Public Schools	69	Minto, ND	Optimal
Climax-Shelly Public School	71	Climax, MN	Optimal
Century Elementary	60	Grand Forks, ND	Acceptable
Nathan Twining AFB	57	Grand Forks AFB, ND	Acceptable

Table 4
Secondary education SDSS results

School Name	SDSS Points (%)	City, State	Ranking
Minnewaukan Public Schools	95	Minnewaukan, ND	Optimal
Climax-Shelly Public School	71	Climax, MN	Optimal
Minto High School	60	Minto, ND	Acceptable
Fargo South High School	55	Fargo, ND	Acceptable

"acceptable" primary and secondary schools in relation to MSU are shown in Figures 2 and 3.

Discussion

Initial inspection of the SDSS results confirm the considerable difficulties faced by MSU in getting teacher education candidates into school systems comprised of diverse students for their clinical experience teaching sessions. Not only did the results fail to qualify for NCATE, they are particularly troublesome since they show schools less than 50 miles away do not possess the diversity necessary for teacher education candidates to implement teaching strategies that would incorporate diversity learning exercises. Without a diverse classroom to begin with, teaching tolerance and plurality becomes a greater challenge for the teaching candidates. Indeed, many local schools accumulated the least points in the study, relating directly to the lack of ethnic diversity in the smaller towns along the Red River of the North as seen in Figure 1.

Despite the initial shortcomings of MSU's location, this does not mean the situation is completely dire. Indeed, the SDSS revealed two key areas to target to increase MSU teacher education candidates' exposure to diversity. As seen in Figures 2 and 3, Minnewaukan Public Schools next to Devils Lake accumulated the highest point totals in both primary and secondary education. This is a direct result of the large number of Native American students coming from the Spirit Lake Nation. When the distance from campus is factored in to the study however, MSU teacher education candidates would likely need to acquire a place of residence closer to the area. An opportunity much closer to campus is identified in Figure 2 in the region of Grand Forks located at Nathan Twinning Air Force Base. Considering the diverse nature of those serving in the US military, it follows that there is an associated level of diversity among their children in the primary school at the base. Few MSU education candidates have had their clinical experience teaching sessions at either Minnewaukan Public Schools or the Air Force base, illustrating considerable opportunity for expanded collaboration with schools in those areas.

SDSS ranking also found that Climax-Shelly in Minnesota was rated highly for diversity on both the primary and secondary school levels. This suggests that further expansion of clinical placements into eastern and northeast Minnesota could prove useful since, as shown in Figures 2 and 3, a daily commute from campus would be feasible. Finally, Minto Public Schools were also rated highly for diversity on both school grade category levels, possibly as a result of a growing community of new immigrants. While this may present an opportunity to emplace teacher candidates in a diverse school, it is more likely simply a statistical anomaly related to a very small student population. More detailed information regarding the dynamics of this school system is required.

Conclusions and Implications

The goal of this project was to build a SDSS to best place teacher education candidates within local schools for teacher observation and clinical teaching experience sessions while providing optimal exposure to diversity. In this case, the SDSS cartographically illustrated both the complexity of the initial problem and provided possible solutions. In so doing, it demonstrated how publically available data can be evaluated, displayed, and then critically interpreted to generate solutions to specific questions. Based on the spatial nature of the visualizations produced by GIS and SDSS, the expansion of "geographical area" categories used in clinical experience teaching sessions would considerably assist MSU students in becoming more culturally responsive, reflective, and dynamic educators. However, it may also come at a cost to local school systems. If these future teachers migrate away from the small communities along the Red River of the North to other areas of the country, it follows that many will not return. The cumulative effects on a region suffering from sustained depopulation and rural decline could be debilitating.

The accuracy of any SDSS is partially contingent on the quality of its data – in this case it was structured on a division by grade level and includes weighted layers based on expert-evaluated parameters. North Dakota does not publish primary language and exceptionality information on the school level, and neither state provides detailed information regarding the diverse nature of their teaching staff. Furthermore, this model simply provides locations. In doing so, it fails to engage larger theoretical debates found in the literature over the semantics of "diversity", or even whether the identification of diversity actually builds cultural responsiveness. Despite these limitations, the model did suggest a number of key target schools previously only tangentially considered.

Model results also showed that few local P-12 schools outside of the two metropolitan areas of Grand Forks and Fargo/Moorhead are optimal locations for candidates. As MSU students must now look to these more distant urban centres to gain experiences teaching students of different cultures, they face the prospect of longer commutes and considerable competition from teacher education candidates of larger research universities for a limited number of clinical experience teaching positions. As such, considerable opportunities exist to expand the presence of MSU teacher education candidates in Minnewaukan Public Schools, Climax-Shelly Public School, the Nathan Twining AFB, and possibly the Minto School system. Considering the more general lack of ethnic diversity near MSU, its Educator Preparation Program must further reach out to newer, more dis-

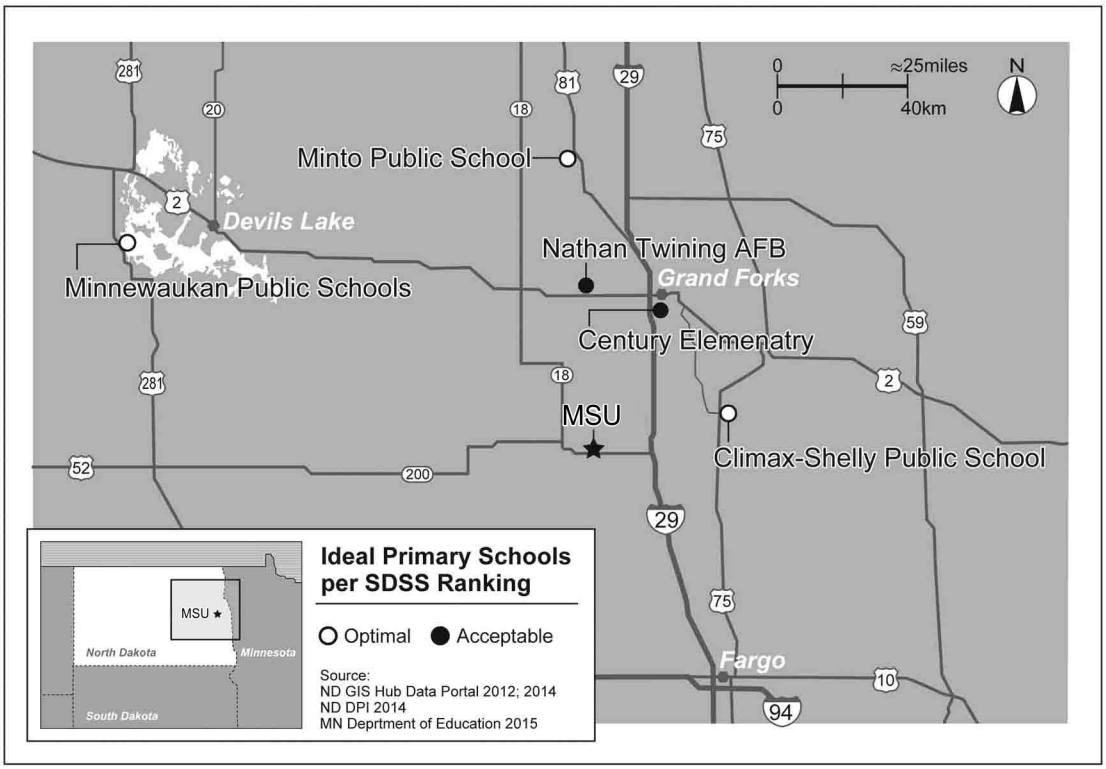


Figure 2
Suitability results for primary education as calculated by the SDSS

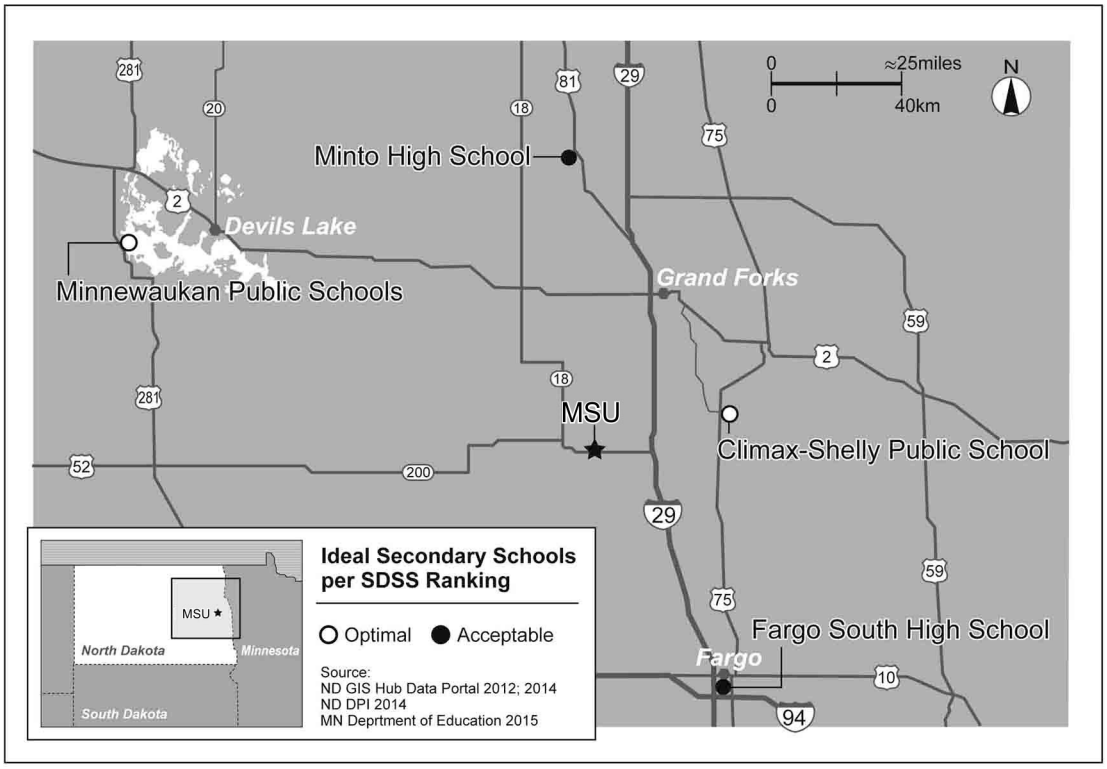


Figure 3
Suitability results for secondary education as calculated by the SDSS

tant, and possibly highly urbanized places across the Midwest as locations for candidates to interact with diversity. This includes intentionally taking students to the diverse learners through immersion field experiences.

Throughout this study data was divided, evaluated, displayed, and then critically interpreted separately based on primary or secondary specialization. This ability to cater analyses to specifically user-defined criteria is a valuable advantage of a SDSS. Likewise, new data may be added and the corresponding results easily updated within the system. The SDSS afforded MSU the ability to statistically and spatially explore placement options as it continues to identify future opportunities for its students. It became a vital new tool, demonstrating how freely-available data can be analyzed in a GIS and cartographically displayed to help generate ideas and find solutions to difficult problems.

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Notes

[1] This study was conducted in partial fulfillment of the requirements of the graduate certificate program in Geographic Information Science at the University of North Dakota in Grand Forks, USA.

[2] Technically, the accrediting body is now the Council for the Accreditation of Education Preparation (CAEP). This article refers to the period of time just prior to the consolidation of NCATE and TEAC into CAEP. In effect, RNDU had a CAEP team under a NCATE legacy visit.

[3] While the licensed version of this software was used for this project, the free version available at www.arcgis.com provides similar analytical capabilities.

[4] Note the possible confusion with semantics. For example, the North Dakota Department of Public Instruction refers to this as "ethnicity" and has no cat-

egory for "race". For North Dakota, "Ethnicity" is divided into "White", "Native American", "Black", "Asian", and "Hispanic".

[5] I cannot be more precise than 100 as some of the schools have closed or amalgamated. In other cases, our records were missing some data.

Prairie Perspectives: Geographical Essays
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Canadian Association of Geographers
Association Canadienne des Géographes

An icy response to the collective need for winter walkability: Mobilities research and the *Surefoot* Winter Walking Conditions Bulletin

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The icy and snow-packed conditions of sidewalks in winter cities create inequitable access for pedestrians. Safe Communities Winnipeg's Surefoot *initiative was a unique endeavour to develop a winter walking advisory to address fall-related injuries. This article reports on a mobilities research approach to producing geographic knowledge concerning the shared meanings and experiences of physical movement in difficult walking conditions characterized by variable friction conditions of ice and snow. The research provided the basis for the creation of a rating scale accounting for the level of difficulty of walking on winter sidewalks. However, public, media, and municipal rejection of the winter walking conditions bulletin exposed profound societal hostility towards accessible pedestrian environments. These findings reveal the need for multi-method research incorporating human-centred approaches with physical analysis of winter conditions. It is imperative that further research provides a foundation for winter cities that are responsive not only to car drivers, but also to persons of all physical abilities who walk and cycle in extreme northern climates.*

Keywords: Winter pedestrian conditions, mobile methods, sidewalk advisory system, accessible winter cities

Introduction

On the northern prairies of North America, winter conditions lasting up to six months present unique barriers to movement. The cold, wind, and precipitation typical of high continental latitudes leads to varying and unpredictable accumulations of ice and snow that contribute significantly to safety issues for pedestrians using walkways as a means of mobility. Despite the many impediments to winter walking, most research on winter conditions in cities overlooks how humans actually move and instead emphasizes the design of outdoor spaces to enhance comfort and engagement (Eliasson et al. 2007). The absence of a focus on pedestrian-friendly winter environments... raises the question of whether sustainable mobility approaches are a priority in northern climates.

While winter pedestrian planning processes have long developed in European spheres, they are of comparatively recent concern in North America. In addition, the region faces many challenges. There is a lack of strong transportation planning such as infrastructure development, while land-use patterns characterized by low-density design and separation of uses continue to be promoted supporting car-centric cities (Lo 2009). In planning discourses on winter pedestrianism, the domination of an automobile-based mentality leads to inequity and, ultimately, hierarchies of power based on accessibility to mobility. For example, Perrier et al. (2006) found that literature on snow clearing is

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exclusive to road maintenance. In places like Winnipeg, Canada, this observation may be verified: policy and budget concerns of both the municipal government and public on snow clearing are directed specifically for roads. Driving is assumed to be the main mode of transport and there is limited attention placed on sidewalk conditions and the distinct needs of pedestrians.

Winnipeg's snow clearing policies are based on a system that treats roads and sidewalks equally (City of Winnipeg 2011). The emphasis on street clearing techniques without recognition of distinct sidewalk conditions is compounded by a myriad of factors including the packing of ice and snow by walkers, changing daily conditions such as the shift from freezing to thawing, and micro-environments resulting from sun coverage and blowing snow. Furthermore, the clearing of sidewalks is inconsistent and does not match the attention given to streets. A habitual practice of street clearing is to plow chunks of snow and ice onto sidewalks creating barriers for walkers. This unequal relationship between cars and pedestrians suggests the first step in formulating policy to enable more accessible winter walking should involve raising awareness of how humans experience icy and snow-covered sidewalks.

Most investigations of winter walking conditions are based on mechanical engineering measurements, such as levels of friction and degrees of slipperiness. However, a major shortcoming of these studies is their failure to account for the actual movement of winter walkers. In contrast, this article illustrates how a mobilities research approach allows for exploration of the actions, practices, and experiences of winter walkers and the meaning of walking in spaces with changing ice and snow conditions (Merriman 2014). The mobilities paradigm offers new ways of developing interconnected geographical knowledge regarding the shared meanings and embodied practice of physical movement (Cresswell 2010). Ultimately, consideration of mobilities theory facilitates understanding how disparate experiences emerge between drivers and walkers in winter cities.

This article explores the contribution of the mobilities approach to enhanced safety for winter walkers in three sections. It first evaluates the current contribution of research on ice and snow-covered pedestrian environments to emphasize the need for an enhanced understanding of the experience of winter walking through a mobilities approach. Second, it applies this analysis by reporting on a mobilities research strategy adopted to develop an advisory system for city winter walking conditions. In this section, the *Surefoot*: Winter Walking Conditions Bulletin case study illustrates the value of applying new methods to winter conditions in order to better understand the needs of winter walkers and also illustrates the dominance of a car-centric society. The third section of the article highlights how short-lived municipal support for the sidewalk advisory system and on-going public objection created friction indicative of the institutional constraints at the root of inequitable mobility for all citizens in a winter city.

Slippery winter sidewalks: The measurement or experience of friction?

The traditional approach in mobility research is to focus on how places are connected by transportation (Cresswell 2011). More recently however, studies are less inclined to take movement between places as a given. Mobilities researchers have grown concerned with embodied movement and the meaning and experiences shared while moving from one place to another (Cresswell 2010). The present study seeks to explore the value of the mobilities perspective by emphasizing the investigation of walking as a form of mobility and by studying the spaces in which it occurs. Doing so reveals how traditional research on winter sidewalks is limited by its narrow focus, and demonstrates how the adoption of a more holistic understanding of mobility could potentially contribute to safer winter pedestrianism.

Most research on the safety risks of winter walking conditions is mechanically oriented, emphasizing friction-based measurements of slipperiness based on the biomechanics of walking. While this is an important starting point, there are significant gaps in knowledge regarding how pedestrians perceive and respond to varying conditions such as loose snow and ice. New research underscores how a human-centred perspective can help understand the context of place for winter pedestrians. For instance, the measurement of slipperiness is based primarily on mechanical slip test methods with friction-based criteria (Gronqvist et al. 2001). It explains that slipping occurs "when the coefficient of friction (COF) between footwear and a walkway surface provides insufficient resistance to counteract the resulting force" (Gao and Abeysekera 2004, 573). While this and various methodologies and mechanical equipment have been developed, there is no universal acceptance of slip resistance measurements and few measure icy surfaces (Gao and Abeysekera 2004). But at a deeper level these biomechanical methods fail to bring mobility into the research process and explore the interconnections of action, practices, and experiences. Exploring these elements can produce important new understandings about the microenvironments of winter walking.

The inadequacies of mechanical measurement of risk conditions on winter pavement are revealed by the problems encountered with a predictive model developed by the Finnish Meteorological Institute (Ruotsalainen et al. 2004). As a special version of their road weather model, an instrument was used to monitor the slipperiness of walkways based on surface thickness of water, snow, and ice in order to estimate the prevailing friction. However, the complex weather and environmental factors that cause slippery winter sidewalks limited the model's effectiveness. Estimation of friction slip values was low in the winters of 2011 and 2012 because high snow accumulations caused technical problems with the monitoring instruments (Hippi 2012). The insufficiencies of the Finnish predictive model illustrate the failure of mechanical tests on snow and ice, and highlight the need for innovative methodologies to address the risks to pedestrians in winter conditions.

The friction of ice is a complex problem requiring systematic study of the multitude of factors that contribute to slips and

falls. However, the study of the effect of winter weather on pedestrian accessibility remains limited and the focus of mechanical measurement continues to be on indoor-falls of the elderly or work-related accidents caused by slippery floor surfaces (Li et al. 2006). Yet as Gao et al. (2004) point out, icy and snowy surfaces near melting temperature are more slippery than indoor floors. Overall, the limited investigation of icy surfaces suggests the need for a broadened understanding that could inform policies addressing the risk of slips and falls on winter sidewalks. This need is amplified since the safety of sidewalks in winter is extremely variable due to changing conditions throughout the entire season and the inconsistency of snow clearing. Winnipeg's winters are characterized by extreme cold, Arctic winds, and high snowfall accumulation for an extended period of the season. The cumulative effects of weather and inadequate snow removal create a range of conditions that complicate techniques to measure slipperiness on sidewalks. The city is also characterized by low population densities with a widespread network of sidewalks and varying environmental and infrastructure conditions that result in a wide range of microclimates. Mobilities research shows how the essence of this variability can be captured.

The new mobilities paradigm provides a foundation for developing qualitative methodologies to make richer accounts of perceptions and subjective interpretations of people's experiences of movement (Sheller and Urry 2006). Yet while there has been theoretical advancement, innovations in methods employing mobile practice are only beginning to emerge. Strategies have included both video ethnography and observational fieldwork, but D'Andrea et al. (2011) suggest that more innovative approaches are required that emphasize techniques in mobile situations and that elicit the experiential, embodied, and phenomenological aspects of movement. Here, 'mobile methods' have been proposed as a solution. The key to mobile methods lies in accessing the act of movement that allows the environment to be experienced. Mobile research strategies make less tangible aspects more visible, allowing more accurate tracking, understanding, and representation of the embodied nature of movement (Merriman 2014). In the case of winter sidewalks, physical movement can only be understood through exploring the meanings, narratives, and embodied practice of moving that walkers experience on routes that are uneven and unpredictable.

This article reports on how a mobile methods approach was employed in developing a walking conditions bulletin for residents of Winnipeg. To carry this out, a group called the Safe Communities Winnipeg Falls Prevention (SCWFP) Committee was organized with the purpose of exploring whether a summary evaluation of walking conditions would be adequate for winter walkers and if it could reflect their experiences of various levels of friction on winter sidewalks. To this end, a five-point rating scale reflecting the level of difficulty of winter sidewalks was developed by the research team. Its testing required winter walkers to employ mobile practices through the human-based rating system and, most importantly, included making the field observations for more in-depth understandings of the experience. Mobile methods were instrumental in building this rating system and were seen to provide awareness and perception of slippery conditions that may occur in a winter city. The focus on field observations became an important part of the final advisory bulletin that was developed for reporting winter sidewalk conditions.

Surefoot: Winter Walking Conditions Bulletin

The walkability study in Winnipeg was initiated to explore the value of an advisory system for informing the public about potentially hazardous winter walking conditions. It was based upon the World Health Organization's Safe Communities concept, a widely accepted intervention model for safety promotion and injury prevention (Lindqvist et al. 2001). Initial community consultation in 2008 identified outdoor falls as a key priority area, and a falls prevention committee was subsequently established. In February 2009, emergency departments and family doctors reported an increase in fractures and other fall-related injuries after an unusual and severe ice storm occurred in Winnipeg. The rain and ice resulting from the storm were also the impetus behind the SCWFP Committee's development of an intervention tool for disseminating information to the public about the condition and safety of daily winter weather-related walkways.

As discussed above, a gap in the research literature exists regarding appropriate methods to examine the experience of winter walking conditions. Therefore, the project to develop a winter sidewalk condition bulletin had no parameters or protocol to follow in designing a safety reporting system. It was envisioned that a winter walkway rating system would integrate both a description of the range of sidewalk conditions that occur during a typical winter as well as assess the relative ease of travel on these sidewalks. To this end, the research team developed a preliminary instrument comprising a five-point scale which rated winter walking safety as either *very easy, easy, moderate, difficult,* or *hazardous*. The label assigned to each level of difficulty was related to the concept of accessibility: *very easy* portrayed conditions that all walkers would be capable of traversing while *hazardous* imparted that conditions were so difficult as to be impassable. The rating system also captured the condition of the walking surface in relation to snow ploughing and sanding, along with descriptors such as 'foot-packed,' 'icy with loose snow on top,' or 'slushy.'

Besides establishing levels of difficulty, a mobilities approach suggested it was equally vital to physically explore these ratings and descriptors to approximate understanding them from the perspective of the winter pedestrian. During the winter of 2009–2010, 20 older volunteers reported walking conditions using the sidewalk condition ratings instrument at random locations throughout Winnipeg. The observations of this group were essential to determine if a shared understanding existed of the categories of the five-point scale which could reflect experiences of walking on winter sidewalks in various locations and in changing conditions. As mobilities research notes, the inclusion of the experiences and perspectives of older adults reveals that a range of different mobilities exists which are often constrained by institutional assumptions about the meaning of 'normal'

walkers (Cresswell 2010; D'Andrea et al. 2011). To this end, the SCWFP Committee's investigation also attempted to better understand the pedestrian environment through the lens of people with mobility challenges.

To ensure consistency and adequate spatial coverage of the city, one student research assistant took multiple observations along predetermined routes throughout all parts of the city. Walking conditions were also rated on a range of streets that had different levels of snow clearing priority (P1, P2, and P3). The research assistant carried out winter sidewalk observations two days per week for approximately five months. On these days, the researcher would typically spend from four to six hours collecting data on sidewalk conditions along two of the six data collection circuits located on major bus routes covering all parts of Winnipeg. For each planned route, between three and five data collection stops were completed along high priority (P1) sidewalks with closely proximate lower priority sidewalks (P2 and P3) being rated at the same time.

The mobile methodology employed by the field researcher ensured both precision in data collection and approximation of the embodied experience of movement. Indeed, the difficulty levels of the ratings instrument would have had little meaning without the mobile methods employed to expand the researcher's understanding of the experience of walking in winter. Field notes about sensory cues showed how winter walkers respond to slip hazards by adapting their walking speed. The level of difficulty of sidewalks representing the three snow-clearing priorities was noted. Walking conditions and weather patterns were also observed. Being immersed in pedestrianism throughout the winter, the researcher became increasingly aware of these conditions. The framework (Figure 1) that evolved was more informative than merely a five-point rating system would have been. This immersion as a winter walker confirmed that the ascribed level of difficulty was a reflection of predominant weather and surface conditions and the level of precaution a walker must take to avoid the risks of slips and falls.

Using the ratings instrument and general descriptors, a total of 516 observations were completed by both the volunteers (n=204) and the research assistant (n=312) through the winter of 2009–2010. Ratings of sidewalks were recorded on 63 out of 94 potential days during this winter season. The data observations provided important geographic knowledge concerning the human experience of movement in winter conditions. These were evaluated using statistical methods to determine if the observed difficulty of travel was associated with weather-related factors. A weak positive relationship ($R^2 = 0.2335$) was noted between precipitation and observed level of difficulty of sidewalk travel indicating that respondents generally rated travel as more difficult on days when snowfall was reported. In one instance the average difficulty level of sidewalks after a January snowfall remained above previous levels for the remainder of the winter illustrating how accumulations of snow created increasingly difficult conditions. In contrast, there was virtually no correlation between daily temperature extremes and observed sidewalk difficulty ($R^2 = 0.0007$, daily maximum temperature; $R^2 = 0.0003$, daily minimum temperature).

DIFFICULTY	DESCRIPTOR	CAUSAL FACTORS
EASY	Bare pavement, no ice	
MODERATE	Mostly bare pavement, some isolated slippery sections	i.e. First wet snowfall of season
	Compacted snow, isolated slippery sections (not plowed?)	
	Compacted snow, recently plowed (can be very slippery if below -20°C)	
	Compacted snow, isolated minor drifts	i.e. During or immediately following strong winds
	Loose snow, 0 to 5 cm accumulation	
DIFFICULT	Fresh snowfall, exceeding 5 cm accumulation	
	Compacted snow, frequent major drifts	i.e. During or immediately following strong winds
	Loose snow, slushy	Temp approaches 0°C
	Compacted snow, unven icy sections	Cold period following temporary melting
	Ponded water, icy sections	Temp remains near 0°C during night
HAZARDOUS	Freezing rain	Freezing rain
	Icy spots in morning melting through the day	Temp approaches 0°C during day, drops well below freezing at night

Figure 1
Winter walkway condition rating tool: Framework

A further analysis of the multiple observations recorded by the volunteers and field researcher encompassing the extensive network of Winnipeg sidewalks confirmed that the ratings were consistent overall throughout the city. No significant difference ($\chi^2 = 0.421$) was found in the level of difficulty with which P1, P2, and P3 sidewalks were rated. Accordingly, it was concluded by the SCWFP Committee that a general winter sidewalk condition report would be relevant as an advisory system to inform pedestrians of potentially hazardous winter environments. Other mobilities research on Winnipeg winter sidewalks also confirms the validity of the five-point rating scale. Photographs of winter sidewalks were used for older participants to consider the meaning of walking on these varying surfaces and to rate level of difficulty. Based on two data sets consisting of 91 respondents, the internal consistency of the winter sidewalk difficulty scale was tested using Cronbach's alpha (Lyubomirsky and Lepper 1999). In both samples, the items of the scale demonstrated excellent internal consistency with alpha's of 0.84 (2012–2013 sample) and 0.83 (2013–2014 sample) respectively.

The winter walkway reporting system was based on the development of a framework of five levels of difficulty linked with a set of condition descriptors and causal weather factors. The winter sidewalk condition bulletin was finalized to include both the five levels of difficulty and the related sidewalk conditions. It was anticipated that this information would be a basis for winter walkers to make informed decisions about walking particularly in hazardous conditions. Community support for the initiative was illustrated through collaborative resources including sponsorship by local businesses and the identification of a marketing approach for a walking bulletin concept. A branding company provided free expertise creating a label, designing marketing material, and developing an effective website for the bulletin. The participation of this company was the final phase of developing *Surefoot:* Winter Walking Conditions Bulletin. *Surefoot* was promoted as a sidewalk condition rating system with five levels of difficulty to identify the perceived level of risk for slips and falls on winter sidewalks (Figure 2).

Public support for the winter sidewalk advisory was also demonstrated through several focus groups hosted in 2012 that included older adults and persons with physical disabilities (n=46). These focus groups confirmed that an advisory system was helpful for those who experienced difficulties physically negotiating winter sidewalks. For example, 54% of focus group participants indicated in a survey that the advisory bulletin would be either 'useful' or 'very useful' in making decisions about footwear, taking extra care in walking, and avoiding travel during periods of hazardous pedestrian conditions.

The intended goal was to have the daily condition bulletin reported via local media outlets. It was proposed that *Surefoot* would create greater awareness about potentially hazardous conditions and raise understanding in the community about the difficulty in maintaining adequate sidewalk conditions for all potential users in a winter city. The bulletin was launched in February 2012 to raise public familiarity about the winter conditions that could contribute to falls-related injuries. The launch consisted of a formal announcement by a Winnipeg city councillor who had been a founding member of the SCWFP Committee. At the time, his comments were used as a marker for the level of support from representatives of the municipal government for the initiative:

> This is a ground breaking and valuable new resource in protecting those with mobility issues, especially seniors. I think anyone in our community who's slipped on winter ice can appreciate the importance of the service. Before venturing out on a winter day, we encourage Winnipeggers to check the daily walking conditions bulletin and take appropriate precautions (Smith 2012).

In addition to the official website, the City of Winnipeg placed a link on its own front page to the daily *Surefoot* rating. Their support of the initiative extended into services, and it was the night supervisor in the Department of Street Maintenance who conducted the rating of sidewalks on a daily basis and then conveyed his assessment to the city's communication team. The City participated in the *Surefoot* program throughout 2012 and 2013. However, public and media criticism following the initial exploratory research of the sidewalk rating system ultimately led to diminished support by the City, so that by the onset of winter 2013–2014 the *Surefoot* rating was hidden deep in its webpage structure.



Figure 2
Surefoot: Winter Walking Conditions Bulletin

An icy response: The demise of *Surefoot*

Ultimately, the end of Surefoot reflected larger societal sentiment that winter walking safety was far less important than the needs of the driving public—suggesting a hierarchy of mobility echoed by several writers (Cresswell 2010; Vannini 2010; D'Andrea et al. 2011). Despite community collaboration and support, the SCWFP Committee decided in late 2013 to withdraw the winter sidewalk advisory initiative. The committee had been directed by the necessity of the bulletin as a public health intervention tool to reduce the number of falls-related injuries in winter, but the ongoing negative response of both the public and media led to the end of the initiative. It was determined that acceptance of this approach would require evaluation of its impact. However, since the City withdrew its support in the symbolic action of essentially burying the Surefoot rating bulletin, such an evaluation was not possible.

Throughout the research phase of the project several media outlets garnered interviews with the author as lead investigator of the study. The reporting was generally supportive and emphasized that greater awareness was essential to improve pedestrian safety in winter. While the media appeared to understand the goals of an advisory system, the public's response to the media reports foreshadowed the demise of *Surefoot*. For example, after an interview on a local radio program, postings on the broadcaster's website included many comments that questioned the utility of a winter sidewalk advisory bulletin (CBC 2011). One commenter suggested users could simply "look out the window" to ascertain walking conditions, thus demonstrating that those without mobility challenges are not aware of the existence of barriers to winter walking, such as visual impairments. Such responses ultimately highlighted that increased awareness of the needs of winter walkers was imperative to address improved conditions for all pedestrians in all weather conditions.

After the launch of *Surefoot*, Bartley Kives (2012) of the *Winnipeg Free Press* wrote a persuasive article on the bulletin stressing its efficacy. He emphasized that the cost of developing the winter walking conditions bulletin was minimal, and that the daily rating update would not incur additional expenses to the City. Moreover, Kives wrote that the sidewalk rating was an important prevention tool in reducing the number of falls-related injuries in winter: "*SureFoot*, a daily measure of winter-walking conditions created in an effort to cut down on the number of falls, fractures and hospital stays that result from icy streets and sidewalks" (Kives 2012). He also indicated to readers that the initiative could significantly decrease health care costs and improve the quality of life of Winnipeg residents:

> But *SureFoot* may nonetheless cut down on the $164-million annual cost of treating Manitobans who are injured as a result of falls, said Dr. Lynne Warda of the Winnipeg Regional Health Authority. Approximately 2,000 Manitobans are admitted to hospitals each year because of falls and spend an average of 33 days in a hospital, Warda said. Some elderly people do not fully recover from bone fractures suffered in falls and wind up in long-term care facilities as a result, she added (Kives 2012).

Unfortunately, the media promotion of *Surefoot* was short-lived, as illustrated by an incendiary article in the *Winnipeg Sun* after the first snowfall of winter 2012–2013:

> It's a website aimed at keeping the public informed on winter sidewalk conditions, to prevent slips and falls. But it has stumbled somewhere along the way. And questions have arisen as to whether SureFoot.org has fallen, and can't get up. While Winnipeg endured its first significant snowfall of the season on Saturday, SureFoot.org highlighted a forecast of temperatures between 23 C and 28 C with sunny conditions and a "chance of rain" (Romaniuk 2012).

The comment was representive of other attempts to condemn the value of the winter walking conditions bulletin based on first-time operational difficulties. Soon after, an opinion column was published in the *Winnipeg Sun* that further dampened public perceptions of the need for a winter sidewalk advisory bulletin:

> City hall paid out $5,000 to help create a website that tells people whether city sidewalks are slippery in the winter. We kid you not. Even though the real solution to helping reduce slip and falls would be to clear sidewalks properly, including the use of more salt and sand—as well as taking your own precautions like wearing spiked shoe covers or using a cane if necessary—the city saw fit to blow $5,000 on a website that will achieve nothing (Brodbeck 2012).

The theme of ill-spent government funds in relation to the winter walking conditions bulletin took hold at the national level during the winter of 2012–2013. First, the Canadian Taxpayers Federation awarded *Surefoot* a prize for poorly spent public money. This was soon followed by *Maclean's Magazine* on the front page of their January 14, 2013 issue, with the title "99 Stupid things the government did with your money last year" signifying the final blow for *Surefoot* (Kirby et al. 2013). While many of the items listed in the article represented millions of dollars in government-funded projects, it was difficult to understand the inclusion of *Surefoot*, which operated at a cost of approximately $3000. As Figure 3 illustrates, the magazine made no attempt to understand the goal of the winter walking conditions bulletin, but rather dismissed any value of the initiative to address the need for winter cities to be responsive to all citizens. The obvious message from the public and media was that pedestrian safety in winter is not worth even a few thousand dollars.

Conclusion

Mobility is considered fundamental by many to equal participation in modern society, yet a hierarchy exists where car travel is considered more valuable than walking (Cresswell 2010). The overall interpretation of the attempts by the SCWFP Committee to establish a winter walking advisory represented a lack of understanding about the needs of winter pedestrians. The insensitive response of the public and media to *Surefoot* and the de-



Figure 3
Stupid things the government did with your money last year. Originally published in Maclean's™ magazine on January 14, 2013. Used with permission of Rogers Media Inc. All rights reserved.

mise of the initiative effectively illustrate what Cresswell (2010) refers to as the politics of movement, wherein domination is by those who move the fastest and furthest. Moreover, it signals the need for greater awareness by the public and governments about the need for snow clearing policies that view pedestrians equally in the sharing of urban space and are responsive to unique sidewalk environments.

While Winnipeg's *Surefoot* garnered negative impressions of the utility of an advisory system for winter walking, the research developed for the initiative still represents the value of mobilities studies. Furthermore, it shows that work is required to design health and safety promotion strategies for winter walking that is informed by both measures related to conditions and surface friction, as well as the perceptual experience of pedestrians. Moreover, the use of exploratory mobile methodologies in this study has broadened understandings of a multi-method approach when investigating winter walking conditions. With the depth of understanding achieved by focusing on movement in winter space, the winter walkway advisory bulletin was informed by these textured and in-depth accounts of weather effects and sidewalk surface conditions related to potential slip hazards. There are important opportunities in geography to effect further theoretical development incorporating the subjective experience of body movement that will highlight the value of the intersections between health geography and the study of movement, particularly by introducing new dimensions to the multi-disciplinary study of the hazards of winter pedestrianism.

Overall, this study demonstrates the contribution that mobile practice can make in informing the development of systematic strategies to ensure pedestrian safety in winter. In North America, this research is in its infancy and the design of winter cities has not yet embraced a focus on pedestrianism. Looking to the example of northern Europe and further collaboration amongst northern countries in general is imperative to extending our comprehension of the intrinsic and extrinsic factors that are crucial in creating safe walking conditions in winter. By embracing mobile methodologies, researchers are able to expand their understanding of pedestrian movements while providing the public health sector, community organizations, and planners with the necessary capacities to promote the development of safe urban environments for pedestrians (Hein et al. 2008; Miaux et al. 2010).

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Prairie Perspectives: Geographical Essays
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Evaluating methods for the propagation and selection of sites suitable for the commercial cultivation of red osier dogwood (*Cornus sericea*)

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*Red Dog Enterprises is a Manitoba company investigating the cultivation and extraction of nutraceutical products from red osier dogwood (*Cornus sericea*). This species contains a variety of biochemical products that have potential benefits as antioxidants used to fight against cancer and neurodegenerative diseases, and provides natural alternatives to antibiotics commonly used in the livestock industry. The objectives of this research were to identify and develop effective methods of propagation from either seeds or cuttings and to identify sites meeting a selection of criteria, both of which are considered crucial for successful commercial cultivation. Following recommendations of a previous pilot project, trials were conducted using various pre-treatment methods to improve germination success. In addition, propagation trials using both soft and hardwood cuttings were conducted. Based on an analysis of favourable soil conditions identified at naturally occurring stands, habitat requirements outlined in the literature, and a selection of socioeconomic criteria developed in consultation with Red Dog Enterprises, a GIS model was developed to identify suitable sites. The results of the germination and propagation studies indicated that commercial production from seeds is not likely a viable alternative due to low germination success. Propagation trials revealed that cuttings collected in the fall, when sugar content is high, are particularly susceptible to rot. The GIS model identified numerous suitable sites for commercial production within the pilot study area that met all established criteria and provides an effective and flexible tool that can be modified to alter the variables used to define the criteria or add additional criteria as needed. Future research will investigate propagation through the collection of cuttings selected at specific times of the year and the application of the site suitability model to other study areas.*

Keywords: red osier dogwood, site suitability analysis, nutraceutical, propagation

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Introduction

Through secondary metabolism, plants produce a wide variety of biochemical products, some of which have been found to have therapeutic potential in human and animal nutrition, health, and disease (Farnsworth and Morris 1976; Chevalier 1996; Daniel 2006). The genus Cornus, commonly known as dogwood, is promising in this respect. It is widely distributed in eastern Asia and across North America and ethnobotanical reports have indicated that several Cornus species are effective for the treatment of human and animal illness and disease (Densmore 1974; Turner et al. 1990). However, several technological and economic hurdles are typically faced by entrepreneurs who wish to isolate and commercially market the active compounds of such therapeutic plants. In the case of red osier dogwood (Cornus sericea), especially problematic issues are the development of effective methods of commercial propagation and the identification of sites meeting ideal physical and socioeconomic criteria for producing marketable quantities.

Red Dog Enterprises Ltd. (RDE) is a company based in Swan River, Manitoba, Canada investigating the cultivation and extraction of nutraceutical products from red osier dogwood. The company has conducted unpublished field trials demonstrating the effectiveness of these products for a variety of ailments including gout and hypertension in humans, as well as the ability to fight infection, reduce inflammation, and promote growth in livestock. RDE is currently working with faculty at the University of Manitoba Richardson Centre for Functional Foods and Nutraceuticals (RCFFN) to develop methods that will optimize the extraction and production of these products. Concurrent with this initiative, a pilot project was conducted in 2013 at Brandon University investigating germination techniques that would optimize propagation and commercial production. The long-term goals of RDE and RCFFN are to develop a viable nutraceutical industry based on the cultivation of red osier dogwood that will focus on the use of marginal rural lands, provide an innovative and ecologically friendly alternative to existing commercial agriculture, and increase the diversity and resilience of the rural economy.

The objectives of this project were (1) to identify suitable sites for the cultivation and harvesting of red osier dogwood based on a suite of site suitability criteria established in consultation with RDE, and (2) to pursue recommendations proposed by a previous germination pilot project (Polk 2013) to identify and develop best practices for commercial cultivation.

Background

Red osier dogwood typically grows in thickets 2 to 3 m high with characteristic white flowers and white berries that appear in late summer and develop a blue tint late in the fall (Figure 1). The thicket structure of red osier dogwood commonly provides shelter for small animals and as a result it has been widely employed in wetland restoration projects (Gleason and Cronquist 1991; Stevens and Dozier 2002). The red osier variety of dogwood has

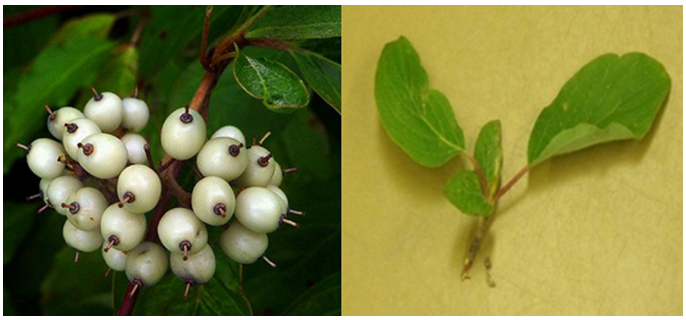


Figure 1
Characteristic white berries and opposite leaves of red osier dogwood (Polk 2013)

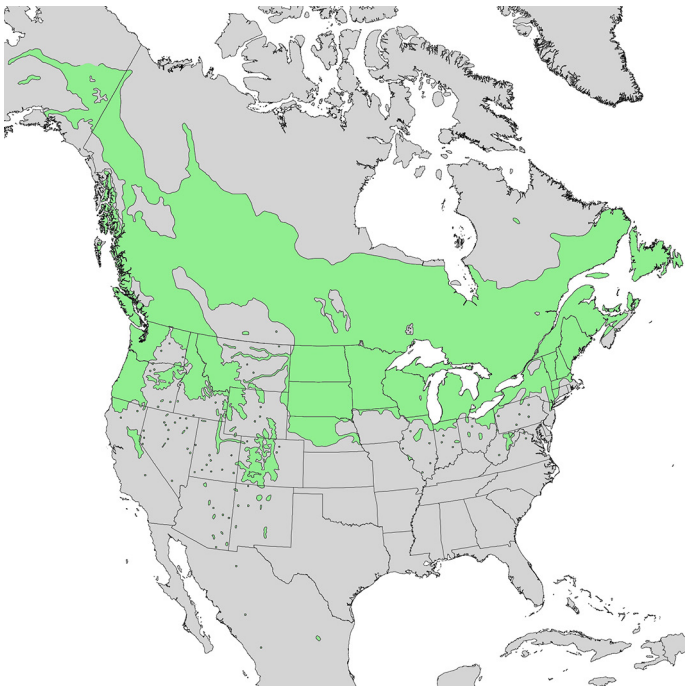


Figure 2
North American distribution of red osier dogwood (Little 1977)

opposite leaves and branches (Figure 1) and white pith. While younger branches are green, mature branches may vary in colour from purple to brown or red depending on the amount of direct sunlight they receive. Identified by its Latin name, Cornus sericea, red osier dogwood is found across Canada (Figure 2) and prefers wet, open habitats, where it will tolerate flooding and up to 75% shade.

Red osier dogwood contains quercetin, gallic acid, ellagic acid, and tyrosol (Tanaka et al. 2003; Mulabagal and Tsay 2004; Krishnaiah et al. 2007; Isaak et al. 2013). These antioxidants possess the unique ability to neutralize oxidative stress associated with obesity, diabetes, and inflammation (He and Giusti 2010; Powlowska et al. 2010; Isaak et al. 2013) and may also help fight against cancer (Krishnaiah et al. 2007; Tanaka et al. 2003), and cardiovascular disease (He and Giusti 2010; Pow-

lowska et al. 2010). In one study, Sordillo and Aitken (2009) suggested that these compounds also have the potential to reduce antibiotic use in livestock, provided that a supplement can be manufactured. They argue that since oxidative stress is a significant problem for cattle in situations such as extreme heat, antioxidants combined with micronutrients may provide a means of reducing the need for antibiotics. Along similar lines, Isaak et al. (2013) suggest that since plant phenolics are beneficial to improving general health, red osier dogwood could be given as a dietary supplement to livestock. Krishnaiah et al. (2007) also argued that natural antioxidants derived from plants should be considered safer for human consumption than synthetic antioxidants, as the latter often have associated side effects.

Based on these potential nutraceutical properties and the success of their informal field trials, RDE requested assistance from the Brandon University Outreach Program in identifying an efficient method of propagating red osier dogwood in western Manitoba. An initial pilot project was designed and conducted by Zachary Polk and William N.H. Paton. Their findings are the basis of the research presented here. Polk (2013) evaluated different methods of breaking seed dormancy as a means of increasing germination success. A blender was used to separate the pulp from the berries and procure seeds. Various pre-treatments were applied in an attempt to break seed dormancy, including sulfur powder, water soaking, and scarification of the seed coating through treatment with concentrated hydrochloric acid (HCl) for different lengths of time.

The results of Polk (2013) study indicated that seed viability was not significantly improved through any of the methods used to break seed dormancy. The scarification treatment resulted in many rotted seeds with only a single seed of all those treated found to be in the initial stages of germination. Overall, only 28–38% of the remaining seeds tested had the potential to germinate. It was concluded that the blender method used to separate the pulp from the seeds negatively affected seed viability and that further research be conducted using an alternative technique such as soil screens to separate the pulp from the seeds. It was also suggested that since many other factors may affect seed viability, further research should consider other methods of propagation, such as cuttings and layering techniques, as they may be more effective means of cultivation.

In addition to evaluating propagation methods, the pilot project (Polk 2013) sampled and tested soil properties at 25 naturally-occurring stands of red osier dogwood across southwestern Manitoba (Figure 3) to evaluate whether any commonalities existed between them. The results of the soil surveys (Table 1) suggested that naturally occurring sites in southwestern Manitoba share a number of common soil conditions including high sand content, neutral to alkaline soils, and low organic content. Consequently, it was recommended that potential cultivation sites take these criteria into consideration.

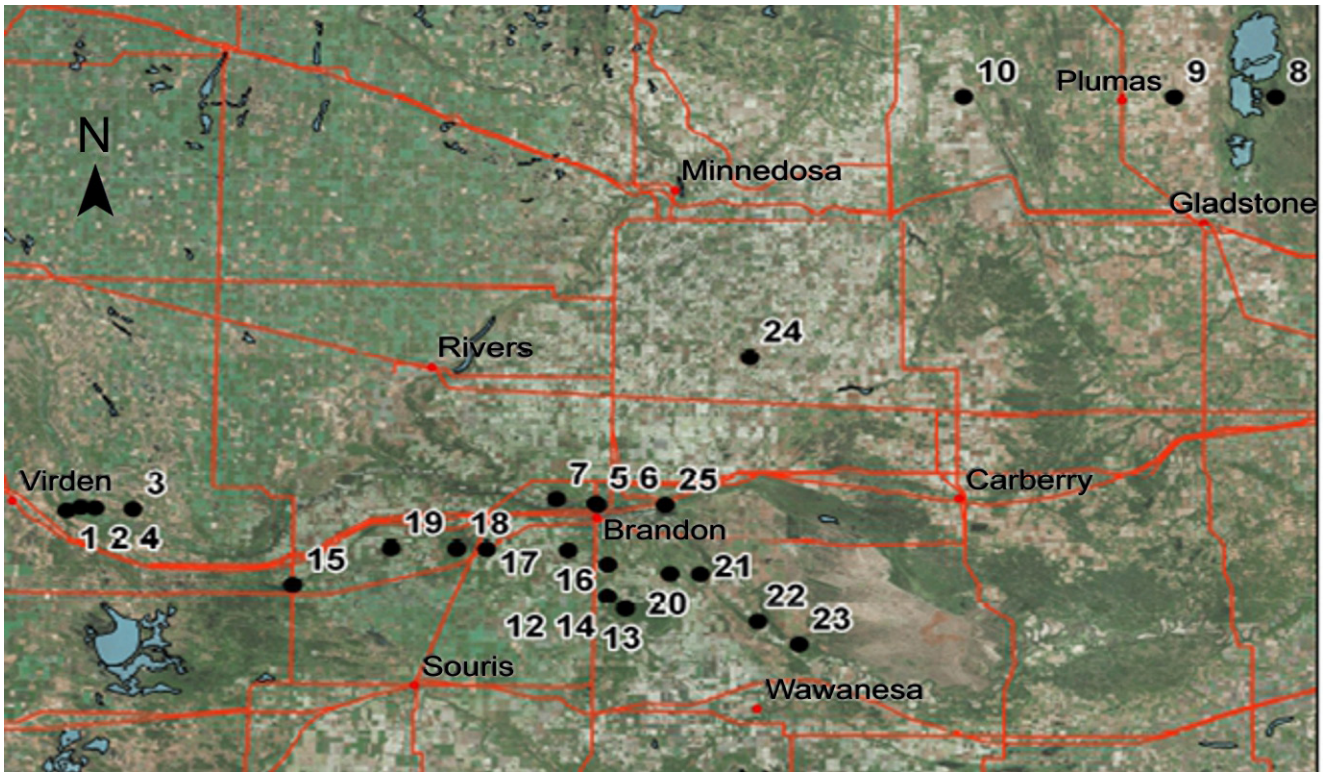


Figure 3
Location of naturally occurring sites tested by Polk (2013)

Table 1
Soil characteristics of red osier dogwood sites in southwestern Manitoba tested by Polk (2013)

Site #	pH	Sand (%)	Silt (%)	Clay (%)	Organic Carbon (gC/kg)
1	7.97 ± 0.01	51.7 ± 18.4	28.9 ± 11.0	19.4 ± 18.4	18.79 ± 0.45
2	8.16 ± 0.03	59.4 ± 1.6	21.1 ± 2.1	19.4 ± 2.8	27.58 ± 3.58
3	7.75 ± 0.13	67.2 ± 3.9	26.1 ± 3.9	6.7 ± 0.0	41.78 ± 0.55
4	7.93 ± 0.08	84.4 ± 2.8	10.6 ± 2.1	5.0 ± 1.4	19.24 ± 0.35
5	7.82 ± 0.09	45.6 ± 3.9	35.6 ± 2.1	18.9 ± 2.1	31.33 ± 0.26
6	7.96 ± 0.11	65.0 ± 2.4	25.0 ± 2.4	10.0 ± 2.4	34.45 ± 1.27
7	8.05 ± 0.02	67.8 ± 0.8	21.1 ± 0.8	11.1 ± 1.6	43.56 ± 2.13
8	8.07 ± 0.01	63.9 ± 0.8	22.8 ± 0.8	13.3 ± 0.0	27.79 ± 1.84
9	8.01 ± 0.08	72.8 ± 1.6	18.3 ± 2.4	8.9 ± 2.1	23.42 ± 0.70
10	8.04 ± 0.04	48.9 ± 0.8	35.0 ± 1.4	16.1 ± 0.8	30.45 ± 1.28
11	7.76 ± 0.01	32.2 ± 12.6	48.3 ± 8.3	19.4 ± 4.8	10.55 ± 3.07
12	8.25 ± 0.02	34.4 ± 3.1	47.2 ± 11.6	18.3 ± 13.0	18.47 ± 2.00
13	8.04 ± 0.10	45.0 ± 2.7	28.9 ± 2.1	26.1 ± 0.8	17.65 ± 1.54
14	7.53 ± 0.16	59.4 ± 4.4	25.0 ± 4.1	15.6 ± 1.6	42.49 ± 0.78
15	8.04 ± 0.14	76.7 ± 3.3	16.7 ± 1.7	6.7 ± 1.7	16.85 ± 1.49
16	8.35 ± 0.02	60.0 ± 0.0	25.8 ± 2.5	14.2 ± 2.5	13.74 ± 1.62
17	7.90 ± 0.15	85.8 ± 4.2	10.0 ± 1.7	4.2 ± 2.5	35.41 ± 2.09
18	8.06 ± 0.08	65.8 ± 2.5	23.3 ± 0.0	10.8 ± 2.5	20.96 ± 2.80
19	7.64 ± 0.04	42.5 ± 0.8	37.5 ± 2.5	20.0 ± 3.3	37.22 ± 1.56
20	8.16 ± 0.01	80.0 ± 0.0	9.2 ± 2.5	10.8 ± 2.5	21.17 ± 1.07
21	8.24 ± 0.04	80.8 ± 2.5	13.3 ± 0.0	8.3 ± 2.5	79.01 ± 0.36
22	8.08 ± 0.02	61.7 ± 0.0	18.3 ± 1.7	20.0 ± 1.7	35.53 ± 0.42
23	7.81 ± 0.30	85.0 ± 1.7	9.2 ± 0.8	5.8 ± 0.8	28.69 ± 2.96
24	7.59 ± 0.41	59.2 ± 2.5	24.2 ± 4.2	16.7 ± 1.7	33.33 ± 0.20
25	7.27 ± 0.49	77.5 ± 0.8	14.2 ± 0.8	8.3 ± 1.7	63.78 ± 1.53

Germination and propagation study

Based on the results of the pilot project, a second phase of the seed germination and propagation study was conducted to further evaluate germination success with improved seed pre-treatment techniques. In addition, this study assessed methods of propagation through the use of semi-hardwood cuttings. Among the parameters assessed for the successful propagation of cuttings were the appropriate type and concentrations of rooting powders and requirements for bottom heating and misting. Successful propagation was determined through a count of roots forming along the stems of the cuttings, often referred to as adventitious root formation (Hartmann et al. 2011).

Seed germination

According to Hartmann et al. (2011), the seeds of ripened, white fruit have the highest germination success. Approximately 250 g of white fruit were collected from a stand of red osier dogwood in Brandon, Manitoba on 30 September 2014. The fruit remained in cold storage for two weeks, facilitating the removal of pulp from the seeds using a 4 mm sieve and water rinses. Floating seeds, which accounted for approximately 5% of seeds collected, were considered unviable and discarded (Dehgan and Yuen 1983; Meerow 2004). The remaining seeds were dried and stored in a dark location to prevent early germination (Kilpatrick 2015). Based on an examination of the seeds after pulp removal, this method appeared to be less damaging to the seeds than the blender used in the Polk (2013) pilot study.

During the initial trial 300 seeds underwent three different treatments before planting. The first 100 seeds were stored in a cold room at approximately 4˚C. Commonly known as stratification, this technique is a cold treatment used to replicate winter conditions found in temperate climates and is used to break seed dormancy (Hartmann et al. 2011). The next 100 seeds were soaked in distilled water for two minutes then placed in an incubator at 20˚C. This treatment was meant to act as a control group to compare with the stratified and acid treatments. The final 100 seeds were soaked in concentrated hydrochloric acid for two minutes then given the same incubation treatment. This treatment was suggested by Polk (2013) and is meant to mimic the effect of stomach acids on the seed coating as it passes through the gut of a bird. This is a technique commonly used to break dormancy of hard-coated seeds and also removes harmful bacteria (Yildiztugay and Kucukoduk 2012).

In January 2015, the pre-treated seeds were planted in moist vermiculite and loosely covered with plastic lids to maintain moisture, following a method recommended by Kilpatrick (2015). Adequate moisture levels were maintained through monitoring with a standard soil moisture meter while seed viability was assessed by examining an open seed to view the embryo with a dissecting microscope (Meerow 2004; Sawma and Mohler 2002).

Cuttings

As reported by Hartmann et al. (2011), in situations where the dormancy of seeds are so difficult to break that it hinders germination success, cuttings may be a less expensive and more effective method of propagation. Furthermore, based on the limited success of the pre-treatments used in the pilot study, Polk (2013) suggested that the use of cuttings be considered. Consequently, in addition to the seed germination treatments already described, two cuttings trials were also conducted.

Hardwood cuttings (n=120), consisting of the previous season's growth were taken in April 2015 and semi-hardwood cuttings (n=150), consisting of the current season's growth were collected in November 2015 using methods described by Hartmann et al. (2011). The semi-hardwood cuttings collected had new buds while the hardwood cuttings were collected from older parts of the tree. The hardwood cuttings were cut at both ends, with the top cut on an angle to differentiate between top and bottom. The prepared cuttings were wrapped in moist paper towel and plastic wrap then placed in cold storage (Kilpatrick 2015).

A commonly used growth medium consisting of equal parts soaked and drained sand and peat moss was prepared and placed in large covered trays to maintain moisture and humidity (Cooper 1935; Hartmann et al. 2011; Kilpatrick 2015). Heating mats set at approximately 18–21°C were placed under the trays to encourage root growth (Cooper 1935; Hartmann et al. 2011; Kilpatrick 2015). Slow release fertilizer (14N-14P-14K) was added to the medium in the recommended amount according

to the product's instructions. Since stored carbohydrates would reduce rooting ability, the buds and the bottom ends of all the cuttings were removed (Hartmann et al. 2011). Rooting powder was applied to the base of cuttings before planting and excess powder was tapped off. Since cuttings have different hormone requirements for root growth (Cooper 1935; Kilpatrick 2015), Stim Root No. 1 and No. 3 were mixed for semi-hardwoods to a concentration of 1000–3000 ppm while No. 3 was used for hardwoods at 2500–5000 ppm (Hartmann et al. 2011). Trays were stored in the dark until leaves appeared and then moved to the greenhouse. The cuttings were monitored for root growth by removing cuttings from the medium three times a week and observing the presence of root formation.

Early results of this trial showed a lack of root formation and the development of black rot that was likely caused by soil compaction and the time of year the cuttings were collected. Consequently, a second trial was performed using the same process as described above but with cuttings collected earlier in the growing season that were placed in jars rather than trays. This method reduced soil compaction and allowed potential root formation to be viewed without having to remove the cuttings from the sand-peat moss growth medium. The jars were stored in a greenhouse and covered with plastic wrap to maintain moisture and bottom heat was applied to promote root growth (Cooper 1935; 1938). Both trials were monitored daily to maintain moisture using a standard moisture meter to maintain soil within the moist range.

Results of germination and propagation study

No germination was observed in any of the seeds planted in the stratification, control, or acid pre-treatment seed germination trials. Consequently, a second germination trial was performed to determine if a longer duration of soaking in acid was required to induce germination. This time, 80 seeds were soaked in concentrated HCl for four minutes. However, this treatment resulted in germination of only one seed out of the 80 planted.

In four of the 120 hardwood cuttings root growth was evident during cold storage. Leaves also emerged from all other cuttings when moved to the greenhouse, but subsequently dried out and died as no roots had formed to sustain their growth. The second trial which used cuttings collected earlier in the season yielded similar results with fungi growing on the erect stems. The seasonal timing when cuttings are collected was suggested as a possible cause as elevated sugar content at certain times of the year may increase susceptibility to black rot (Svendsen and AAFC 2016).

Seeds are typically the most cost effective means of plant propagation. Kilpatrick (2015) has recommended that as few as five seeds need to be planted, following a float/sink viability test, to ensure one successful seed germination under field conditions for most horticultural species. Consequently, given the very low rate of germination success, these trials would suggest that seed propagation may not be a viable approach for the mass production of red osier dogwood. These results are similar to the pilot study conducted by Polk (2013) and reaffirm the difficulties of commercial propagation using seeds.

Since red osier dogwood seeds have thick, hard seed coats (Hartmann et al. 2011; Macphail Woods 2016) it is believed that up three years of dormancy are necessary for germination to occur under natural conditions (Kilpatrick 2015). In nature, germination success is likely improved as the seeds pass through the gut of birds or herbivores, softening the seed coat through a process less severe than the HCl treatments tested in this study (Traveset et al. 2001). Hard coated seeds that are collected for propagation typically require scarification and strong acid pre-treatments, followed by stratification to mimic natural processes for successful germination in the greenhouse to occur (Hartmann et al. 2011). However, since red osier dogwood is a double-embryo seed with one mature and one immature embryo, the scarification and strong acid pre-treatments with HCl likely exposed the immature embryo to the external aqueous environment, promoting fungal rot. In the future this could be confirmed by examining seed embryos treated in this manner prior to planting.

Based on the recommendations of the pilot project (Polk 2013) trials conducted in this study used cuttings taken in early fall, however, this experiment failed to produce viable plants due to the development of black fungal rot. This was an unexpected result, since previous research on another species of dogwood (Cornus mas L.) had demonstrated successful propagation using softwood and semi-hardwood cuttings taken in early August (Ivanicka and Cvopa 1977). It is believed that the poor results obtained here may be due to the fact that dogwood is high in soluble sugars during the mid-August to late-December period, making it particularly susceptible to rot.

Svendsen and AAFC (2016) confirmed that cuttings taken between mid-August and December will not root until chilled to between 0–7°C. However, dormant hardwood cuttings collected from September to October and planted directly in the ground will root the following spring. Therefore, semi-hardwood and hardwood cuttings should be taken during the growing season before early to mid-August. Further, Svendsen and AAFC (2016) found that cuttings taken from January through to budbreak in March and April should root under greenhouse conditions. This suggests that winter hardening may cause the sugars to polymerize, greatly reducing the potential for rot. Further, he recommends that cuttings should be 20–30 cm in length and pencil-thick at the base. Cuttings used in this project were typically shorter.

Site suitability analysis

Despite the abundance of red osier dogwood throughout southwestern Manitoba, a number of site suitability criteria were considered in order to identify potential sites that would maximize yield and profitability as well as utilize marginal agricultural lands. In consultation with RDE, a variety of physical, cultural and socioeconomic criteria were developed with an aim to locate areas best suited to cost-effective cultivation and transpor-

tation of raw product. It was determined that general categories for consideration should include soil conditions, climate, current and potential land use and value, site accessibility, and proximity to a potential labour force. The general criteria also provided an excellent starting point from which a suite of specific site suitability criteria were developed, as described below.

A common approach for performing multiple criteria site suitability analyses (MCSSA) is to represent each criterion in map form and combine the individual component maps to evaluate and determine suitable sites (Malczewski 2004). A geographic information system (GIS) is ideally suited to addressing exactly this type of problem and was therefore used to identify suitable sites for the propagation and cultivation of red osier dogwood. While the ultimate goal was to identify sites across southwestern Manitoba, an initial pilot study area was selected so that a workflow and subsequent model could be perfected on a study area of a more manageable size. The resulting model could then be applied to the overall project study area or any other area in the future. In addition, criteria within the model, such as buffer distances or acceptable land capability classes, were set as parameters within the model so that a user can adjust these criteria to suite their specific analysis.

The pilot study area covered the rural municipalities of Cornwallis, Langford, Whitehead, North Cypress, South Cypress, and Oakland (Figure 4). The initial suite of general criteria developed with RDE were narrowed down to a set of eight specific, quantifiable criteria based on physical and socioeconomic variables and for which geospatial data layers were available through the Manitoba Lands Initiative website (Table 2). Suitable values for each of the soil criteria were based on characteristics at naturally occurring sites within southwestern Manitoba as described by Polk (2013) and possessing habitat characteristics reported by Little (1977). Socioeconomic criteria and other habitat criteria, such as protected status and suitable land cover type, were determined by RDE. Criteria used to evaluate accessibility or proximity to a labour force were likewise determined by RDE, although these criteria were set as parameters in the model, so can be easily adjusted.

Table 2
Selected physical and socioeconomic criteria (Province of Manitoba 2016)

Criteria	Suitable Characteristics	Attribute Field	Acceptable Values
Soils			
Drainage	well or imperfectly drained	C_DRAIN	23, 25
Texture	fine or coarse loam	C_SURFTEXT	22, 23
Salinity	non to weakly saline	C_SALT	21, 22
Capability	moderate to severe limitations	C_AGRI	3, 4, 5
Soil pH class	moderate to slightly alkaline	C_SOIL	2, 6, 16, 18, 19, 20, 25, 26, 32, 35, 36, 42, 44, 49, 53, 56, 57, 68, 69, 71, 72, 73, 74, 79
Land cover type	agricultural cropland grassland/rangeland forage cropland	GRIDCODE	1, 4, 12
Protected status	not within protected areas	STATUS	not protected
Accessible by road	within 1.6 km of paved or gravel roads	BUFF_DIST	BUFFDIST ? 1.6 km
Proximity to labour and processing facilities	within 20 km of populated places	BUFF_DIST	BUFFDIST ? 20 km
Minimum site size	≥ 16 hectares (40 acres)	area (ha).	area ≥ 16 hectares

Typically, criteria used in MCSSA are evaluated in one of two ways. The binary model produces a map depicting suitable versus unsuitable sites, while the index model produces a map in which the rank ordered suitability of sites is identified (Chang 2015). The type of data available for each component map and its role in determining suitability typically determines which of these two models is selected. For example, if soil salinity is a key factor determining site suitability and the habitat characteristics of the phenomenon in question are such that a finite cut-off or limiting value is a logical selection, then a binary model identifying sites as either suitable or unsuitable is most likely appropriate. Alternatively, if the phenomenon is able to tolerate a range of soil salinity, and no limiting value exists, then a range of rank ordered suitability or index values may be developed.

Initially, attempts were made to evaluate the criteria using the index model to determine rank ordered levels of suitability based on soil drainage, texture, salinity, pH, agricultural capability class, and land cover type. However, this approach was abandoned when no previous research describing these specific habitat criteria could be identified. Consequently, there was no objective way to effectively evaluate and assign index values to various levels or amounts of acceptable soil salinity criteria or a range of other criteria. As a result, the binary model of analysis was employed because the finite limiting conditions for each of the criteria was either previously determined through the Polk (2013) study, or was well documented in the existing literature (Little 1977). Sites that met all of the criteria outlined in Table 2 were considered suitable, while sites that failed to meet even one criterion were considered unsuitable. Put in simple terms, the "one strike and you're out" form of the binary model is often employed when an unsuitable instance of any one criterion has been determined to eliminated a candidate site from consideration.

Constructing the model

The advantages of developing a binary model in a GIS are that parameters and variables can be easily adjusted and that the model can be executed multiple times as criteria change, new decision rules are considered, or criteria are added (Chang 2015). In addition, the model can be shared and executed as a tool in ArcGIS, effectively encapsulating the workflow and the expert knowledge of the model's development team within a user-friendly interface (Chang 2015). An end user would then input the geospatial data layers for their own study area, adjust the parameters, set variables, and run the model. When executed as a tool within ArcGIS the model follows the prescribed workflow

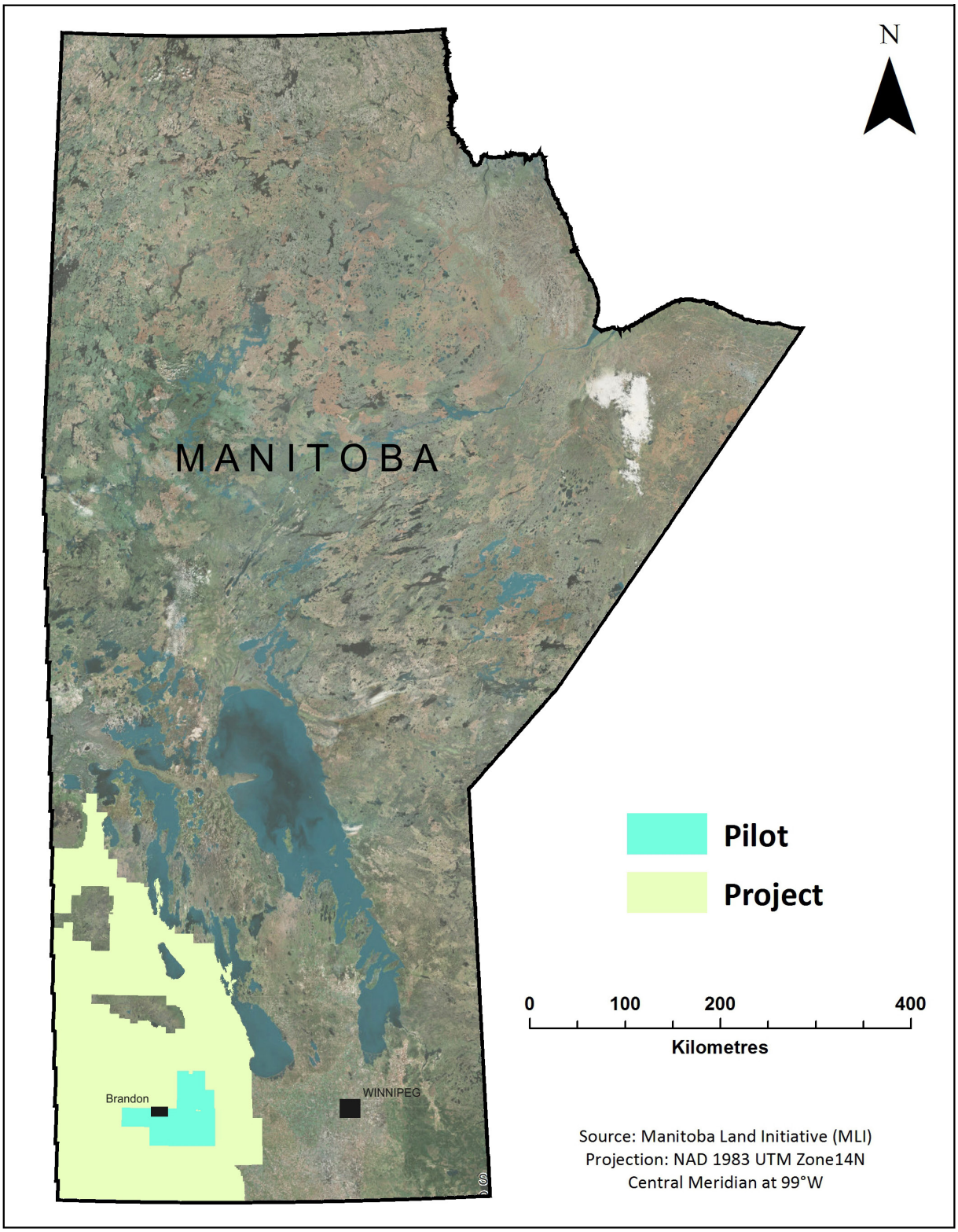


Figure 4
Location of project and pilot study areas within Manitoba

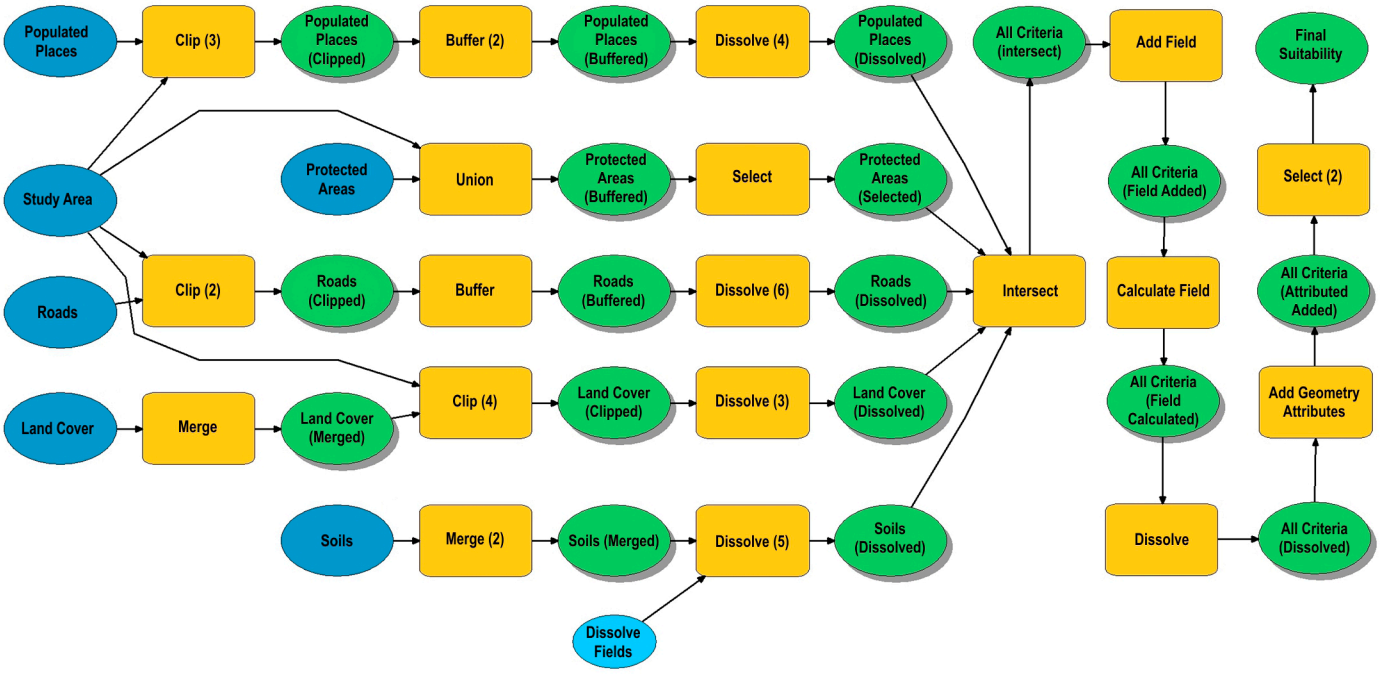


Figure 5
Schematic illustrating the model created within Model Builder

of the development team, selects sites meeting the criteria, and creates a new output geospatial data layer depicting polygons representing suitable sites.

Figure 5 depicts the workflow that was developed in the ArcGIS ver. 10.3 Model Builder application. In this figure, the input geospatial data layers representing each criterion are depicted by blue ovals, analytical operations by orange rectangles, temporary output data layers by green ovals, and parameters set by the user by cyan ovals.

In the following description of the workflow depicted in Figure 5, words describing ArcGIS functions (i.e., the names of tools and operations) are italicized. First, the populated places, roads, and land cover data layers (Figure 5a) were clipped to the pilot study area. Next, multiple land cover data layers covering the study area were merged (Figure 5b) and the resulting output layer dissolved (Figure 5b) by land cover type to remove the remnant township boundaries. Likewise, the soil data layer was merged (Figure 5b) and then dissolved (Figure 5b) to remove the rural municipality boundaries. The protected areas layer and the study area layer were combined using the union map overlay operation (Figure 5c). Protected areas were then selected and deleted using the select by attributes function (Figure 5c). The buffer tool (Figure 5d) was applied to the roads and populated places layers to create buffer zones of 1.6 km and 20 km respectively. The two output buffer layers were then dissolved (Figure 5d) to remove internal boundaries between buffer polygons. The application of the intersect map overlay tool (Figure 5e) combined all of the component layers and their associated attribute tables into one output layer to which further analysis could be applied. A new field was added to the attribute table (Figure 5f) into which values (i.e., suitable or unsuitable) were calculated. A selection by attribute query was performed using the calculate field tool (Figure 5g) to select out suitable versus unsuitable values. A python script was used to perform this selection. If the selection met the criteria, the value was calculated as suitable. If the selection did not meet the criteria, the value was populated as unsuitable. The output layer was then dissolved (Figure 5h) based on final suitability. Last, the geometry attribute tool (Figure 5i) was applied in order to select sites with an area greater than or equal to 16 ha. (40 ac.). The final output layer represented all suitable sites found within the pilot study area.

Results of site suitability analysis

Figure 6 illustrates the suitable sites identified for the pilot study area based on the results of the model as described above. The model identified 321 suitable sites within the pilot study area that satisfied all criteria. The majority of suitable sites occur along or adjacent to riparian habitats because they meet the established soils criteria and are typically of marginal agricultural capability. Other suitable areas were identified in ephemeral wetlands, such as the Douglas-Griswold marsh, and on marginal agricultural lands. An overwhelming proportion of the pilot study area was deemed unsuitable because it either did not meet the socioeconomic criteria, or was excluded since it was already productive agricultural land. The largest site covered an area of 902 ha. (2255 ac.), the average site size was 92 ha. (230 ac.), and the total area of suitable sites was 29,596 ha. (73,990 ac.) or 6.5% of the total pilot study area.

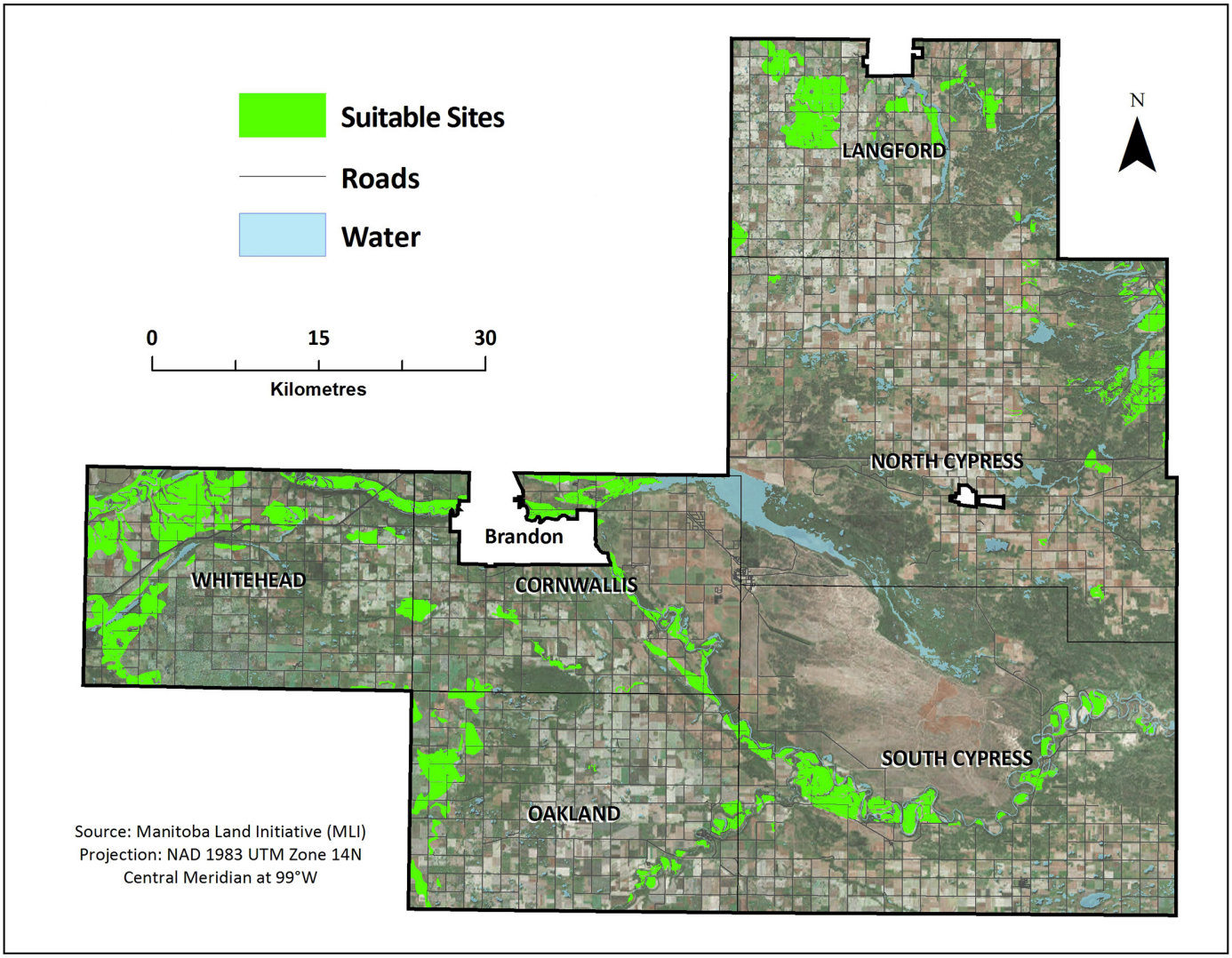


Figure 6
Map illustrating sites suitable for the cultivation of red osier dogwood

Conclusions

While the seed germination and cuttings trials conducted were unsuccessful, valuable lessons regarding pulp removal, the effectiveness of pre-treatment trials involving cold treatment by stratification, acid treatment, and best practices for collection and preparation of cuttings are described. Consequently, this research has contributed to the potential development of a viable nutraceutical industry using products derived from red osier dogwood by eliminating these specific pre-treatment and cuttings methods as viable propagation methods and providing informed recommendations for further research. In particular, commercial production from seeds appears unlikely and cuttings collected between mid-August and January are particularly susceptible to rot. Fortunately, new information suggests that cuttings collected prior to mid-August, or past seasons growth collected after January to just before bud break, so that winter hardening has reduced the sugar content, may be more successful and warrants further research.

This research has also resulted in the development of an effective model that can be used to identify suitable locations for commercial production. This model has the advantage that it can be modified to either alter the parameters or variables used for existing criteria, such as the proximity to roads or minimum site size, or to add additional criteria in the future as required. The model can then be applied to any selected study area provided that the input data layers are available. The next steps in this regard will be to apply the model to the larger project study area.

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Using fine fuel moisture codes to understand the effects of climate change on the eastern boreal forests of Canada

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Warming temperatures caused by anthropogenic forcing are expected to result in increased drying of forest fire fuels across Canada. However, previous research in the eastern boreal forest region suggested that increased precipitation and relative humidity may offset warmer temperatures, leading to increased fuel moisture and decreasing fire ignition potential. To test this hypothesis, two scenarios modeled by the Coupled Global Climate Model (CGCM4) were used to measure the difference in ignition potential. Monthly values of the Fine Fuel Moisture Code (FFMC) component of Natural Resource Canada's Fire Weather Index system were compared between two climate scenarios, one representing a baseline scenario from 1981 to 2005 and one from 2071 to 2100 simulating a future with 4.5 Wm^{-2} of radiative forcing (RCP 4.5). All locations in the study area showed increasing average FFMC values—and therefore a higher frequency of fires—in the RCP 4.5 scenario, with the months of June and July showing the most statistically significant changes. All the fire months, extending from May to September, had statistically significant increases in temperature as well, ranging from 3° to 4°C. However there was little to no significant evidence of changes in precipitation or relative humidity. It was concluded that the increase in temperature was the driving variable causing FFMC values to rise.

Keywords: fine fuel moisture codes, climate change, forest fires, eastern boreal forest, Canada, climate models

Introduction

Increasing temperatures resulting from climate change have become unequivocal across the globe, especially in higher latitudes where this effect is known to be more pronounced (IPCC 2014). In Canada, where annual temperatures across the country have increased 1.3°C since 1948 (Lemmen et al. 2008), understanding how forest disturbance dynamics respond to climate change is an important concern. Climate change is already understood to be a growing influence on fire regimes and it is expected that the warming process will significantly alter these regimes throughout the ecosystems of Canada (Wotton et al. 2010).

Under these conditions, Canada's immense boreal forest region is of particular concern as its tree species and ecosystems are adapted to and dependent on periodic forest fires, whose frequency may be altered due to a rapidly changing climate. The mean annual temperature in the boreal region is projected to increase by 3.3° to 5.4°C compared with historic norms (1961–1990) by 2071–2100, with the largest increase in the Boreal Shield West ecozone (Gauthier et al. 2014). The length of the growing season is also expected to increase by nine to ten

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days from 2011 to 2040 and 21 to 46 days from 2071 to 2100, with the greatest of these increases in the Boreal Cordillera and Boreal Shield East (Gauthier et al. 2014).

Increased temperatures and longer drought periods have already been observed to result in increased forest fire frequency (MNR 2013). However, a study completed by Bergeron and Flannigan (1995) carried out on islands in Lac Duparquet in the southern boreal forest of Quebec found that forest fire frequency in this area decreased in a 2 x CO_2 scenario. They hypothesized that increased precipitation would offset the increasing temperatures and lead to fewer wildfires in specific regions (Bergeron and Flannigan 1995; Flannigan et al. 2005). Precipitation regimes in the Boreal Shield East, which extends from Lake Winnipeg to Newfoundland, are also subject to lake and ocean influences and from storm movement from the eastern USA. This results in significantly more precipitation than the Boreal Shield West region, which extends from Manitoba to the Yukon (Price et al. 2013). The specific regional influences have resulted in the observed increase of fire frequency in the Boreal Shield West but a decrease in the Boreal Shield East (Price et al. 2013). Notwithstanding the different findings in the east and west, to understand the effect of climate change on fire frequency and future area-burned in the overall boreal forest region many studies in Canada use components of the Fire Weather Index (FWI) system in combination with global climate models (cf. Bergeron and Flannigan 1995; Wotton et al. 2003; Flannigan et al. 2005; Podur and Wotton 2010; Van Bellen et al. 2010; Wang et al. 2015). The FWI is a combination of indices that provide numerical fuel moisture estimates based on meteorological conditions.

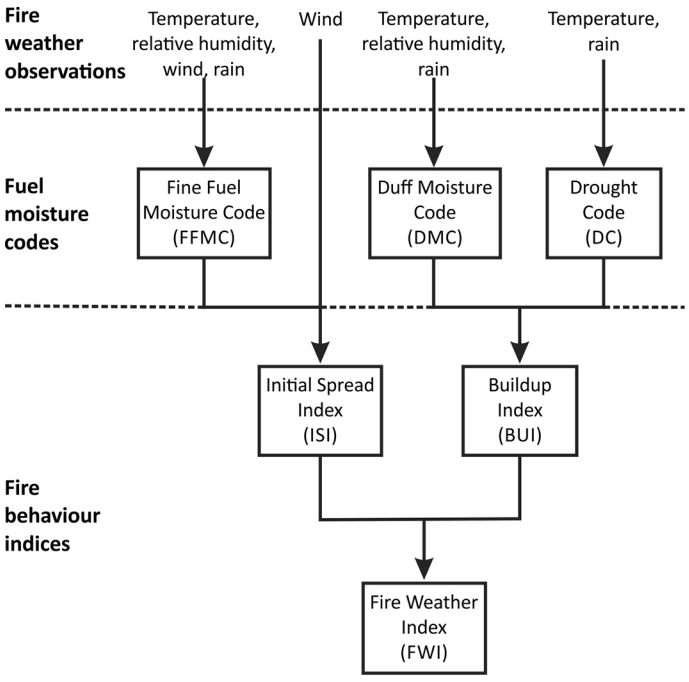


Figure 1
Diagram illustrating the components of the FWI System. The six standard components provide numeric ratings of relative potential for wildland fire. Adapted from Natural Resources Canada (2016)).

The focus of this study is how climate change will affect future forest fire frequency in the Boreal Shield East region. Future weather conditions produced by climate models may be input into the FWI as a method of predicting how forest fire disturbance regimes may be impacted by a changing climate. The FWI is comprised of six components; three fuel moisture codes and three fire behaviour indices, which together provide a numerical rating of the potential frontal fire intensity (De Groot, 1998). However, fire intensity is not tightly linked to fire frequencies as frequency is primarily determined by climate conditions (Van Bellen et al. 2010). To assess potential changes in fire frequencies we will utilize a key component of the FWI system: the Fine Fuel Moisture Code (FFMC).

The approach of this study is to expand and follow up on Bergeron and Flannigan (1995) in order to test their projection of reduced FFMC in the region of Lac Duparquet. Based on their study, a reduced FFMC implies a greater moisture content and reduced fire frequency. This is a prudent approach since we have found a general lack of climate change related studies that focus on the effect of changing forest fire frequency across the Boreal Shield East region since Bergeron and Flannigan's 1995 study. Their study is also one of the few studies that utilizes Canada's tailor-made FWI system in conjunction with climate model outputs to project future fire, which is why this approach should be further validated using current climate model projections. The present study is therefore a means of testing their conclusions and the consequences for the broader Boreal Shield East region using Canada's FWI system. The refinement of climate models since this original study has provided more detail and confidence with respect to regional changes in temperature and precipitation. We have updated the inputs by making use of a more modern climate model with a finer grid, which will be more representative of regional variability. We have also broadened the area of study, expanding westwards into Ontario and further east into Quebec, noting that it is inappropriate to generalize fire regime characteristics from small regions to the entire boreal zone (Bergeron et al. 2004).

Although Bergeron and Flannigan conducted their study in 1995, no direct follow ups have been undertaken. However, a few recent investigations have been made into this issue, including Bergeron et al. (2004), who examined fire frequencies using 2 and 3x CO_2 climate change scenarios. They found that real and simulated future fire frequencies are lower than the historical fire frequency for the majority of the 18 locations studied throughout ecozones of the Canadian boreal forest including the Lac Duparquet area. They also identified northern Ontario as having a slightly higher future fire frequency. In another study, Wang et al. (2015) used three climate models to project changes in FWI across Canada, and found increases almost everywhere. Our study will contribute to these analyses by further investigating the question of whether regional climate change impacts

such as increasing temperature and precipitation are likely to increase or decrease future forest fire frequency in the Boreal Forest East.

Climatology

Understanding the regional effects of climate change is critical in predicting how fire frequency will be altered, as fire occurrence and spread is strongly influenced by fuel moisture, which is in turn strongly influenced by weather (Podur and Wotton 2010). Currently the Boreal Shield West region receives about 600 mm of precipitation annually compared to its eastern counterpart, which receives approximately 1000 mm annually. Price et al. (2013) projected increases in precipitation by 2100 of 11% and 13% in the Boreal Shield West and Boreal Shield East respectively (Price et al. 2013). Changes in precipitation at the regional scale have also been projected. For example, the annual precipitation for Thunder Bay, Ontario between 1971 and 2000 was 711.3 mm, but based on high emission scenarios they can expect a 3.9% annual increase in precipitation by 2020, 6.5% by 2050, and 11% by 2080 (ICLEI 2013). It is not just the frequency of precipitation events that is projected to change, but extreme and heavy precipitation events are also expected to become more intense and more frequent. Historically, the majority of flooding in Ontario municipalities has been associated with spring snowmelt runoff. However, only 34% of floods between 1990 and 2003 occurred in the spring, with the remainder occurring in other seasons due to heavy rainfall, rain-on-snow conditions, and ice jamming (Chiotti and Lavender 2008). Whether the increase in precipitation and the subsequent moisture content of litter and other cured fine fuels such as needles, mosses, and twigs will be enough to offset the increased drying due to temperature increases is uncertain (Bergeron and Flannigan 1995; Podur and Wotton 2010).

The Fine Fuel Moisture Code

The Fine Fuel Moisture Code (FFMC) represents the moisture content of the top 1 to 2 cm deep litter layer. This layer is indicative of the ignition probability since fires usually start and spread in fine fuels (De Groot 1998). The standard daily FFMC calculation uses temperature, relative humidity, wind speed, and 24-hr precipitation values measured at noon Local Standard Time (LST). These values are used to predict peak burning conditions that will occur around 1600 hr. LST, under the assumption that the measured weather parameters follow a normal diurnal pattern (Van Wagner and Forest 1987). At the start of its calculation each day, the previous day's FFMC is converted back to moisture content, mc, (Wotton 2009) via the equation,

$$mc=147.2x\frac{101-FFMC}{59.5+FFMC}$$

Any rainfall above the threshold of 0.5 mm that has fallen in the previous 24 hours is added to the moisture of the layer, which in turn depends on the original moisture content of the layer itself. Thus, the layer's moisture exchange with the atmosphere is calculated for the day (Wotton 2009).

Sunlight continues to be a critical process missing from Van Wagner's diurnal FFMC calculation method (Anderson 2009). In order to reduce bias from the sun's radiation, calculations are turned off at night by setting the FFMC to zero between sunset and sunrise. The final numerical value produced by the FFMC calculation ranges from 0 to 99 with a high potential for fires to ignite in the boreal forest above 85 (De Groot 1998).

Research Methods

The grid points defining the study area are located in the Boreal Shield East region, over an area spanning from eastern Manitoba across the Clay Belt of northern Ontario just below the Hudson Plains and continuing through southern Quebec to encompass an area from N 48 50.400, W 92 48.600 to N 51 37.800, W 61 52.800 (Figure 2). This includes the region studied by Bergeron and Flannigan (1995). This ecoregion is characterized by even-age communities of fire adapted-species such as black spruce (*Picea mariana*), jack pine (*Pinus banksiana*), and lodgepole pine (*Pinus contorta*), but is dominantly populated by balsam fir (*Abies balsamea*), a fire intolerant tree species indicative of infrequent fire regimes in the Boreal Shield East (Gauthier et al. 2014).

To specifically target fire frequency in relation to climate change, the FFMC component of the FWI was used along with simulated weather variables provided by the Canadian General Circulation Model Fourth Generation (CGCM4) to project fire ignition potential (von Salzen et al. 2013). Results were compared between a simulated baseline and a future scenario in which carbon concentration had increased. To remove any bias between the model and local conditions, CGCM4 output was used for both the baseline and future period. The baseline time period included the months of May to September over a period of 25 years, from 1981 to 2005. Daily weather variables were retrieved from CGCM4 for every grid point within the study area at a spatial resolution of 1.41° longitude x 0.94° latitude. The daily variables included 24-hour precipitation (mm), wind speed (km/h), relative humidity (%), and temperature (°C). These were used to calculate the standard daily FFMC from the months of May to September over the baseline time period for each grid point within the study area. The formulas for the standard daily FFMC can be may be obtained from the Canadian Forest Service Publications (Anderson 2009). The daily FFMC codes were averaged over every month.

The future climate scenario was taken from the CGCM4 climate model driven by radiative forcing from Representative Concentration Pathway 4.5 (RCP 4.5). RCP 4.5 is one of several scenarios of greenhouse gas concentrations developed for use with climate models (Thomson et al. 2011). In RCP 4.5, greenhouse gas concentrations are stabilized by the year 2100 at

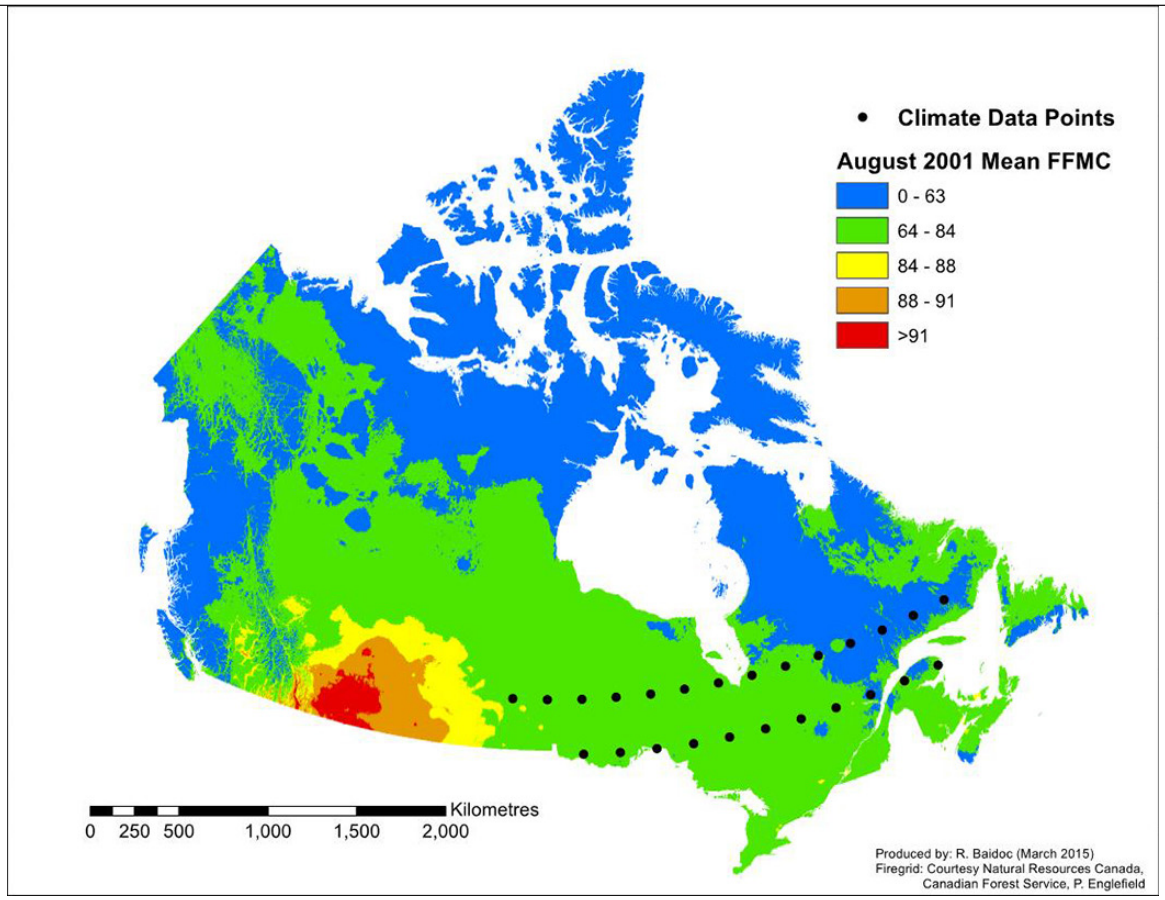


Figure 2
Study area showing locations of the 25 grid points. A base map of the August 2001 mean FFMC values is provided as an example here to illustrate the variability in FFMC values across the country.

approximately 650 ppm CO_2 equivalent, producing a radiative forcing of 4.5 W/m^2. This is considered a medium-low forcing scenario. The mean monthly FFMC values of the RCP 4.5 climate scenario and the baseline scenario were both averaged annually to produce 25-year FFMC averages for each month over each grid point. Next, annual averages of the five months at each grid location for the baseline and the RCP 4.5 scenario were compared. As a comparison between model and reality, actual FFMC values averaged from each month over the same time frame and location as the baseline scenario, were obtained from the Canadian Forest Service (CFS 2015), and compared with the baseline scenario produced by the climate model.

To test for statistical significance, we applied a two-tailed t-test for difference in means to the baseline and RCP 4.5 scenarios. Any p-value below 0.05 was deemed to indicate a significant difference in FFMC values. Similar t-tests were also applied to the meteorological variables of the two climate scenarios in order to check the statistical significance of differences in atmospheric conditions that might explain the FFMC results. We applied the same test to the baseline climate scenario and the observational data for the baseline period obtained from MNR to investigate differences between FFMC values produced from climate model simulation and those based on observed weather conditions.

Results

We found that the 25-year average FFMC for each month increased in the RCP 4.5 scenario, and this was true across the study area for each of the 25 grid points. t-tests were done to test for statistically significant differences between the FFMC means of both scenarios. Statistical significance here should be interpreted as evidence of climate change as opposed to climate variability, since it indicates a difference in mean values beyond what could be expected from variability alone. Between the 25-year average FFMC values of the baseline and RCP 4.5 scenarios, eight of the 25 cells showed significant difference in May, 16 points in June, 23 in July, eight in August, and four in September. Table 1 shows the average change in FFMC values for the months of June and July, the months that most commonly had p-values less than 0.05. None of the June numbers in the baseline column cross the threshold of 85, which would indicate a high potential for fire to ignite. However, we see an increase in mean FFMC in the future scenarios, and as the mean value rises closer to the threshold it will be crossed more frequently in individual months. For July, the mean FFMC surpasses the threshold eight times, including two cells in the baseline scenario and six more cells in the future scenario. The locations of these increases are illustrated in Figure 2 (June) and Figure 3 (July).

Table 1
Comparison between the 25-year average FFMC values of the baseline and RCP 4.5 scenarios for the months of June and July. Bolded differences represent statistical significance (p-value < 0.05). Bolded-italicized FFMC values represent values exceeding the fire ignition threshold (85).

	June FFMC Averages				July FFMC Averages			
Grid Point	Baseline (1981-2005)	RCP 4.5 (2076-2100)	Difference	*p-Value*	Baseline (1981-2005)	RCP 4.5 (2076-2100)	Difference	*p-Value*
48.84, -92.81	78.67	80.63	1.96	1.1E-01	84.40	***85.93***	**1.53**	4.2E-02
48.84, -90.00	80.35	83.94	**3.58**	1.1E-02	84.76	***88.57***	**3.81**	6.6E-07
48.84, -87.19	69.87	72.98	3.11	1.4E-01	74.60	78.94	**4.34**	2.6E-03
48.84, -84.38	80.91	84.42	**3.51**	3.3E-03	83.39	***87.45***	**4.06**	1.9E-04
48.84, -81.56	73.68	77.94	**4.26**	4.8E-03	75.65	79.46	**3.81**	2.3E-02
48.84, -78.75	72.00	78.94	**6.94**	1.1E-04	73.11	79.99	**6.88**	4.1E-03
48.84, -75.94	74.19	79.00	4.82	7.0E-03	72.32	79.22	**6.91**	2.6E-03
48.84, -73.13	71.36	76.05	**4.69**	3.3E-03	66.72	74.89	**8.17**	3.8E-04
48.84, -70.31	64.88	69.48	**4.60**	1.2E-02	57.01	65.76	**8.76**	2.1E-04
48.84, -67.50	59.07	62.42	3.35	1.2E-01	47.93	55.34	**7.41**	7.9E-03
48.84, -64.69	67.54	70.03	2.49	2.1E-01	62.14	68.62	**6.48**	4.5E-03
51.63, -98.44	82.53	84.28	**1.76**	4.2E-02	***86.11***	***88.08***	**1.97**	3.2E-03
51.63, -95.63	82.10	84.15	**2.05**	2.1E-02	***85.79***	***87.68***	**1.89**	4.4E-03
51.63, -92.81	79.20	81.75	**2.54**	3.0E-02	83.36	***85.21***	**1.85**	4.0E-02
51.63, -90.00	77.33	82.86	**5.53**	1.3E-04	82.60	***86.77***	**4.17**	4.7E-04
51.63, -87.19	75.90	81.56	**5.66**	4.5E-05	80.71	***85.52***	**4.81**	4.3E-04
51.63, -84.38	75.14	77.99	**2.85**	1.7E-02	78.33	81.34	**3.01**	2.9E-02
51.63, -81.56	75.52	79.48	**3.96**	6.5E-04	79.23	81.62	**2.39**	3.6E-02
51.63, -78.75	73.67	78.80	**5.13**	1.6E-04	77.97	79.85	1.88	1.3E-01
51.63, -75.94	69.15	75.09	**5.94**	1.2E-03	71.35	75.80	**4.45**	1.1E-02
51.63, -73.13	65.51	69.69	**4.17**	4.6E-02	59.82	69.13	**9.31**	1.8E-04
51.63, -70.13	62.56	64.13	1.57	4.4E-01	53.28	63.44	**10.16**	1.7E-04
51.63, -67.50	60.17	62.79	2.62	2.2E-01	52.71	63.12	**10.41**	3.3E-05
51.63, -64.69	59.01	62.50	3.50	1.3E-01	54.76	63.59	**8.83**	4.8E-04
51.63, -61.88	55.83	59.79	3.96	9.8E-02	51.26	59.40	**8.14**	9.4E-04

Looking at changes in the driving variables (Table 2) and how they may have caused the increase in FFMC values in the future climate scenario, we noticed a significant change in monthly mean temperature. Comparing the baseline scenario to the RCP 4.5 scenario over the entire study region, the largest temperature increase occurred outside the fire season in the month of March. However, the next largest increases were in June (+4.2°C) and July (+3.9°C); the months with the most consistently significant increases in FFMC values. July had the highest monthly temperatures in both climate periods, followed by August and then June. The average relative humidity for the months of June and July also showed statistically significant ($p < 0.05$) differences between the scenarios, as in June the average relative humidity decreased from 64% to 60% and in July it decreased from 65% to 59%. There was no significant change in average monthly precipitation or wind speed over the 25-year period for either month.

These changes in atmospheric conditions were representative of the changing conditions for the months of May, August, and September as well, where no changes in average precipitation or wind speed were observed (Table 2). Furthermore, the months of May, August, and September showed no statistically significant change in relative humidity. When compared to June and July, the lack of significant changes in precipitation combined with decreasing relative humidity and increasing temperatures explains why these months had the most significant changes in FFMC values.

Finally, in comparison with the observation-based values from the MNR, the baseline FFMC values are somewhat higher with a $p < 0.05$ for 16 points (Table 1). A look at the model and observation-based temperatures indicates the same, suggesting that temperatures in the CGCM4 baseline are warmer than observations.

Discussion and Conclusions

The most important finding in our research was that average monthly FFMC values for each grid point increased in the RCP 4.5 scenario, with the majority of statistically significant increases occurring within the months of June and July. We conclude that the changes in FFMC values between the baseline and future climate scenarios were due to increasing temperatures combined with two other factors: no significant change in precipitation and either no significant change or a decrease in relative humidity. These shifts in meteorological conditions caused an increase in

Table 2
Difference in climatological variables, averaged over all points for the 25-year baseline and RCP 4.5 scenarios. Embolded differences represent statistical significance ($p < 0.05$).

Climatological Variable	25-Year Average for Month of:	Historic	RCP 4.5	Difference	Significant Difference (p<0.05)
Temperature (C°)	May	10.61	15.02	4.41	**1.45E-06**
	June	17.21	21.46	4.25	**1.12E-04**
	July	21.62	25.62	4.00	**9.03E-04**
	August	20.41	23.96	3.55	**1.52E-03**
	September	13.97	17.88	3.91	**4.09E-06**
Precipitation (mm)	May	2.36	2.66	0.30	5.50E-02
	June	2.50	2.55	0.05	8.67E-01
	July	2.63	2.42	-0.21	6.39E-01
	August	2.32	2.48	0.17	6.45E-01
	September	2.46	2.46	0.00	9.92E-01
Relative Humidity (%)	May	62.78	61.33	-1.45	2.95E-01
	June	64.22	59.50	-4.73	**7.20E-03**
	July	65.52	58.53	-7.00	**1.25E-02**
	August	67.24	64.92	-2.32	3.73E-01
	September	74.63	71.97	-2.66	1.02E-01
Wind Speed (km/h)	May	13.36	12.98	-0.38	6.53E-01
	June	13.11	11.96	-1.15	1.38E-01
	July	12.24	11.08	-1.16	1.31E-01
	August	12.03	10.99	-1.04	1.76E-01
	September	13.26	11.78	-1.48	8.94E-02

FFMC values in the future scenario, indicating a potential increase in forest fire frequency throughout the study area. These results do not corroborate the results of Bergeron and Flannigan (1995), which predicted a decrease in FFMC at Lac Duparquet (Figure 3).

The results of this study therefore dispute Bergeron and Flannigan's initial 1995 hypothesis that increases in precipitation and relative humidity would outweigh increasing temperatures in a doubling CO_2 climate scenario. The CGCM4 RCP 4.5 scenario produced warmer temperatures without a compensating increase in precipitation throughout the Boreal Shield East region. The result was an increase in FFMC values over the 25-year period for each grid point in that scenario, which is representative of an atmosphere with a greenhouse gas concentration rising to 650ppm CO_2 equivalent in 2100. Bergeron et al. (2004) used output from CGCM1 to model fire frequency at locations across Canada, including several in our study region. They predicted increases in current fire frequency at most locations with an exception at Abitibi East Quebec, owing to a slight increase in precipitation eastward across the province (Bergeron et al. 2004). However, our study of nearby points—with no modelled increase in precipitation—had an increase in FFMC. A more recent study by Wang et al. (2015) used climate output from three general circulation models including CGCM3 to model the Fire Weather Index. They projected increases in nearly all fire zones across Canada, including the Boreal Shield East—a change consistent with this study.

It is suggested that if greenhouse gas levels continue to increase we can expect increasingly severe fire weather conditions across most of the Boreal Shield East region. This effect could be even more pronounced in the Boreal Shield West region, which is more prone to dry conditions and could lead to more intense fires causing larger areas burned in the future (Wang et al. 2015). Whereas temperature may be considered the best predictor of area burned (Wang et al. 2015), at the regional level the topography of the land can heavily influence other meteorological variables such as precipitation and humidity, both major influences on the drying effects of increasing temperatures. Hence, fire weather severity may be variable at the regional level, but the general long-term trend is likely to increase. This will lead to challenges that may overwhelm our fire management capacity.

Avoiding greenhouse gas emissions would be the most effective approach to mitigating the problem of climate change influencing forest fire frequency (Rhodes and Jaccard 2013; Pacala and Socolow 2004). However, in a future scenario where fossil fuel combustion is still a common source of energy, we must rely on Canada's forest stewards to employ risk management in planning processes, implement a selection of diversified mitigation strategies, and adopt an adaptive management framework.

Forest fire management in the face of climate change is a complex issue with many variables involved. In managing risk, high levels of uncertainty exist despite using sophisticated climate and fire regime models. The complexity owes to the interchange of different factors. For example, although weather is the main driver of the total area burned by fire each year, fuel type changes and demographic changes also have a significant influence on the final amount. These fuel type changes may be due to forest succession, logging, direct climate change and insect influences, which will all impact future fire behaviour and fire occurrence. Ongoing demographic changes could also influence human-caused fire occurrence and fire suppression objectives in populated areas. More studies should expand their focus beyond the impacts of climate change on forest floor fuel moisture to include the impacts climate change may have on tree line shifts, as different trees species produce varying fuel loads as well as the existing trees becoming more or less susceptible to burning. There should also be more focus on the effects of climate change at the regional scale to account for the large areal variability of weather variables and surface conditions. As the continued advancement of climate models will allow meteorological predictions to be produced at a finer scale, we can gain a better understanding of how fire regimes react to a changing climate.

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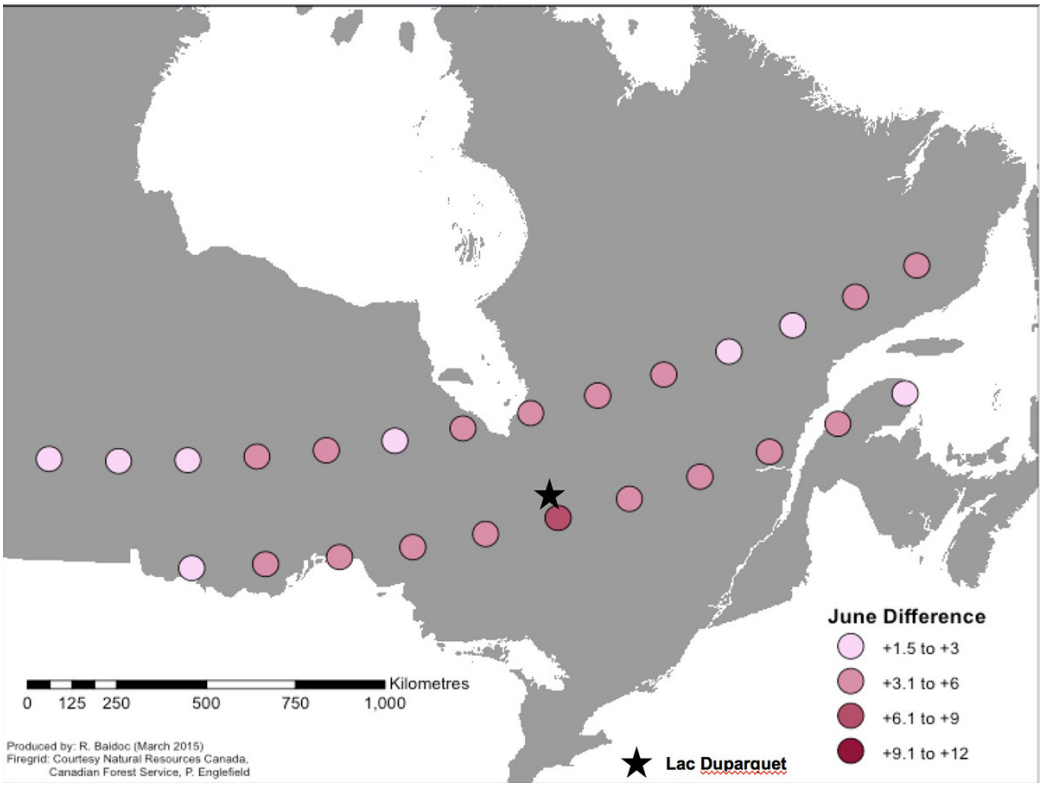


Figure 3
A visual representation of the differences in FFMC values at each grid point between the baseline and RCP 4.5 climate scenarios for the 25-year averages of the June months. All grid points exhibit an increase in average FFMC values. The star indicates the location of Bergeron and Flannigan's 1995 study area.

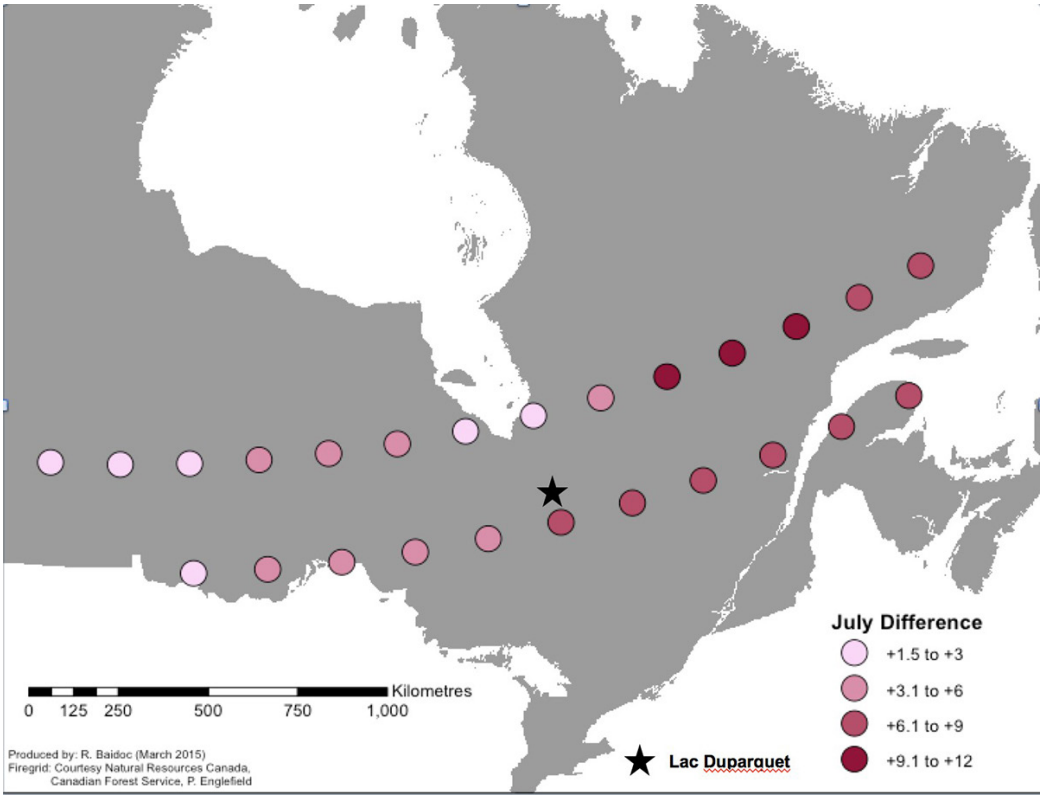


Figure 4
A visual representation of the differences in FFMC values at each grid point, between the baseline and RCP 4.5 climate scenarios for the 25-year averages of the July months. All grid points exhibit an increase in average FFMC values. The star indicates the location of Bergeron and Flannigan's 1995 study area.

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Sediment fingerprinting in the Lower Little Bow River using Cs-137 as a tracer

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The Lower Little Bow River watershed is a source of irrigation water for southeast Alberta. However, sediment in the river can be detrimental to both irrigation pump equipment and the health of the river. In order to understand and manage how sediment moves through a watershed, a study of sediment sources was conducted along a reach of the Lower Little Bow River employing fingerprinting techniques. The radionuclide cesium-137 was used as a tracer to determine whether the sediment in the river is being generated by surface or subsurface erosion processes. The main sources of sediment were found from subsurface erosion of an irrigation return-flow channel, coulee walls, and the river's stream banks. This demonstrates that subsurface erosion is the principle generator of sediment in the Lower Little Bow. Through measurement of multiple points along the reach, the study also determined that the composition of the suspended sediment load did not change as it moved downstream in the river.

Keywords: soil erosion, sedimentation, sediment fingerprinting, cesium-137, irrigation, Alberta

Introduction

The sources of suspended sediments in watersheds can be identified through the technique of fingerprinting using environmental tracers. Employing this technique, Davis and Fox (2009) demonstrated that nutrient-bound sediments within a watershed can cause significant deleterious effects on the aquatic ecosystem as well as water quality. This decline is linked to eutrophication, where an increase in nutrient concentration causes excessive algal growth on the surface of water (Barthod et al. 2015). Moreover, contaminants such as industrial chemicals, metals, and pathogens can be transported within watersheds by sediment acting as a vector. As a result, the amount and nature of sediment and its transport can have a significant impact on the ecology, food web, mortality, reproductive stress, and economic value of

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a watershed ecosystem (Koiter et al. 2013a). In the Lower Little Bow River (LLBR) considered in this study, the large amount of sedimentation occurring is a concern for these reasons. More sediments will result in turbidity and siltation, creating opportunities for nutrient transfer and damaging equipment such as irrigation pumps. In order to manage and improve the health of sediment-affected watersheds, it is essential to discover the sources of those sediments.

Study area

The focus area for this study was the LLBR watershed, located within the Oldman River basin of southeast Alberta, Canada (Figure 1). The study was conducted in a 2565-hectare subcatchment located at 112°37'30"W, 50°00'00"N that was originally part of an Agriculture and Agri-Food Canada Watershed Evaluation of Beneficial Management Practices (WEBs) project (AAFC 2013). Weather in the LLBR watershed is characterized by strong chinook winds and a regional average annual precipitation of approximately 386 mm a year (AAFC 2013). Its watershed is a mixed grass sub-region with geology mainly dominated by sand and coarse gravel and its surface material is mostly glacial till (Miller et al.2011). The classifications of soils found in the study area are Orthic Dark Brown Chernozems, Rego Dark Chernozems, and Orthic Regosols (Rahbeh et al. 2013). Agricultural uses within the watershed include cereals, forages, and intensive livestock and cow-calf operations (AAFC 2013; Rahbeh et al. 2013).

The Travers Reservoir, rainfall, and irrigation return flow are major factors affecting the flow rate within the LLBR (Little et al. 2003). Water for irrigation in the local area is supplied from the river itself, as well as by the Lethbridge Northern Irrigation District (Little et al. 2003; Rahbeh et al. 2011). Irrigation is a cause of concern in the LLBR due to its potential for sediment delivery to the river through irrigation return flow channels (NRCB/CEAA 1998). While irrigation is valuable to agricultural producers, its contribution to sediment loading of the river can have detrimental effects as it can impair pumps used downstream of irrigation return flow channels, necessitating repairs and leading to decreased crop growth and herding.

Cesium-137 (^{137}Cs) as a tracer

Sediment fingerprinting has been used in order to determine better management practices for controlling non-point source pollutants within watershed ecosystems. For example, surface run off is considered a non-point source because of its ability to contribute sediment and or nutrients from a large area rather than a single point source such as a channel. This requires management techniques that can be applied over a larger area rather than management of a single point. By understanding what sources are contributing to the sediment within a river better management practices can be applied to control their negative effects. Fortunately, there are many different biophysical and geochemical properties of sediment and soil that can be used as tracers for linking sediments back to their sources (Koiter et al. 2013a; 2013b). In order to determine the proportion of each source contributing to the suspended sediment load in a watershed, these natural tracers are measured both in potential sources and in the sediment (Davis and Fox 2009).

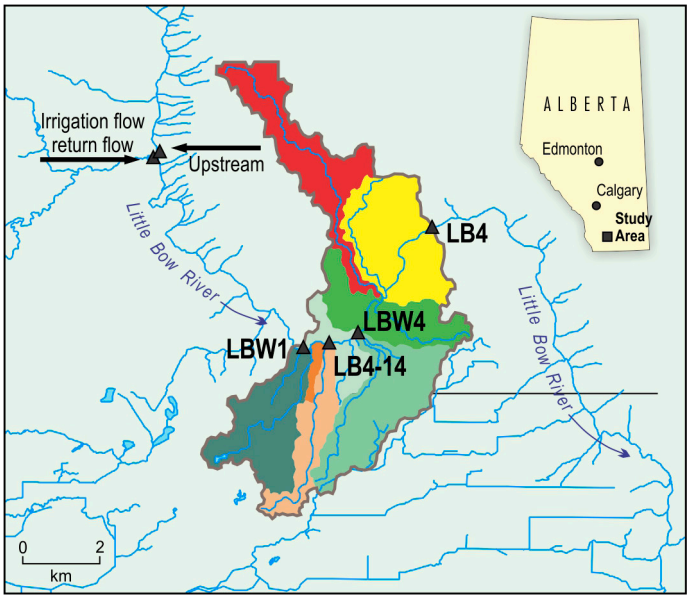


Figure 1
Map showing the Lower Little Bow River with the four sediment collection sites LBW1, LB4-14, LBW4, and LB4 relative to the Upstream and Irrigation Return Channel sediment samples
(Map source: © Her Majesty the Queen in right of Canada)

Radionuclides are environmental tracers than can label soil particles through the process of adsorption to clay minerals and organic matter, both of which have high specific surface areas. This adsorption between radionuclide fallout particles and clay minerals or organic matter can then be measured as a value for the activity of the radionuclide within soil or sediment samples (Koiter et al. 2013a). One readily available radionuclide in the environment is ^{137}Cs, which has a half-life of 30.2 years. Its presence can be linked back to a peak deposition over the period of 1950s–1960s when Cold War thermonuclear weapons testing released them into the atmosphere (Krishnappan et al. 2009; Koiter et al. 2013b). As a result, the presence or absence of ^{137}Cs in soil can be an indicator in distinguishing surface from subsurface materials, determining whether land has been disturbed or remains untouched, and revealing whether soil has been deposited or eroded (Koiter et al. 2013a). For instance, Smith and Blake (2014) showed that an important step in sediment fingerprinting is statistically differentiating the properties that identify target sediment sources; as ^{137}Cs settled onto the landscape, the radionuclide only adsorbed into 10–15 cm of surface topsoil. This range provides the statistical capability to distinguish between surface soils, which will show adsorption of ^{137}Cs, and subsurface materials which will not. ^{137}Cs also demonstrates the highly conservative properties necessary for use as a tracer, resulting from its non-exchangeable behaviour in the soil matrix (Li et al. 2010). Thus ^{137}Cs can be uniquely identified to differentiate be-

tween surface and subsurface sources of sediment contributing to suspended sediment in an aquatic system.

^{137}Cs was used in this study to pursue two objectives: first, to examine ^{137}Cs activity in the sediment as it moves downstream in the reach, and second, to determine if surface or subsurface erosion is the main cause of sediment influx into the Lower Little Bow River.

Methods and materials

Methods of sediment and soil collection

Two general sample types were taken in this study: first, source samples were used to gain information about soil at potential erosion sites contributing to the river, and second, suspended sediment samples were taken in the water once the materials had entered. The sites chosen for suspended sediment collection were locations originally used by Alberta Agriculture and Rural Development to monitor water flow and quality on the LLBR. Four of these monitoring stations—LBW1, LB4-14, LBW4, and LB4—were sampled as part of WEBs between 2009 and 2013 in a sub-catchment of the LLBR (Figure 1). The suspended sediment samples were collected using time-integrated samplers, in this case tubes used to collect sediment by allowing water to enter and exit through small openings thereby reducing flow enough to deposit sediment as it passed through the tubes (Roddan 2008). One tube was placed at each station and sampled periodically throughout June to December. In 2013, only LBW1 and LB4 were sampled. These were included as part of the previous 2012 sample inventory.

The sediment sources chosen for examination were areas considered to be potential contributors to the sediment load of the river. These source areas included coulee walls, irrigated and non-irrigated cropland, native pastures, and stream banks. All were sampled near to and upstream of the sediment traps along transects extending away from the river, with samples taken at lower, mid, and upper slope positions. Samples were collected from the surface to a depth of 10 cm, and in 10-cm increments to a depth of up to 30 cm on the land and up to 60 cm from stream banks. Coulee wall samples were taken intermittently down the face of the wall. All samples were dried and sieved down to 2.0 mm then shipped to the Environmental Radiochemistry Lab in the Department of Soil Science at the University of Manitoba for analysis. Source samples were collected throughout the same 2009–2013 time period as the sediment samples.

Two areas outside of the reach of the river and sub-catchment were also sampled. An upstream sediment source was sampled in order to discriminate sources contributing to the sediment load from sources further upstream, and an irrigation return flow channel was sampled upstream from the other sediment collection sites. As Figure 1 shows, the irrigation return flow channel was upstream relative to the other sediment collection sites, however, it was downstream of a sample taken to represent the upstream sediment entering the reach from the larger watershed. A sample was collected from the outlet of the irrigation return flow channel due to a concern that sediments from irrigated fields and the erosion of the channel itself result in a large amount of sediment being delivered to the river.

Gamma ray spectrometer methods

Sediment and soil samples were analyzed for ^{137}Cs activity using gamma ray spectrometry (Wallbrink et al. 1999). Analysis was carried out for up to 24 hours per sample depending upon the amount of soil used and the concentration of ^{137}Cs. Samples were placed in containers and packed to ensure a uniform geometry and bulk density. The height of the sample in the container and the gamma detector efficiency for that container geometry were recorded. Depending on the amounts of sample available, containers with different geometries were used. The amount of activity was determined from the gamma spectrum obtained from each sample and in order to account for decay, each measurement was corrected back to a single date based on the first year of sampling: 1 January 2009. The following equation was used to determine ^{137}Cs activity (Slavicek 2011), and once the value of ^{137}Cs activity was obtained, it was used to determine whether ^{137}Cs was present and at what levels in the landscape.

$$\text{Cs activity} = \Sigma Cs / 0.85 \times \text{Eff-137} \times 1/e^{-\lambda t}$$

where

Cs activity is the activity of Cs-137 at time of sampling (dps)
ΣCs is the counts per second (cps) of 662 Kiloelectron volt (keV) photo peak
Eff-137 is the counting efficiency for Cs-137 at 662 keV for the sample geometry used (container)
0.85 is the percent of the 662 keV peak of Ba-137M
λ is decay constant for Cs-137 (years)
t is elapsed time (years) between sampling and counting

The mean ($X = (\Sigma x)/n$) and standard error ($s = \sigma/(\sqrt{n})$) of ^{137}Cs activity for a sample area can be determined by using the ^{137}Cs activity in Becquerels per kilogram (Bq/kg). This was done by grouping the areas that had been sampled into similar source types and comparing these source types to the ^{137}Cs activity levels found in the sediment sampling sites. Five types were distinguished from the total amount of soil samples collected and were assigned names according to their origin. The classification utilized Agricultural Land, Coulee Walls, Irrigation Return Flow, Stream Bank, and Upstream as source types. The mean and standard error values were used to identify whether or not ^{137}Cs is present in the area sampled and to calculate the average activity level for the source as well as the average activity level of the sediment collected at that site over the five-year period. An analysis of variance was done on the average values of ^{137}Cs activity for the four sites, LBW1, LB4-14, LBW4, and LB4, to demonstrate any change in activity between them.

Results

^{137}Cs activity in source material

The nature of ^{137}Cs activity in the soil is a useful tool in understanding both surface soil erosion processes, such as rill or sheet erosion, and subsurface soil erosion processes such as gully or channel erosion. During erosion processes silt, clay, and light organic particles are preferentially detached and transported. These particles make up the majority of sediments suspended in streams and deposited in waterbodies. Coarser particles like sands and gravels may not be detached and transported by the river, and even if they are, they may settle out and be deposited along the flow path as conditions change and transport capacity decreases. As a result, river-borne sediments tend to be enriched with finer materials and depleted of coarser ones. The sediment detached and transported by the river will also become concentrated in ^{137}Cs, since it preferentially binds with the clay and organic material in soil. Where soil containing ^{137}Cs is the only source of sediments, the concentration in or activity of ^{137}Cs in the sediment will be markedly higher than the soil from which it originated due to this enrichment process.

The activities of ^{137}Cs found in the LLBR sediment sources varied significantly. The highest level of activity was found in the Agricultural Land sources, likely because this was the sample area with the greatest amount of surface material (Figure 2). Here, ^{137}Cs would have been initially deposited from the atmosphere in the 1950s. When all sites are considered, the measured ^{137}Cs activity on average was 5.43 Bq/kg. The subsurface sources had significantly lower levels of ^{137}Cs activity, with the Coulee Walls source having 0.31 Bq/kg and the Stream Banks source having 0.77 Bq/kg (Table 1). These differences in activity between sources demonstrate that surface material will contain more ^{137}Cs in comparison to the amounts found in subsurface material.

Upstream and Irrigation Return Flow sources

The Upstream and Irrigation Return Flow source samples both had ^{137}Cs present. The sediments contained an average ^{137}Cs level of 3.47 Bq/kg, while the Irrigation Return Flow sediments had an average of 0.27 Bq/kg (Table 1). This demonstrates that the sediment source had an influx of ^{137}Cs-rich material from the land surface higher up the river, which was carried in the sediment load into the study reach of the LLBR. Conversely, low levels of ^{137}Cs were found in sediments from the Irrigation Return Flow source. This demonstrates that the majority of the sediments entering the river from this channel originated in subsurface sources, most likely from the irrigation return flow channel itself (Figures 2 and 3).

^{137}Cs activity in sediments

Fifty sediment samples were collected over the five-year study period. ^{137}Cs was present in the samples at each of the four sites in the LLBR. This demonstrates that at some point, sediments rich in ^{137}Cs from the land surface entered the river. When analyzed using gamma spectrometry, the average levels of ^{137}Cs activity ranged from 1.22 Bq/kg to 1.47 Bq/kg (Table 1). In order to assess whether the suspended sediment composition significantly changed as it moved downstream through the sites at LBW1, LB4-14, LBW4, and LB4, average levels of ^{137}Cs activity for each of these sites were compared. If the difference in means was significant it would indicate that the amount of ^{137}Cs activity changed during the movement downstream, suggesting that a different source other than those identified for the upstream areas must be contributing sediments into the river to change the suspended sediment composition. With a p-value of 0.54 ($p > 0.05$) it was found that there was no significant difference of ^{137}Cs activity between the LBW1, LB4-14, LBW4, and LB4 sites. This demonstrates that the suspended sediment composition does not significantly change as it moves downstream and that the sources sampled throughout the reach are consistent moving from upstream to downstream between the four sites. Moreover, it shows there is no source that is contributing significant amounts of sediment to the river downstream that is different from sampled sources upstream (Figure 3). However, the sediment samples still read much higher than the average ^{137}Cs activity downstream at the four sites (Figure 3). The ^{137}Cs activity of the Upstream sediment sources was 3.47 Bq/kg compared to the sediments found at the other four sites, which ranged from 1.22 to 1.47 Bq/kg (Table 1). This significant difference in activity demonstrates that upstream of LBW1, LB4-14, LBW4, and LB4 sites more ^{137}Cs-rich material is being added at some point. It also demonstrates that there is significant change in the sediment composition as it moves from the Upstream site to the four downstream sites.

Table 1
Average ^{137}Cs activity in Bq/kg for sources and sediments in the LLBR

	Samples	Mean	n	Standard Error
Source	Upstream	3.47	5	0.29
	Irrigation return flow	0.27	8	0.11
	Agricultural land	5.43	104	0.45
	Coulee wall	0.31	6	0.26
	Stream bank	0.77	45	0.15
Sediment	LBW1	1.27	15	0.14
	LB4-14	1.22	10	0.10
	LBW4	1.47	10	0.18
	LB4	1.43	15	0.13

Discussion

Source ^{137}Cs activity related to sediment ^{137}Cs activity

The activity levels of ^{137}Cs in the study area sources can be compared to the average amount of ^{137}Cs found in the sediments collected at the four downstream sites: LBW1, LB4-14, LBW4, and LB4. Sediments from gully or channel erosion will have little or no radionuclides present, while surface erosion processes such

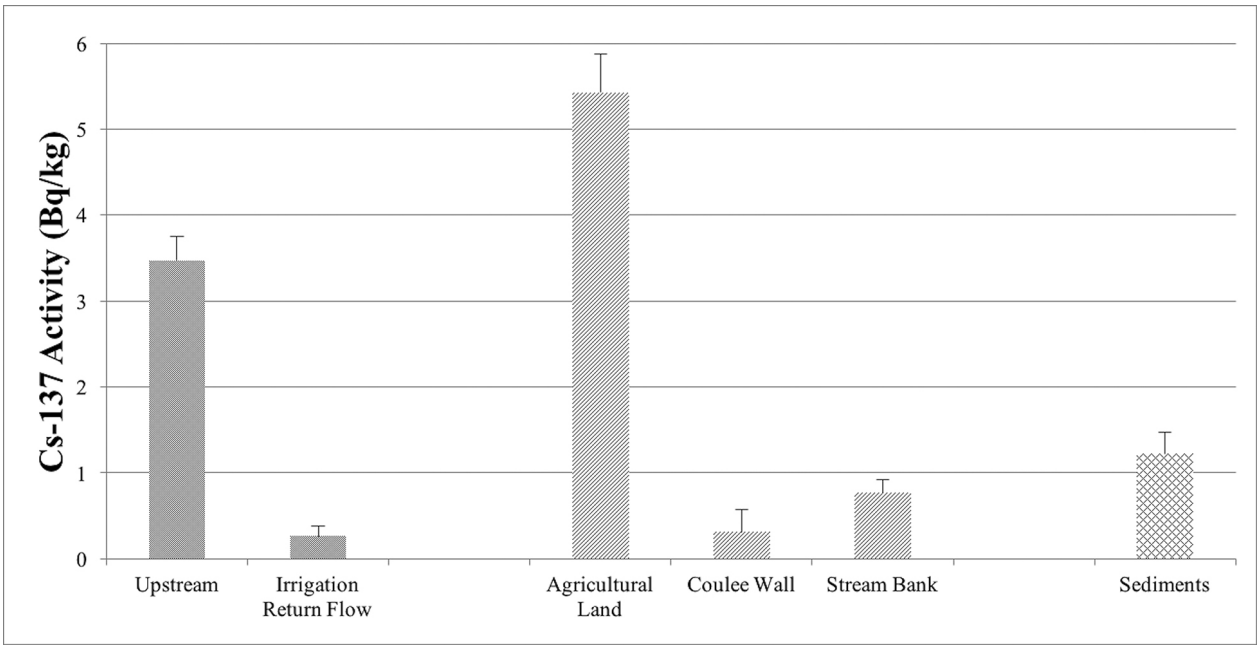


Figure 2
^{137}Cs activity for different sediment sources throughout the LLBR study area in comparison to the average ^{137}Cs activity for LBW1, LB4-14, LBW4, and LB4

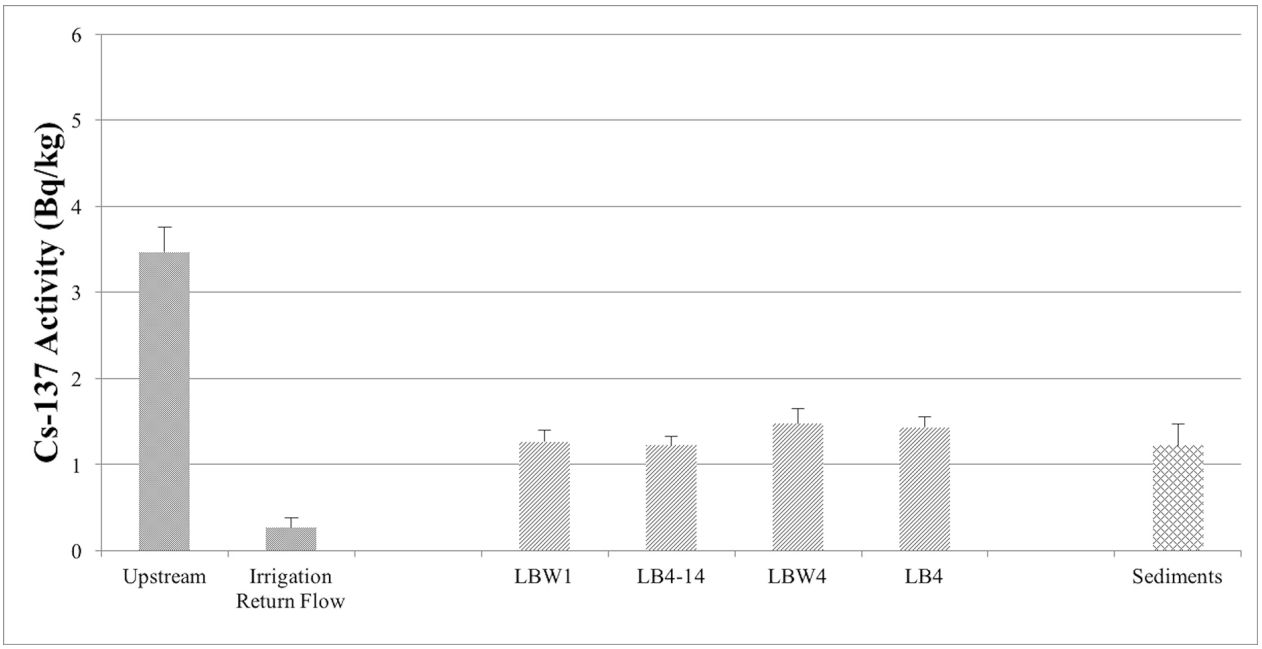


Figure 3
^{137}Cs activity of sediment at monitoring stations throughout the LLBR study area in comparison to the average ^{137}Cs activity for LBW1, LB4-14, LBW4, and LB4

as sheet and rill erosion will have significantly higher amounts of radionuclides present (Olley et al. 2013). The ^{137}Cs enrichment of fine sediments explains which sources are contributing the most to the sediments in the river. If surface material was the sole source of the sediment in the river, samples would show either the same ^{137}Cs activity or higher than the source due to enrichment (sediment ≥ source). As seen in Figure 3, the Agricultural Land sources had the highest amount of ^{137}Cs activity while the average sediment ^{137}Cs activity is significantly lower than this source. These findings lead to the conclusion that the main cause of sediment into the LLBR is not from agricultural land. In a similar study conducted in Georgia, Mukundan et al. (2010) apportioned sources for streams within the southern Piedmont region as having 60% of the suspended sediment load from stream bank erosion, and only 10–15% from pasture land sources. The LLBR study is consistent with these results, as demonstrated in Figure 3 where the Coulee Walls and Stream Banks sources both had lower than the average sediment ^{137}Cs activity. They are lower because both sources contribute sediment through the erosion of subsurface material, which does not contain high concentrations of ^{137}Cs (Olley et al. 2013). This further demonstrates that the main cause of sediment influx into the LLBR is from the erosion of subsurface sources. This method is not specifically apportioning how much each different subsurface source is contributing, but it can distinguish that the sediment loading is not caused by surface erosion from the Agricultural Land source.

Sediment ^{137}Cs activity related to Upstream and Irrigation Return Flow sources

In a study done by Olley et al. (2013) using the ^{137}Cs method, it was found that the dominant source of sediment in river catchments is channel erosion. This conclusion is supported by the LLBR results, where most of the erosion processes contributing sediment were subsurface and channel erosion. The Upstream and Irrigation Return Flow sediment samples were both taken upstream and out of the reach of the sites where the sediment and soil sources were sampled in the LLBR (Figure 1). The upstream sediment ^{137}Cs activity was significantly higher than the average sediment ^{137}Cs activity, and the ^{137}Cs activity for the irrigation return flow was minimal due to the sediment being scoured from channel erosion. As seen in Figure 1, the Irrigation Return Flow samples were taken downstream from the Upstream sample site. In order for upstream sediments to have the ^{137}Cs activity decrease to the amount that is found on average for LBW1, LB4-14, LBW4, and LB4 sites, a large influx of non-^{137}Cs-rich sediment would be required to dilute the ^{137}Cs activity. The irrigation return flow is a non-^{137}Cs-rich source that could be diluting the upstream sources by the addition of sediment to the river from channel scouring. Further study of how much irrigation return flow channels are contributing to sediments in the LLBR will determine whether they should be managed differently and whether they are the main reason for sediment loading in the river.

In the Mukundan et al. (2010) study multiple tracers were used to fully apportion sources of sediment entering the streams of a watershed. The use of multiple tracers gave a better understanding of what may be causing sediment loading in a watershed, which in turn was able to facilitate mitigation efforts. In this study of the LLBR, using only ^{137}Cs as a tracer, it was difficult to determine exactly how much each source was contributing to the total sediment load. While it was possible to conclude that the suspended sediment load was mostly derived from subsurface sources, how much each individual source was contributing was not determined using ^{137}Cs alone. The ability to apportion these sources precisely would allow for proper mitigation practices to be considered. It is known that irrigation return flow channels, coulee walls, and stream banks are all contributing as subsurface sources, but each needs to be managed in a different way if it is the main contributor of sediment.

Conclusion

The method of using ^{137}Cs as a tracer in this sediment fingerprinting study has shown that the main cause of sediment delivery into the LLBR is from subsurface erosion processes. This was concluded based on observations of sediment samples from sites representative of subsurface erosion, such as irrigation return flow channels, coulee walls, and stream banks. However, as the ^{137}Cs data have shown with the Irrigation Return Flow source activity and the Upstream source activity, it is difficult to know from the tracer alone whether the irrigation return flow channel is the main source of sediment into the LLBR in this reach of the river or whether it is similar in proportion to the other subsurface erosional sources like coulee walls and stream banks. In order to specifically apportion how much each source is contributing to the total suspended sediment load, other sediment tracers should be combined with ^{137}Cs and used with more sophisticated sediment fingerprinting methods. Other techniques such as colour analysis in diffuse reflectance spectrometry, alpha and gamma spectroscopy, or geochemistry using other spectrometry methods to look at other radionuclides could be used in combination to trace sediments, while the source apportions could be modeled using un-mixing models such as mixSIAR.

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Prairie Perspectives: Geographical Essays
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Canadian Association of Geographers
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Comparison of small mammal species in natural versus agricultural habitats at the Brandon Research and Development Centre

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*Intensification of agricultural practices has put pressure on small mammal species diversity. Small mammals that use natural habitats for food, shelter, and refuge from predators can be displaced as a result of having more cropped land with less natural surrounding areas. However, small mammals can also be beneficial to agriculture as they aerate soil and provide it with nutrients, consume crop-threatening insects, and are an important lower trophic level component in the diet of secondary and tertiary consumers such as coyotes and raptor species. As part of a larger-scale wildlife resource inventory on the grounds of the Agriculture and Agri-Food Canada Research Centre in Brandon, Manitoba, small mammals were trapped and results compared between natural and agricultural environments on the property. The species trapped in this study included the meadow jumping mouse (*Zapus hudsonius*), American deer mouse (*Peromyscus maniculatus*), meadow vole (*Microtus pennsylvanicus*), southern red-backed vole (Clethrionomys gapperi), masked shrew (*Sorex cinereus*) and northern short-tailed shrew (*Blarina brevicauda*). Our results showed that the natural areas contained a higher diversity of species as well as a higher number of individuals. Results from this preliminary analysis indicate that it is important to have natural areas interspersed throughout agricultural areas. Conducting further research in a larger variety of natural and cropped habitats, over a longer period of time, will allow researchers to draw more thorough conclusions with respect to small mammal diversity and habitat selection in agricultural landscapes.*

Keywords: agriculture, small mammals, habitat selection, trapping

Introduction

Recent intensification of agricultural practices (Firbank et al. 2008) is leading to greater anthropogenic influences on land use. The alteration from natural ecosystems to agroecosystems has incurred negative impacts on biodiversity (Firbank et al. 2008), reducing the population of pollinators, insect-eating birds, small mammals, and species that prey on agricultural pests (Scherr and McNeely 2008). Intense alterations in land use also have the potential to reduce habitat for specialist species and put many others at risk of endangerment. The disappearance of specialists

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finely attuned to their ecological niches may also result in the growth of generalist species populations able to thrive in a variety of different environments (Tscharntke et al. 2005).

Modifying the landscape is known to have negative impacts on the diversity of small mammals (Fischer and Schroeder 2014), which can in turn affect the nature of human agricultural practices. Small mammals in agricultural environments can be seen from two different perspectives. While from an anthropocentric standpoint they may be viewed as economically harmful pests, from a biocentric point of view they are important lower trophic components of the food web (Fischer and Schroeder 2014). Many species of small mammals also burrow, which contributes to aeration of the soil and through the addition of urine and feces brings minerals down that improves its structure and chemical composition (Hull Sieg 1987). Small mammals such as the American deer mouse (*Peromyscus maniculatus*) act as insectivores, consuming crop-threatening insects such as caterpillars and grasshoppers (Scherr and McNeely 2008). Removing small mammals from an agro-natural setting will therefore have detrimental effects on many ecological and economic processes (Hull Sieg 1987).

It is important to understand how small mammals are impacted by agriculture due to the important ecological roles they play (Hull Sieg 1987). Firbank et al. (2008) identify three agriculturally-related factors that contribute to biodiversity loss. The first factor is the conversion of natural land to cropped fields. Clearing land of trees and associated plants reduces habitat niches for wildlife (Firbank et al. 2008). Species faced with habitat loss will react in one of four ways: tolerate the changes and stay where they are, move to another area, adapt through plasticity, or become extinct (Mills 2007). In agricultural settings isolation caused by fragmentation will also cause species populations to decline (Andrén 1994). While species dependent on natural habitats are devastated by the permanent removal of their original habitats, those able to subsist in the modified environment also face the annual disturbance of crop harvest. Species that inhabit crop fields for seeds and shelter lose these resources during tilling, mowing, and harvesting activities. However, when cropping occurs, small mammals may seek refuge in untilled adjacent fields (Aschwanden et al. 2007) or natural areas (Blitzer et al. 2012). A mosaic of natural and semi-natural areas provides small mammal over-wintering and nesting habitats that are less exposed to agricultural chemicals (Blitzer et al. 2012). For predators, these natural areas therefore hold prey that have lower toxin loads than prey exposed to the application of pesticides. The natural area prey source therefore reduces bioaccumulation of pesticides in prey and biomagnification of the chemicals for high trophic level predators (Shore and Douben 1994).

The agro-natural landscape mosaic created by farming is also important with respect to habitat connectivity and the creation of abrupt habitat edges. Converting native habitats to cropped land-cover types decreases connectivity and increases edge effects (Fischer and Schroeder 2014). Fragmenting natural areas can therefore result in disjunction of small mammal populations that do not move very far from their natal area (Benton et al. 2003). Vegetation patches for nesting and foraging are also crucial, as the cost of travelling between patches for resources can become unsustainable in heavily fragmented areas (Benton et al. 2003). Consequently, small mammals in agricultural settings may benefit from the presence of natural corridors or non-cropped areas such as forest fragments and hedges interspersed throughout cropped land cover (Benton et al. 2003; Firbank et al. 2008).

The second major agricultural factor affecting small mammals suggested by Firbank et al. (2008) is arranging or combining crops to increase soil productivity, control pests, and reduce diseases. Crop rotation is beneficial for replenishing important nutrients in the soil but does not provide a consistent, stable habitat for small mammal species (Benton et al. 2003). A lack of crop variety in the rotation may also reduce diversity as it reduces the variation of habitats. The final factor relates to productivity adaptations such as fertilizer applications to increase crop yield or employing chemical herbicides, pesticides, and fungicides to reduce pests (Firbank et al. 2008). These auxiliary energy flows can have negative population scale impacts by reducing aspects such as reproduction rates (Shore and Douben 1994).

The population dynamics of small mammal species are usually predicted by their classification as either 'generalists' or 'specialists.' A generalist species is one that exhibits a broad use of different food sources and habitats, while specialist species appear to have more specific and narrow environmental tolerances (Pandit et al. 2009). When habitat availability is altered the abundance of specialist species is affected more drastically than that of generalists, since the latter are able to change their habits as conditions warrant (Coda et al. 2015). Specialist species are currently more susceptible to extinction because of rising fragmentation and habitat loss (Pandit et al. 2009). Most of the studies conducted on the roles of small mammals in agricultural settings have discovered that, depending on the habitat matrix, the main small mammal families present are mice, voles, and shrews (Wrigley et al. 1979; Chapman and Ribic 2002; White et al. 2012). Most small mammal species that are found in areas that have been impacted by agriculture are generalist species. They do not require a wide range of habitat variables and therefore are able to survive in habitats that have become degraded. Each of these groups can have a different environmental impact depending on their diet, the shelter they seek, and the need to seek refuge from predators. For example, mice often increase crop yields naturally by acting as seed dispersers throughout fields. In deforested landscapes the dispersal of seeds by small mammals is also critical in ecological succession when restoring natural areas (Blitzer et al. 2012). It is therefore important to understand how these species and ones like them use the environment or contribute to agricultural processes.

The research presented in this article is focussed on the diversity of small mammals present in cropped and adjacent natural habitats at the federal Brandon Research and Development Centre (BRDC) maintained by Agriculture and Agri-Food Research Canada in Brandon, Manitoba. The research is part of an ongoing comprehensive wildlife resource inventory towards the

development of a species-at-risk management plan on the property. The hypothesis tested in this study is as follows:

H_0 = There is no difference in species diversity in cropped versus natural habitats

H_a = There is a difference in species diversity in cropped versus natural habitats

A corollary question attempted to confirm whether specialized species are more likely to be found in natural areas and generalist species in cropped areas.

Methods

The trapping period for this study began August 16, 2015 to correspond with an active movement period for the target species when juveniles are weaning and all individuals are beginning to prepare for winter. The trapping period ended just prior to harvest on September 11, 2015. Based on the observations of the researchers at BRDC, this is typically the time of year when small mammal dispersal is greatly decreased as individuals move into hibernation locations. Line transect sampling was used to determine population estimates in the different areas surveyed. Following Heroldová et al. (2007), 100-metre trap lines were set in four cropped habitat types and five natural habitat types (Table 1) with proportional representation used to calculate how many trap lines were to be placed in each. As a result, the number of times individual habitat types were sampled reflected the relative percentage of its land-cover type.

Sixty-five percent of the traps were placed in cropped habitats and 35% in natural habitats (Figure 1). The trap lines were placed within each chosen land-cover type sites that were best representative of the area. Each trap line contained 20 Victor® Mouse Trap snap traps placed 5 m apart, baited with a mixture of peanut butter and bacon fat (Figure 2). Killing traps were used in each in order to test for fleas on individuals as part of another study. Trap lines were set for two nights at each location and checked daily each morning. The traps were rotated from site to site throughout the trapping period. All trapping was conducted by Agriculture and Agri-Food Canada.

Results

A total of 109 individuals were trapped over 38,380 trap hours (Table 2). The six species recorded included American deer mouse (*Peromyscus maniculatus*), meadow jumping mouse (*Zapus hudsonius*), meadow vole (*Microtus pennsylvanicus*), southern red-backed vole (*Clethrionomys gapperi*), masked shrew (*Sorex cinereus*), and northern short-tailed shrew (*Blarina brevicauda*). Because there was more agricultural land cover than natural land cover in the study area, a correction factor of 0.486 was applied to the cropped habitat data to correct for bias towards increased observations in agricultural habitats.

Due to small sample sizes, pooled small mammal presence between natural versus agricultural habitats was compared statistically. Since the samples were not normally distributed, results were compared using a non-parametric Mann-Whitney U-test. The test indicated that there was a significant difference in the species caught between habitats ($U=968.5$, $p<0.000$). While all six species were present in the natural habitats, only American deer mouse, meadow jumping mouse, and meadow vole were recorded in the cropped areas. Least representative were the two shrew species, which were only caught in the riparian land covers within the natural habitat types. The American deer mouse constituted the greatest number of individuals caught and was also captured in the greatest number of land-cover types, including both natural and agricultural habitats.

Discussion

The study revealed a higher diversity of species in the natural habitats than in the cropped habitats. These results are similar to Umetsu and Pardini's (2007) finding that different sets of species appear between native vegetation and agricultural habitats, and they are consistent with removal of natural habitat described by Firbank et al. (2008). There was also a higher relative abundance of small mammals trapped in areas of natural land cover (n=43) versus cropped (n=32 after correction). These results support

Table 1
Land cover description of agriculture and natural habitat types sampled

Habitat Type	Land Cover Type	Total Area	Total Trapping Hours	% of Total Study Area
	Cropped:			
Wheat **Soybeans** **Barley** **Canola**	All crops are a mono-culture with no under story, litter or any other vegetative layers	362.83ha	25, 820	65%
	Natural:			
Alfalfa (Tame Pasture)	Large amount of litter (dead grass), native pasture that was broken then planted with tame species like alfalfa, timothy grass, clover etc.			
Oak Bluff	Small forested patch, **herbaceous layer**: timothy, brome, plantain, dandelion and bluegrass, **shrub**: willow, rose, snowberry, **trees**: oak, aspen, green ash			
Riparian	River/Small stream running through, one area previously grazed by cattle, **herbaceous layer**: reed canary, common reed, carex (mixed sedges), cattail, water parsnip, water hemlock, wild mint, nettle, marsh marigold, **shrub**: willow, dogwood, hawthorn, **trees**: green ash, aspen, oak, balsam poplar, cottonwood	197.35ha	12, 560	35%
Shelter Belt	**herbaceous layer**: brome, **shrub**: none, **trees**: green ash			
Rough Pasture	May or may not have been broken sometime in the past and tends to have a larger compliment of native species that have come in as the 'tame' species have died out or been over-grazed out.			

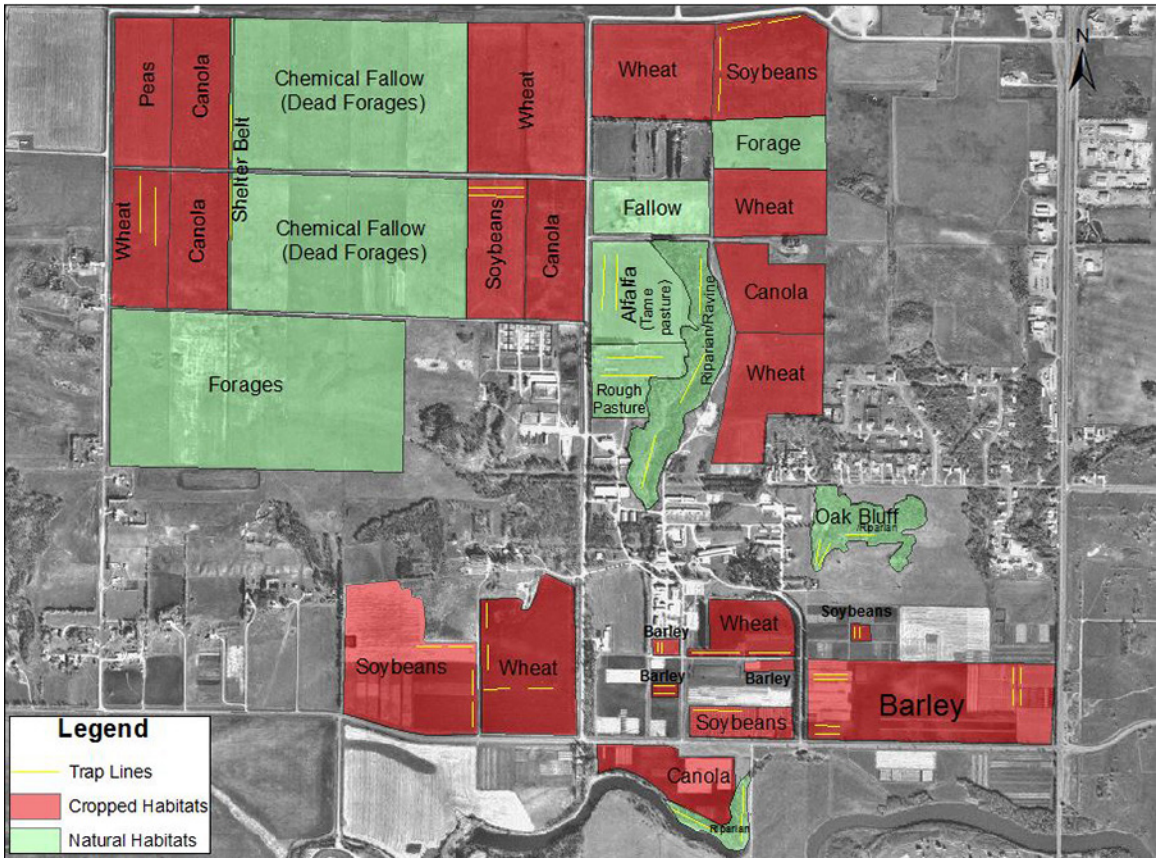


Figure 1
BRDC study area showing habitat types classified as natural (green) and cropped (red)



Figure 2
Snap trap placed in a riparian habitat (Photo credit: M. Dubois 2015)

Table 2
Number of individuals by species trapped per habitat type

	Agricultural Habitat (corrected)				Natural Habitat					Total # of Individuals
Species	**Wheat**	**Soybeans**	**Barley**	**Canola**	**Alfalfa (Tame Pasture)**	**Oak Bluff**	**Riparian**	**Shelter Belt**	**Rough Pasture**	**All Habitat Types**
American deer mouse (*Peromyscus maniculatus*)	13 (6.32)	24 (11.66)	15 (7.29)		1		1	3	10	67
Meadow jumping mouse (*Zapus hudsonius*)		1 (0.49)					2			3
Southern Red-backed vole (*Clethrionomys gapperi*)						1	7			8
Meadow vole (*Microtus pennsylvanicus*)	2 (0.97)	2 (0.97)	7 (3.4)	2 (0.97)			8		1	22
Masked shrew (*Sorex cinereus*)							3			3
Northern short-tailed shrew (*Blarina brevicauda*)							6			6
Total/Land Cover Type	15 (7.3)	27 (13.12)	22 (10.69)	2 (0.97)	1	1	27	3	11	109
Total/Habitat Type		66 (32.08)					43			
Total # of Traps Tripped		82 (39.85)					61			

our alternate hypothesis that species diversity would be higher in natural areas. For example, the riparian habitats showed the highest level of diversity with all six species represented. Although a portion of the riparian area had been previously grazed by cattle, it was one of the least disturbed of the sample sites. The natural habitats are therefore an important indicator of small mammal diversity. Moreover, they remain a valuable natural ecosystem component as dispersal of seeds by small mammals is critical in tree succession and bringing back natural vegetation to previously altered habitats (Blitzer et al. 2012).

Fischer et al. (2011) found small mammals to have varying responses to landscape complexity when analysed at multiple scales. They suggested that this demonstrated both species-specific ecological needs and functional spatial scales for conservation management. Our study supported the expectation that simplified systems such as agricultural land cover result in lower abundance, richness, and diversity.

Andrén (1994) has suggested that generalist species may be able to utilize smaller land areas at higher densities than what would normally be expected. In this study, the highly generalist American deer mice were caught in the greatest numbers and across all land-cover types, supporting Andrén's findings (1994). In another study, Pandit et al. (2009) found that species abundance for generalists was influenced by the spatial distribution of habitat patches whereas specialists were more influenced by the local environmental conditions within the habitat. For example, the two shrew species were only found in natural land cover types where water was present. Since this species is deliberate in selecting habitats that include an aquatic component, they confirm our hypothesis as well as Pandit et al.'s (2009) observations that more specialized species are more likely to be found in natural habitats. Another specialist, the southern red-backed vole, was trapped in a natural area of dense green biomass. Thus when the availability of natural habitat is reduced the effect is greater on specialist species than it is on generalists (Pandit et al. 2009). This theory is confirmed by this study where it was found that the number of individuals trapped and the species diversity was greater in the natural habitats.

In agreement with other studies, our preliminary results indicate that anthropogenic land-use changes can alter small mammal species diversity or behaviour. They also confirm Mills (2007) observations that when habitat deteriorates or is altered specialist species will relocate to find a more suitable habitat while generalists will thrive. It also agrees with Umetsu and Pardini (2007), who posited that seed dispersal may decrease if small mammal species disappear. Since seed dispersal is important for forest regeneration in previously agricultural landscapes, the reduction of natural regenerative processes on a large scale

increases as fragmentation occurs. Most natural habitat patches in agricultural settings are isolated from each other with little or no corridors or stepping stones. With respect to this degree of fragmentation, Umetsu and Pardini suggest that the secondary vegetation areas surrounding parcels of forest are important to conserve as they "harbor richer, more abundant, and less spatially variable small mammal assemblages" (2007, 527). This implies it is as important to protect natural areas currently existing within the fragmented landscape, as it is to promote new growth and natural corridors in areas no longer used for farming.

Currently, there is little pressure from the research community to assess the conservation status of any of the species trapped in this study. This is likely because none of the species captured in this study have been assessed by the Committee on the Status of Endangered Wildlife in Canada, none are listed in the federal Species at Risk Act, nor are any listed by provincial acts across Canada. However, they are listed as important prey and therefore dietary components of at-risk species such as the burrowing owl (*Athene cunicularia*), ferruginous hawk (*Buteo regalis*), and the short-eared owl (*Asio flammeus*) (COSEWIC 2006, 2008a, 2008b; Wildlife Branch 2016). Since this study indicates that natural areas provide specialist habitats and maintain diversity among small mammals, it follows that the at-risk species which prey on these animals also implicitly rely on the natural areas. A reduction in prey diversity due to fragmentation could result in the collapse of an ecological niche or lead to a change in the role or position of a species within its environment (Layman et al. 2007).

Because the data set in this study was relatively small and the trapping period was short, by necessity land-cover types were combined within the larger habitat categories. A larger sample size over a longer trapping period would allow for individual comparisons of the land covers. For example, in our study the largest number of deer mice were caught in soybeans. This could be significant since it has been suggested by Burnett (2014) that as the climate warms and dries in the prairie ecozone there could be an increase in soybean crops planted in the southern prairies. It may be worthwhile to explore whether small mammals preferentially select certain crops. The addition of other crop types in a larger study would also add to this avenue of inquiry.

It would also be useful to examine the effect of fragmentation and whether there is small mammal movement between habitat patches. For example, given the higher abundance of species in the natural areas in our study area it stands to reason these areas act as sources that repopulate cropped area sinks that have been depleted of their resources and have become low quality habitats. It would also be valuable to understand exactly how species deal with annual crop harvest and habitat loss. There is some evidence that individuals that inhabit crop fields move to the natural areas following harvest (Aschwanden et al. 2007; Blitzer et al. 2012). However, the extent to which the degree of fragmentation limits movement requires more attention.

Conclusion

The preliminary results of this study highlight differences in species diversity between natural and cropped habitats. This research supports the notion that natural habitat patches must be present and interspersed throughout areas where the land use is predominantly agricultural in order for the native diversity of small mammal species to persist (Benton et al. 2003). However, the maximum degree of natural habitat fragmentation within the agricultural landscape still needs to be assessed. Regardless of whether they are viewed as pests or important parts of the ecosystem, the way small mammals are affected by anthropogenic landscape change warrants more attention. Integrated management practices should be used within agricultural and other heavily altered settings in order to ensure that small mammal species have sufficient food, water, and shelter in order to sustain their populations. The positive environmental impacts of small mammal species in agriculture must be recognized in order to maintain a healthy ecosystem.

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Prairie Perspectives: Geographical Essays
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French and Belgian land settlement patterns in three communities in Saskatchewan in the early 1900s

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French and Belgian settlement patterns were studied in three communities in southwestern Saskatchewan. The areas, settled in the early 1900s, were of moderate agriculture capability. Though colonizing priests toured the Canadian prairies and located land they deemed culturally advantageous and suitable for farming, priests' and settlers' correspondences show that both were unfamiliar with land capability for agriculture on the prairies. Adverse terrain was often visible, affecting colony site and individual homestead selection. Bush and distance from water were important, socio-economic factors influenced settlement, and co-nationals often homesteaded together. Railway routes were unknown and did not influence homestead patterns and settlement did not expand outward from towns. While economics played a role, the colonizing priest was particularly influential in attracting settlers to Ponteix. A priest and a government agent were important at Dollard. Family attracted many homesteaders to Fife Lake. Family influenced land selection in all three settlements, but was most significant at Fife Lake and Dollard.

Keywords: land settlement, French, Belgian, Canadian prairies, Saskatchewan

Introduction

Many ethnic groups settled on the Canadian prairies. Studies have suggested that different groups preferred particular land characteristics (Schlichtmann 1977). Unique geographies related to environmental and social preference also developed within group settlements. This article examines French and Belgian land settlement patterns in three communities in southwestern Saskatchewan. It examines the physical location of settlements, the economic choices made in land selection, settlement structures relative to social groups, and the effects of colonizing priests.

General location of group settlements

The availability of agricultural land for homesteading was of prime importance in the location of group settlements on the Canadian prairies in the late-nineteenth and early-twentieth centuries (Lehr 1974, 21). Until the closing of the frontier multiple settlement sites were available. In choosing where to locate, soil quality, proximity to wood, water, railways, markets and towns were all important to settlers, as were their perceptions of the land (Lehr 1978, 132–133). Early homesteaders on the prairies selected treed land and avoided open prairie. Many felt that prairie land was infertile, at times invoking images of a desert (Cutting 1975, 12; Lehr 1978, 65–66; Richtik 1983). Eventually this image faded and the advantages of prairie land and its easily cultivated soils were recognized, especially as technology developed that increased the chance of success in drier areas. However, the material reality of life on the prairies meant that access to timber remained desirable for building, fencing, fuel, and aesthetics (Cutting 1975; Lehr 1978, 64–66; Richtik 1983). Access to water also influenced prairie settlement patterns, reducing costs and providing for livestock (Lehr 1978,

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65–66, 134; Wiesinger 1985). Thus, Ukrainians, Mormons, and Swedes settled along waterways (Lehr 1972, 1974, 1978, 65–66, 134; Ostergren 1998, 26). On the other hand, poorly drained, marshy land was generally avoided (Tracie 1970; Loveridge 1977; Bower 2006).

Although soil, trees, and water influenced homestead choices, few settlers had the time or capital to compare different sites and thus imperfect knowledge of growing conditions led many to inaccurately appraise land (Loveridge 1977; Lehr 1978, 143). Even surveyors sent out specifically to grade land often provided erroneous evaluations. They described topography generally, and their appraisals of soil, though based on colour and vegetation, were frequently incorrect. Culture also affected which land characteristics settlers deemed desirable. For example, Ukrainian settlers were capital deficient and wood had been costly in their homeland. Many favoured homesteads in the parkland, irrespective of land capability (Canada. Department of Natural Resources n.d.; Lehr 1978, 134–141). Reconnaissance parties, whose leaders' knowledge of the environment varied, further influenced site selection (Ostergren 1998, 26). Eagerness to expand settlement finally led to excessive optimism, rapid settlement, and alienation of areas ill-suited to farming (Cutting 1975, 13; Lehr 1978, 69).

Economic drivers also shaped settlement patterns. Homesteaders eagerly sought sites near railways that increased accessibility to markets. As a result, land settlement in Saskatchewan spread north and south from the Canadian Pacific Railway (Clark 1931, 32). Farmers settled at a maximum of 30 or 40 miles from a railway. The need for access to market was so important that some homesteaders actually avoided high quality land if it was far from a railway (Clark 1931, 16; Loveridge 1977, 191). Only a very few groups, such as the Doukhobors, who sought isolation, did not express desires for these economic advantages (Szalasznyj 1977).

Over time, multiple processes led to the expansion of prairie group settlements. Chain migration, spurred by communication between family and friends, gathered relatives and acquaintances and increased the size of Ukrainian and Finnish settlements; group migration contributed to the growth of Mennonite and Hutterite settlements (Price 1959; Loveridge 1977, 192–203; Pederson 2004).

Internal morphology of settlement

Several economic factors affected agricultural success on the Canadian prairies. The same variables also influenced individual homestead selection and shaped the internal morphology of group settlements (Dick 1985, 18–19). The physical capability of land for production varied within settlements. Better land was usually selected first (Loveridge 1977, 203–204; Wiesinger 1985; Boyd 1989), but homesteaders did not always evaluate land correctly. At Dominion Lands offices homesteaders found, at best, general descriptions of whole townships that were based on surveyors' appraisals: there were no descriptions of individual quarter sections. Homestead choices were often a gamble since few homesteaders made a site inspection before choosing land. The commentary of earlier settlers and land agents often provided the best information available, yet this assisted a few settlers (Mallett 1971, 162–164; Loveridge 1977, 207; Stefanik 2015, 121). Along with land quality, water and wood were important considerations; many sought land with or near these resources (Loveridge 1977, 203–204; Lehr 1978; Pederson 2004, 40). In semi-arid areas, trees were rare and had less effect on homestead selection; settlers had to import wood (Mallett 1971, 25, 162–164).

Settlement theory also suggests that homesteaders would first choose land near service centres, and from there settlement would expand outwards (Bylund 1960; Hudson 1969; Wiesinger 1985). Several studies have challenged this assertion. For example, Loveridge (1977, 204–205) argued that service centres did not affect settlers' location within Sifton Rural Municipality, Manitoba, where most practiced subsistence farming and hence proximity to market towns was less important than soil quality (Cutting 1975, 31). Alternatively, multiple studies have shown the importance of proximity to a railway in individual land selection (Tracie 1970; Hudson 1973, 461; Wiesinger 1985; Pederson 2004). For example, Dick (1985) showed that distance to even a projected railway was more influential in homestead choices at Neudorf and Abernethy, Saskatchewan than were soil quality, access to wood or water, or distance to supply centres.

Family, friendship, and religious ties were another factor in settlement. Homesteaders frequently selected land adjacent to kin, often prioritizing familial proximity over land quality and other economic factors (Hudson 1973, 448; Brunger 1982; Richtik 1985, 1986; Boyd 1989; Pederson 2004, 41). Homesteaders also clustered according to birthplace and prior place of residence (Hudson 1973, 447; Lehr 1978; Fox 1979, 82–82; Ostergren 1998, 28; Boyd 1989). Religious and government institutions affected settlement patterns, often increasing their size and compactness (Katz and Lehr 1993). Churches, which served educational and religious needs, drew settlers and actively took part in forming communities (Lehr 1978, 133). For example, the Catholic Church recruited Francophones for western Canada and it sought to group them together in large settlements where they might maintain their culture (Painchaud 1987; Hamilton 2007). The Canadian government furthered the establishment of such ethnic groups through its agents, who directed homesteaders to particular locations deemed favourable for settlement by specific groups (Katz and Lehr 1993).

Problem and study area

This study uses the above factors to examine the selection of sites for three French and Belgian settlements in southern Saskatchewan. Fife Lake, Notre Dame d'Auvergne, and Dollard are all located in semi-arid southwestern Saskatchewan and were chosen as study areas (Figure 1). These sites allowed consideration of differences in settlement patterns and the effects of religious institutions. Looking at these sites, the study describes individual homesteaders' land choices with regard to soil quality, distance to water bodies, distance to railways, and distance to service centres. Evaluations of soil capability are compared

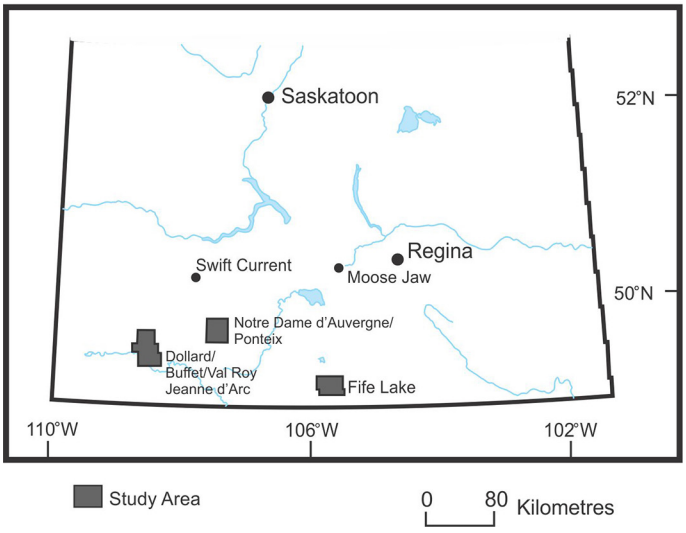


Figure 1
Study areas

Table 1
Geographic factors in land selection by individual homesteaders

Year	Criteria	Homesteaders: French mean (sd)	Belgian mean (sd)	Other mean (sd)
1906	Soil Capability for Agriculture (CLI)	4.00 (0.00)	4.00 (0.00)	4.02 (0.14)
	Distance from Main Water Bodies (km)	3.04 (1.74)	2.63 (1.64)	2.18 (1.21)
1907	Soil Capability for Agriculture (CLI)	4.00 (0.00)	n/a	4.13 (0.44)
	Distance from Main Water Bodies (km)	3.50 (2.22)	n/a	2.95 (1.78)
1908	Soil Capability for Agriculture (CLI)	4.00 (0.00)	4.00 (n/a)	4.08 (0.36)
	Distance from Main Water Bodies (km)	2.46 (1.30)	6.00 (n/a)	2.73 (1.85)
1909	Soil Capability for Agriculture (CLI)	4.00 (0.00)	4.00 (0.00)	4.12 (0.43)
	Distance from Main Water Bodies (km)	2.52 (1.83)	1.72 (1.72)	2.37 (1.74)
1910	Soil Capability for Agriculture (CLI)	4.00 (n/a)	4.67 (0.47)	4.26 (0.60)
	Distance from Main Water Bodies (km)	5.25 (n/a)	4.00 (0.41)	3.67 (1.87)
1911	Soil Capability for Agriculture (CLI)	4.33 (0.67)	4.86 (0.64)	4.56 (0.79)
	Distance from Main Water Bodies (km)	6.31 (0.71)	6.61 (1.03)	4.73 (2.20)
1912–1913	Soil Capability for Agriculture (CLI)	5.00 (1.00)	4.67 (0.75)	4.81 (0.87)
	Distance from Main Water Bodies (km)	3.25 (2.79)	4.48 (2.71)	3.48 (2.32)
Correlation with entry date	Soil Capability for Agriculture (CLI)	0.47	0.50	0.30
	Distance from Main Water Bodies (km)	0.31	0.41	0.22

SOURCE: CLI (1967a)

to those of the Canada Land Inventory (CLI) for agriculture. Though the CLI dates from the 1960s and 1970s, its evaluations of soil capability for agriculture remain valid. Finally, the study describes the effects of family, previous locality groups, and the role of colonizing priests.

Three French and Belgian communities

Fife Lake

Before farm settlement at Fife Lake, traders caught muskrats and fish in the area and used it for grazing livestock (Fife Lake n.d., 2). Early colonists arriving in the area were probably told that its soils were better than those in the hills south of Willow Bunch that they crossed on route. They also learned there would be water, coal, and a picturesque valley location (*Le Patriote de L'Ouest* 1914, 2, 26). Since Fife Lake was relatively uninhabited, a large bloc settlement could develop. Limited prior occupancy was an important feature for French-speaking Europeans since it would permit them to establish a community where they could retain their culture (Jones 1978).

Settlement patterns show a preference for the best land available with proximity to water (Figure 2 and Table 1). Class designations for agricultural capability conceived by the CLI assist interpretation of these early homesteaders' choices, ranging from the best soils in Class 1 to soils with no capacity for agriculture in Class 7. Thus, though it was of moderate agricultural capability, Class 4 land was chosen most frequently and it became the only class of land that French and Belgian homesteaders chose in 1906 and 1909–1910. Rolling, hilly, Class 5 and Class 6 land, that was often visibly less suited for farming was only taken after 1910. Correlation analysis reveals a strong link between land quality and early homestead date by both French and Belgian colonists (see Table 1). Moreover, in the early years of settlement until 1910, French and Belgian homesteaders chose land

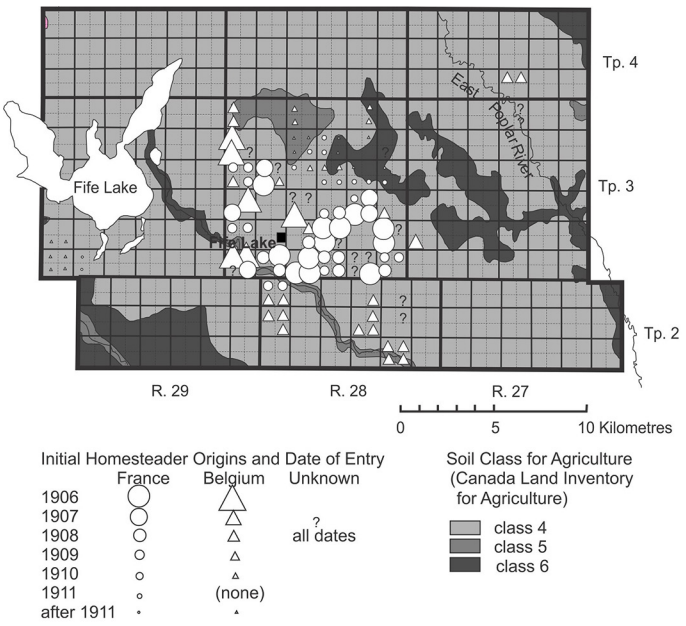


Figure 2
Soil capability for agriculture and settlement at Fife Lake
SOURCES: Homestead files; CLI (1967a); Canada (1906, 1911, 1916); Coronoch Historical Committee (1980); Fife Lake History Book Committee (1981); Rockglen History Committee (2002); Willow Bunch Historical Society (1998)

that was reasonably close to large non-ephemeral water bodies. However, the strength of this relationship was weaker than the strength of the relationship between date of land settlement and soil capability for agriculture.

At Fife Lake, French and Belgian settlers did not display a preference for land near a railway or town that could have brought economic and social benefits. No rail service was pres-

ent during the homesteading period. The possibility of a railway coming to the area was only announced in 1914 and the line itself was not built until 1926 (*Le Patriote de L'Ouest* 1926, 7). The town of Fife Lake was only established in 1928 (Fife Lake n.d., 8). Also unapparent were homestead choices near religious structures. Due to isolation, the settlement lacked a resident priest throughout the homestead period and up to at least 1926, a visiting priest gave mass in settlers' homes (Fife Lake n.d., 7; *Le Patriote de L'Ouest* 1926, 7).

Settlers at Fife Lake homesteaded in clusters based on their origins. Many were from northern departments of France such as Pas-de-Calais and Brittany, while Luxembourg and the Flanders provinces in Belgium were common origins of the remaining migrants. Overpopulation and the farming situation in these areas promoted out-migration. Inheritance laws in France and Belgium required land division among multiple heirs, making farms very small. Rental land was available but high demand meant high rents. Moreover, American grain flooded European markets in the late 1800s and early 1900s, undercutting the value of farm labour and driving mechanization. Small farm size further prevented the purchase and effective use of new equipment and, in France, protective tariffs increased the price of livestock feed. Rural out-migration to towns and large industrial centres developed, including Belgian out-migration to France. But neither towns, with artisans facing a shrinking customer base and competition from large-scale mechanized urban industry, nor large urban industrial centres, could absorb all available labour. Day labourers and tenant farmers became a particularly large component of migrants from Belgium to North America between 1901 and 1912. Farmers came to the Canadian prairies from France and Belgium during this same period.

Religious persecution also drove migration to Canada. In France, the government opposed Catholicism and Prime Minister Emile Combes had restricted the formation of religious communities and dissolved existing congregations. He outlawed teaching by Catholic communities, banned crucifixes from courts, and put religious orders' property up for sale. Aristide Briand, his successor, passed additional laws to separate church and state. Thus, Canadian immigration agents listed economically stagnant, overpopulated Catholic regions such as Brittany and Pas-de-Calais as especially promising for recruitment. Many settlers were also recruited from Luxembourg (Canada Sessional Papers 1900, 43; *Le Canada* 1904a; Châtelain 1947, 59; Commission de l'Atlas Nationale du Belgique 1959; Lefebvre 1959, 25–35; Ennis 1977, 127–132; Milward and Saul 1977, 90, 106–114, 144–175; MFA 1978, 301; Stengers 1978; Lapointe and Tessier 1986, 84–90; Penisson 1985, 74, 88–89; Ross 1986, 119–127; Winchester 1986, 60–78; Jones 1989, 22–29; Jaenen 1991, 9; Douchant and Richtik 1992, 29; Jaumain and Sanfilippo 1996; Pyée 2005, 29–60, 140–158).

When they arrived at Fife Lake, settlers clustered according to general places of origin and family ties (Figures 3 and 4). Early colonists from Brittany clustered in the southern part of the main township while those arriving from departments in northeast France homesteaded further north. Belgian and French colonists often intermixed despite linguistic differences, a practice probably influenced by a common religion and especially by prior residence of many of these settlers in the Forget area of southeastern Saskatchewan (Ross 1986, 107; Jaenen 1999). The

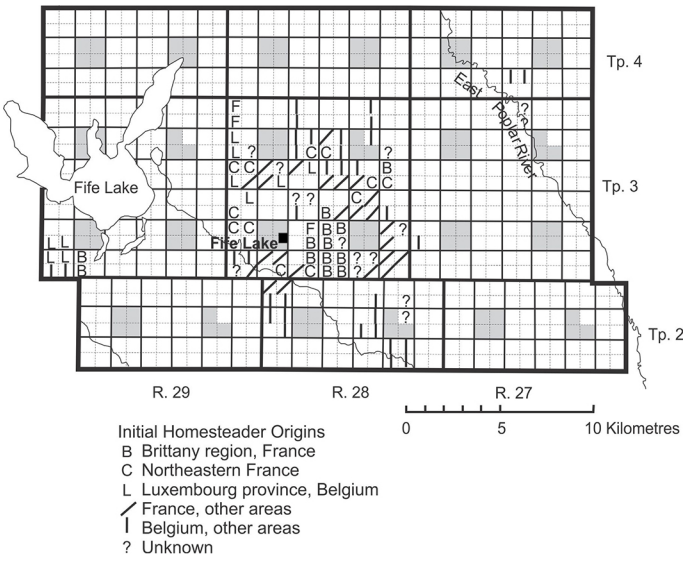


Figure 3
Homesteaders' origins and settlement at Fife Lake
SOURCES: Homestead files; CLI (1967a); Canada (1906, 1911, 1916); Coronoch Historical Committee (1980); Fife Lake History Book Committee (1981); Rockglen History Committee (2002); Willow Bunch Historical Society (1998)

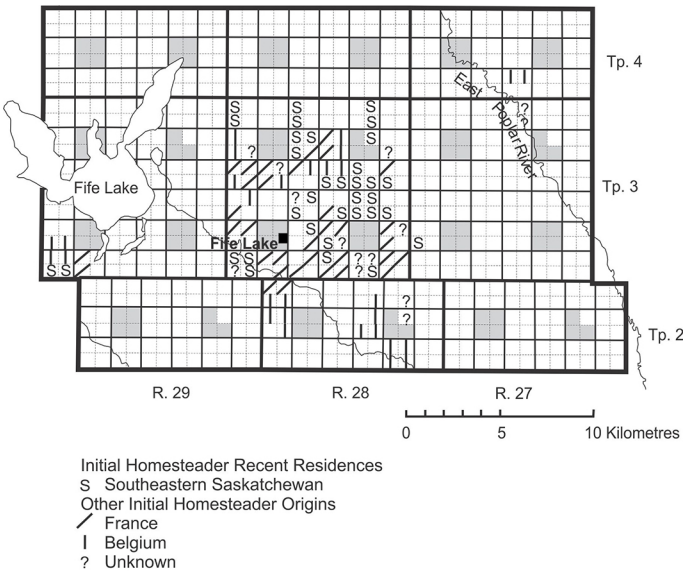


Figure 4
Homesteaders' recent residences and settlement at Fife Lake
SOURCES: Homestead files; CLI (1967a); Canada (1906, 1911, 1916); Coronoch Historical Committee (1980); Fife Lake History Book Committee (1981); Rockglen History Committee (2002); Willow Bunch Historical Society (1998)

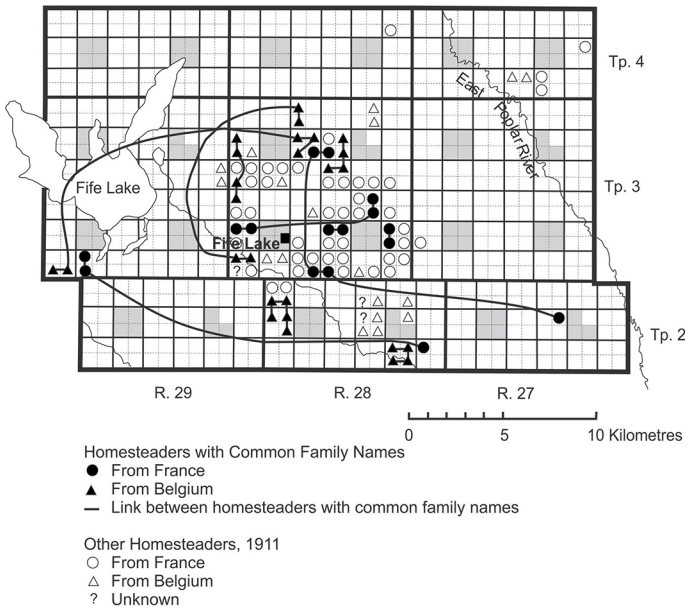


Figure 5
Family name groups at Fife Lake
SOURCES: Homestead files; CLI (1967a); Canada (1906, 1911, 1916); Coronoch Historical Committee (1980); Fife Lake History Book Committee (1981); Rockglen History Committee (2002); Willow Bunch Historical Society (1998)

group from Forget was particularly significant at Fife Lake and was probably larger than indicated in Figure 4. Data for family relationships was limited so last name groups were mapped to show approximate family settlement patterns. Family-based groups were apparent (Figure 5). Some families arrived and settled together, while elsewhere one family member came and others followed, taking homesteads near the first settler if possible. This fits with Jaenen's (1988 153; 1991, 13) contention that chain migration of extended family and neighbours was a main form of migration from Belgium to western Canada during this period.

Notre Dame d'Auvergne

The story of settling Notre Dame d'Auvergne illustrates the issues and competing interests of available resources, prior settlement, limited knowledge, and proximity to services that many colonizing organizers faced and the effect this had on settlement location. In 1900, Father Albert Royer resolved to found a parish in an uninhabited area for people from Auvergne, France. Five years later, after visiting Algeria, Morocco, and Tunisia and not finding a suitable site, he contacted Mgr. Langevin, Archbishop at Saint-Boniface, Manitoba over the possibility of founding a colony in Canada. The prairies had significant advantages that swayed him: homestead land could be owned in three rather than five years, and there was greater religious freedom and linguistic protection than in France. The Catholic Church's criteria and his own evaluations were central to his specific site selection on the prairies. Father Royer sought uninhabited, fertile wooded land like that he had known in France (Royer 1908a 1; 1918–1919, 1–7; *The Echo* 1955, 4; Lacoursière-Stringer 1981, 17).

Father Royer's initial tour of the prairies led him to Weyburn, Swift Current, Calgary, Red Deer, Lacombe, Settler, Ribstone, Battle River, and the Rocky Mountains. He found places that lacked wood, and places that were wooded but partially settled (Royer 1918–1919, 7–8; *The Echo* 1955, 4; Lacoursière-Stringer 1981, 17). He also learned that settlers in the parkland faced difficulties clearing bush to farm:

> En tout cas ce n'etait pas du tout ce que nous avons rèvé. Des bosquets charmants, de petits trembles, c'est joli! Mais celà ferait bien mieux dans le parc d'un millionaire que sur un pauvre homestead dont il couvre les trois quarts, car il faudra tout de suite les arracher à grand'peine pour les remplacer des ceréales ou du foin. Dans ces conditions, un seul quart de section était loin de nous permettre l'aisance, comme nous le constatons d'ailleurs chez un bon abre à Notre Dame de Savoie (Royer 1918–1919, 8).

> In any case this was not at all that they had hoped for. Charming groves, small aspen, were pretty! But this would be better in a millionaire's park than on a poor homestead—where groves covered three quarters of the land, they needed to be removed immediately, despite the difficulty, and replaced with grain or hay. In these circumstances, a single quarter section did not easily permit a prosperous living as is apparent elsewhere at Notre Dame de Savoie.

Winnipeg immigration agent Léon Roy's description of the wheat-growing capacity of the south and of a newly developing area known as La Vieille also enticed him, along with reports of wood and French Canadian colonists (Royer 1918–1919, 8). While he was impressed with La Vieille's soils, bush, and few inhabitants (*Les Cloches de Saint-Boniface* 1908a, 35), its concurrent selection by Father Gravel, a wealthy priest, led to conflict and he soon left in search of a new site. One settler suggested a butte north of La Vieille River that had many advantages, but this location did not meet the criteria that the Church established for new colonies, requiring they be at least ten miles apart (Royer 1918–1919, 12). From Saint-Boniface, Mgr. Langevin provided additional instructions for choosing a new site:

> Tâchez donc de me trouver, pour Notre Dame d'Auvergne, une colline dominant un cours d'eau, et une tracé de chemin de fer, avec aux alentours de bonnes terres pour les colons (Royer n.d.; Lacoursière-Stringer 1981, 17).

> For Notre Dame d'Auvergne, try to find for me a hill overlooking a stream, and a planned railway, surrounded by good land for settlers.

Royer toured southern Saskatchewan seeking these features. The land at Pinto Creek looked good but lacked wood and was

far from planned railways. Land between La Vieille and Willow Bunch was covered with dense grass and seemed fertile, while land at Whisky Creek was "magnificent," but both areas were already settled. He continued, circling through a French Métis colony at Lac Pelletier before heading to Frenchman Creek and Cypress Hills. Here, he found rolling, sandy land. Finally, he reached Swift Current Creek where he found low bush, impressive cattle herds, coal, and a "sort of slate soil" that might bring great riches (SAR 1907a; Royer 1908a, 7–10; 1908b, 92–93; 1908c, 130–131).

Mgr. Langevin's instructions guided Royer's choice among sites. He thus returned to his chosen site for the colony that he called Notre Dame, and later described the superb prairie land with deep humus that retained moisture and overlay a bed of clay. The absence of rocks made up for the lack of wood, while scrub and marsh were not found. There was also a creek and First Nations told him about coal in the area. More promising still, a railway was planned, and in the interim nearby trails would allow communication. Finally, there was sufficient vacant land to found a large community. Royer placed his tent on a hill by a waterway in the settlement, establishing the centre of Notre Dame d'Auvergne (Figure 6) at Section 30 Township 9 Range 11 (*Les Cloches de Saint-Boniface* 1907, 122; Royer 1908, 7–12; Royer 1908, 92, 141; Frémont 1959, 106; Lacoursière-Stringer 1981, 17; Service fransaskois d'éducation adultes 1988; Wilhelm 1990; 1991, 124).

Settlement at Notre Dame d'Auvergne was largely on the best Class 3 land (Figure 6 and Table 2) while poorer Class 4 land was less frequently selected. Stones in Class 4 areas probably deterred settlers. Small areas of rolling Class 6 land and wet Class 5 land along Notukeu Creek were generally avoided. This pattern was apparent despite settlers' limited familiarity with the area and a lack of knowledge of the agricultural capabilities of the soil. At Dominion Lands offices, homesteaders may have viewed maps showing the number of quarter sections available in each township (Canada. Natural Resources Intelligence Branch 1917). Surveyors' descriptions of the land may also have been available, and some land guides requested surveyors' descriptions. Surveyors had classed all land at Notre Dame d'Auvergne as rolling prairie, though found Township 9, Range 12, Township 8, Range 11, and Township 10, Range 10, to be 'gently' rolling prairie. They did not mention bush (SAR 1908a; Canada. Department of Natural Resources n.d.). Priests who had toured the area also assisted with land selection, and they responded to many settlers asking for information about land and for assistance selecting a homestead (SAR 1906).

Water also influenced individual homestead patterns. French and Belgian settlers gathered along the west side of Notukeu Creek where some small clumps of fuel-wood were found. Later, the discovery of good well water at a depth of less than 20 feet and the use of slough water facilitated settlement further from the creek (*Le Patriote de L'Ouest* 1918; Lacoursière-Stringer 1981, 10–15).

Notre Dame d'Auvergne was the first town established in the area and soon the community held advantages for settlers: a church, school, stores and post office (Lacoursière-Stringer 1981, 18). It served French and Belgian settlers and many of them took land close to the community, yet the basic expansion of French and Belgian settlement was on good land near Notukeu Creek and not outwards from the town. The railway

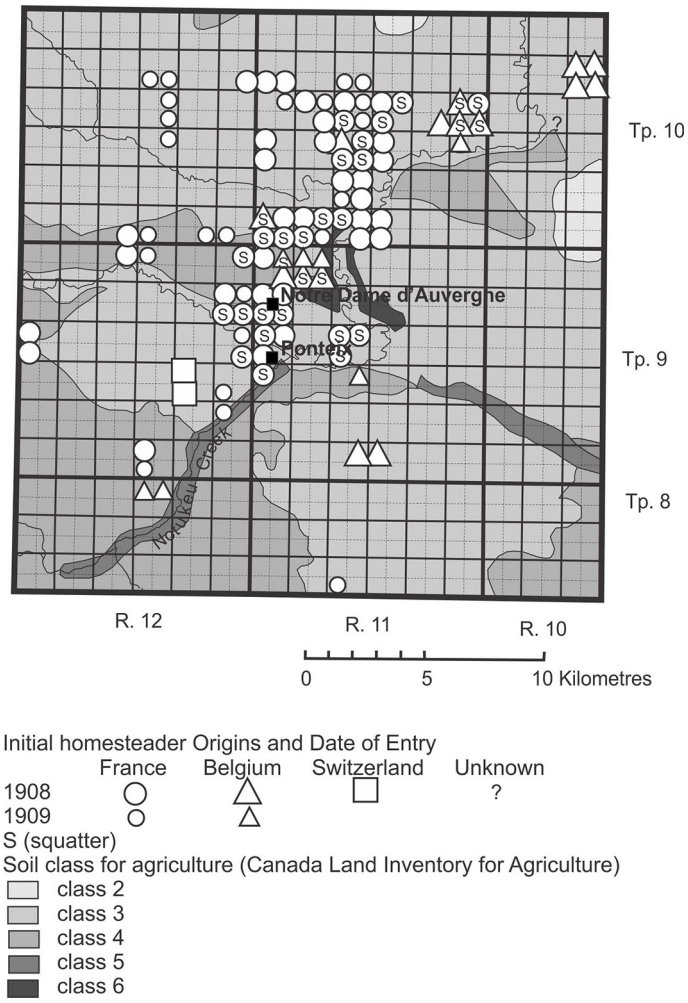


Figure 6
Soil capability for agriculture and settlement at Notre Dame d'Auvergne
SOURCE: Homestead files; CLI (1967b); Canada (1911); Lacoursière Stringer (1981); Ponteix History Book Committee (1991)

Table 2
Geographic factors in homesteaders' land selection at Notre Dame d'Auvergne

		Homesteaders		
Year	**Criteria**	**French mean (sd)**	**Belgian mean (sd)**	**Other mean (sd)**
1908	Soil Capability for Agriculture (CLI)	3.29 (0.57)	3.35 (0.59)	3.23 (0.64)
	Distance from Notre Dame d'Auvergne	5.86 (3.13)	8.62 (5.49)	10.00 (3.34)
	Distance from Notukeu Creek (km)	2.60 (2.20)	2.15 (0.87)	5.49 (3.71)
	Distance from Main Water Bodies (km)	2.38 (1.94)	2.13 (0.88)	4.50 (2.67)
1909	Soil Capability for Agriculture (CLI)	3.42 (0.64)	4.20 (0.75)	3.64 (0.70)
	Distance from Notre Dame d'Auvergne	7.13 (3.12)	7.35 (2.93)	9.91 (3.35)
	Distance from Notukeu Creek (km)	4.65 (3.26)	0.75 (0.67)	4.83 (3.78)
	Distance from Main Water Bodies (km)	3.90 (2.77)	0.75 (0.67)	4.32 (3.16)

SOURCE: CLI (1967b)

did not affect settlement here. The Canadian Pacific Railway only extended a railway into the region in 1913 and up until that time its specific route seemed to be unknown. Nonetheless, the importance of transport to colonists eventually led to the abandonment of Notre Dame and relocation of the village to Ponteix, a site on the railway (Lacoursière-Stringer 1981, 19–20; Service fransaskois d'éducation adultes 1988, 6). Clusters of settlers with particular and common origins were significant in this community (Figure 7). Homesteaders from Auvergne gathered around the initial settlement site while settlers from Brittany homesteaded to the north.

In Europe, conditions in rural Auvergne had favoured out-migration since the mid-1800s. Like other areas in France, it was overpopulated and affected by low-priced American grain imports. Phylloxera had infested vineyards since the late 1800s limiting production, and declines were seen throughout coal mining, textiles, and other cottage manufactories (*Le Canada* y 1904b; 1907a; 1907b; Asselin 1913, 7; Milward and Saul 1977, 80–112; Seys 1980, 403; Lalonde 1983, 61; Betaille 1985, 117–122; Penisson 1985; Roudié 1985; Jones 1989; Pyée 2005, 29–30). Notwithstanding government opposition to out-migration to non-French colonies and despite negative images of the Canadian prairies, the lure of open land influenced residents of Auvergne (*Le Courrier de L'Ouest* 1907, 7; Savard 1968; Beteille 1985, 111; Penisson 1985; Jones 1989, 219–229; Pyée 2005, 33). Residents there saw posters advertising the Canadian prairies at the back of Royer's church, and read advertisements in *Le Croix d'Aveyron*. Their letters reflect the difficult economic and religious situation in Auvergne with several inquiring about their chances of homesteading successfully and having religious freedom (SAR 1907b, 1907c, 1907d; Lacoursière-Stringer 1981, 10).

Similar origins in Europe or at previous sites in the prairies were common among homesteaders (Figure 8). Letters and recollections suggest the importance of encounters with Father Royer in migration to the prairies and in clustering at Ponteix (Ponteix History Book Committee 1991). There were also a few 'step-migrants' who resettled from the French and Belgian community of Whitewood, Saskatchewan (Frémont 1959). Family settlement, at least as suggested by last name groups, was also apparent (Figure 9), though the limited number and small extent of families as compared to other communities, along with letters

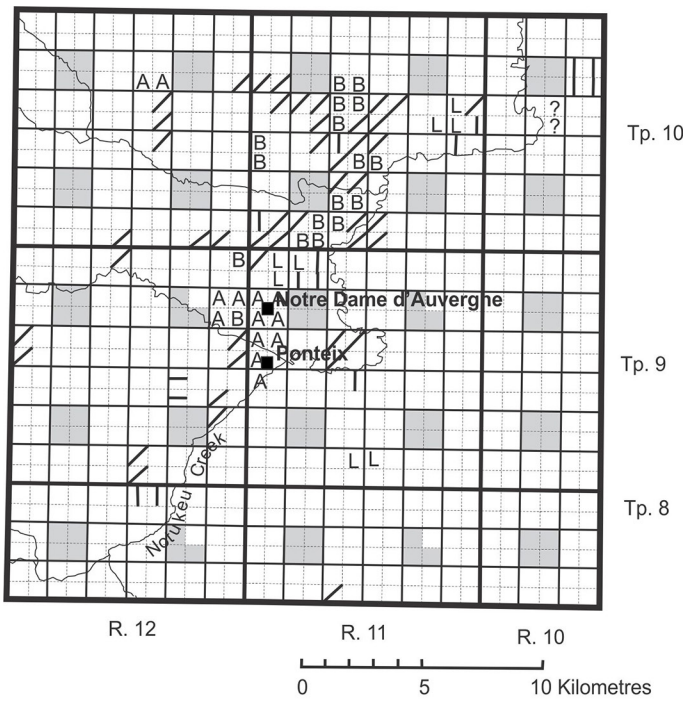


Figure 7
Homesteaders' origins and settlement at Notre Dame d'Auvergne
SOURCE: Homestead files; CLI (1967b); Canada (1911); Lacoursière Stringer (1981); Ponteix History Book Committee (1991)

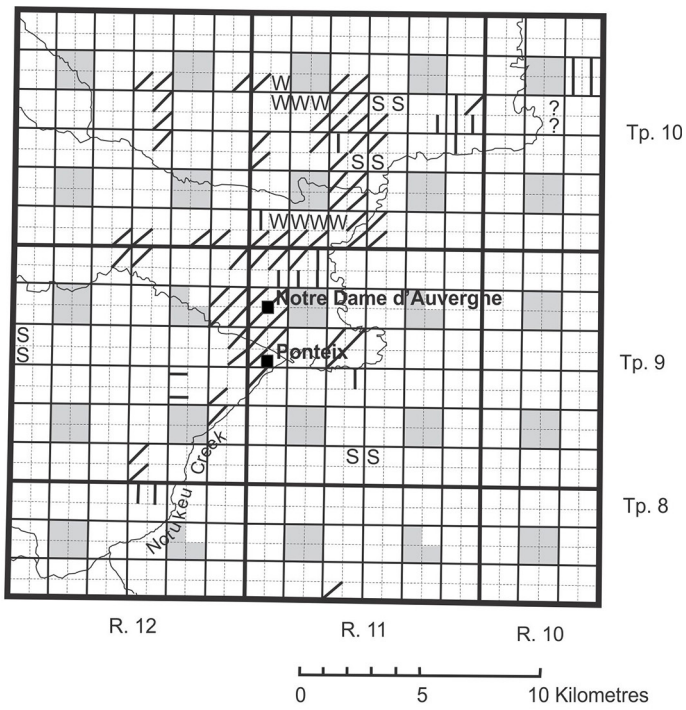


Figure 8
Homesteaders' recent residences and settlement at Notre Dame d'Auvergne
SOURCE: Homestead files; CLI (1967b); Canada (1911); Lacoursière Stringer (1981); Ponteix History Book Committee (1991)

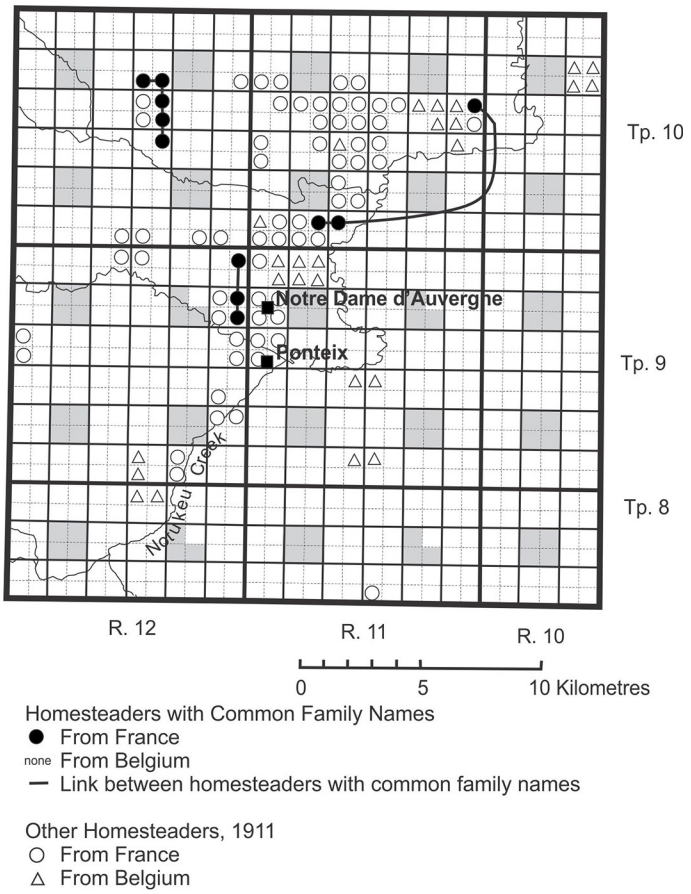


Figure 9
Family name groups at Notre Dame d'Auvergne
SOURCE: Homestead files; CLI (1967b); Canada (1911); Lacoursière Stringer (1981); Ponteix History Book Committee (1991)

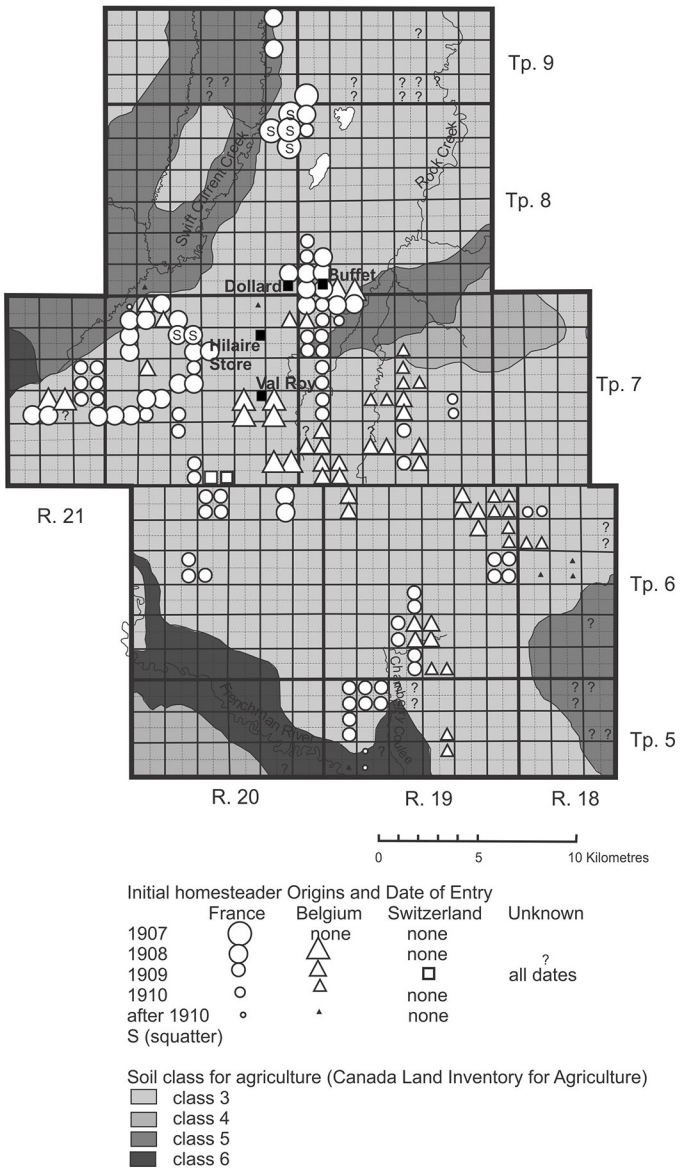


Figure 10
Soil capability for agriculture and settlement at Dollard
SOURCE: Homestead files; CLI (1967c); Canada (1911); South Shaunavon History Book Club (1981); Eastend Historical Society (1982)

and recollections, suggests the greater importance of the colonizing priest. Simple word-of-mouth was likely also important (Beteille 1985, 114; Pyée 2005, 174–182).

Like many colonizing priests, Father Royer was particularly interested in establishing a large, solid community. On several occasions, he sought out Father Gravel's assistance to have land held for squatters and to have local land agents send Francophones to his community. While Royer was able to influence the land commissioner for the area, have himself named as a land guide, and to have a sub-agency of Dominion Lands established at Ponteix, several of his squatters who settled before the survey and left temporarily lost land to others who entered at the time of government marketing. Land near the Catholic Church was especially disputed, and tensions about land take-up led to threats to torch the church (SAR 1908b, 1908c, 1908d, 1908e, 1908f, 1908g, 1909a; LAC 1910, 1911a, 1911b).

Dollard

As at Notre Dame d'Auvergne, a priest selected the initial site for Dollard. Jerome Boutin's exploration of southwestern Saskatchewan, and perhaps some knowledge gained from companions who had been on Father Royer's tour, led to the choice of location. Along with two settlers, Boutin chose a butte and erected a cross for the centre of a colony on Section 6 Township 8, Range 19 West Meridian 3, as seen in Figure 10 (Bleau n.d., 2; *Historique de la Paroisse Jeanne d'Arc* n.d., 2–3; Prince 1989, 42; *Western People* 1992, 8). Fathers Dufresne and then Jayet arrived shortly after, selecting a homestead on Township 14 Section 7 Range 20 West Meridian 3 (Figure 10). The building of a post office, presbytery and church, and the construction of St. Hilaire store followed, establishing a second focal point in the colony. Léon Roy, the French-Canadian immigration agent from Winnipeg who had helped Royer at Ponteix, established a third cluster of homesteaders in the same area in the fall of

1908. He arrived with several relatives and chose land about three miles south of the Boutin group. Roy later commented on the area's first class soil, abundant good water, coal within five miles, wood within five to twelve miles, and plans for a railway (*Historique de la Paroisse Jeanne d'Arc* n.d., 2–3; Bleau n.d., 2; *Les Cloches de Saint-Boniface* 1908, 298; 1910, 104; Prince 1989, 42–45; *Western People* 1992, 8). The three focal points contributed to a dispersed settlement rather than a single unit, or a failed colony as described in some historic literature (Frémont 1959, 110).

In the earliest years of settlement, French and Belgian homesteaders universally took good quality Class 3 land, rather than poorer quarters that were often noticeably topographically adverse. The strong positive correlation shown in Table 3 between land capability for agriculture and date of first entry confirms this. Letters from settlers show they thought about land selection, and expressed opinions and knowledge based on the land's visual characteristics, topography, and colour. Surveyors' comments may have been available to colonists but these only provided general appraisals of the land. For example, one settler wrote to Father Gravel about good brown coloured soil at Val Roy and explained that soils in surrounding townships were sandy. Other letters show scant knowledge of land in Saskatchewan. One letter writer asked if there were vineyards or domestic livestock-raising and another inquired about olive trees and orchards. Alphonse Gouzy asked if the region was grain producing. Yet another potential settler posed the same questions, but also wanted to know if the region was mountainous (SAR 1907d, 1907e, 1907f, 1907g, 1908h). Surveyors' comments offered only loose guidance. Township maps, available to visitors at Dominion Lands offices, were based on surveys. They classed most of the land as rolling or undulating prairie, did not mention bush, and showed that poorer land was to be found along the fringes of the settlement. Township 8, Range 19, the location of the original group, was better than other areas; it was described as level prairie. Father Gravel's own reports furthered views that the land was good, mentioning that it was close to coal mines (SAR 1909b). A few colonists, especially those who had stopped elsewhere in western Canada before settling, may have visited the area, viewed it, and then selected land for family and friends, but more numerous were those who recalled a lack of resources to make reconnaissance visits to look at the land. Some of these homesteaders sought information from colonizing priests or asked that priests or someone the priest knew choose good land for them (SAR 1907h, 1907i, 1907j, 1907k, 1907l, 1907m).

As at Fife Lake and Notre dame d'Auvergne, settlement at Dollard was generally oriented to water bodies. Table 3 and Figure 10 show that French and Belgian homesteaders chose land near to major, non-ephemeral water bodies in the early years of homesteading, though as Table 3 demonstrates, in later years they settled further from streams. However, the correlation between date of settlement and proximity to water was much weaker than that with land quality. Also, as in the other two colonies, there was no apparent relationship between date of settlement and a railway. The railway was only built in 1913, once again after the area was homesteaded. Indeed, a major disappointment came when the CPR selected a town site two miles north of their community, passing though Dollard, suggesting homesteaders were unfamiliar with the railway's planned route (*Western People* 1992, 8). Unlike at Fife Lake and Notre Dame d'Auvergne, French and Belgian settlement in the Dollard communities generally expanded outwards from Buffet and Val Roy. Table 3 shows there were positive correlations between date of homesteading and location near Buffet among French homesteaders and between date of homesteading and distance to both Val Roy and Buffet among Belgian homesteaders. Despite this, Figure 10 suggests a less clear relationship.

Similar to Notre Dame d'Auvergne, the general cluster of French and Belgian settlers at Dollard owed much to the influence of the priest, the government agent, and the desire of settlers to be with others who shared their customs and origins (SAR1908h). Clusters that developed in this block (Figures 11 and 12) seem to have been closely associated with patterns of recruitment, recent residence, and family. For example, step-migrants arriving from France via Whitewood, attracted by Jerome Boutin, family, or acquaintances, concentrated near the original centre of the colony. Recent residence at Whitewood and family ties in southeastern Saskatchewan linked a second cluster of

Table 3
Geographic factors in land selection by homesteaders at Dollard

Year	Criteria	Homesteaders: French mean (sd)	Belgian mean (sd)	Other mean (sd)
1902–1906	Soil Capability for Agriculture (CLI)	n/a	n/a	5.11 (0.31)
	Distance from Buffet (km)	n/a	n/a	13.47 (1.44)
	Distance from Val Roy (km)	n/a	n/a	14.61 (3.84)
	Distance from Main Water Bodies (km)	n/a	n/a	0.69 (0.68)
1907	Soil Capability for Agriculture (CLI)	3.00 (0.00)	n/a	3.25 (0.67)
	Distance from Buffet (km)	7.92 (0.97)	n/a	11.72 (1.83)
	Distance from Val Roy (km)	13.75 (1.08)	n/a	17.23 (2.25)
	Distance from Main Water Bodies (km)	1.75 (0.20)	n/a	1.57 (0.92)
1908	Soil Capability for Agriculture (CLI)	3.22 (0.58)	3.00 (0.00)	3.16 (0.53)
	Distance from Buffet (km)	7.79 (4.45)	7.73 (4.21)	9.12 (3.87)
	Distance from Val Roy (km)	7.59 (3.76)	4.50 (3.54)	10.22 (5.14)
	Distance from Main Water Bodies (km)	3.00 (1.58)	3.73 (1.86)	3.53 (2.39)
1909	Soil Capability for Agriculture (CLI)	3.12 (0.42)	3.00 (0.00)	3.20 (0.62)
	Distance from Buffet (km)	12.34 (6.23)	10.47 (4.11)	14.31 (5.68)
	Distance from Val Roy (km)	9.34 (4.67)	8.05 (3.54)	12.06 (4.85)
	Distance from Main Water Bodies (km)	3.26 (2.16)	2.27 (1.70)	3.61 (2.20)
1910	Soil Capability for Agriculture (CLI)	3.20 (0.40)	3.06 (0.23)	3.74 (1.06)
	Distance from Buffet (km)	10.25 (5.09)	13.72 (6.04)	14.44 (6.57)
	Distance from Val Roy (km)	11.00 (3.49)	12.56 (4.13)	14.13 (4.46)
	Distance from Main Water Bodies (km)	5.20 (2.46)	3.96 (2.74)	3.21 (2.87)
1911	Soil Capability for Agriculture (CLI)	n/a	n/a	4.00 (1.03)
	Distance from Buffet (km)	n/a	n/a	14.91 (6.53)
	Distance from Val Roy (km)	n/a	n/a	14.35 (3.84)
	Distance from Main Water Bodies (km)	n/a	n/a	3.79 (2.92)
1912–1913	Soil Capability for Agriculture (CLI)	5.67 (0.47)	3.75 (1.30)	4.03 (0.93)
	Distance from Buffet (km)	19.08 (6.78)	20.06 (2.46)	12.54 (6.92)
	Distance from Val Roy (km)	15.08 (5.02)	17.63 (1.08)	13.60 (4.28)
	Distance from Main Water Bodies (km)	1.08 (0.62)	5.50 (3.17)	4.44 (3.21)
Correlation with entry date	Soil Capability for Agriculture (CLI)	0.43	0.60	0.34
	Distance from Buffet (km)	0.38	0.39	0.21
	Distance from Val Roy (km)	0.23	0.51	0.19
	Distance from Main Water Bodies (km)	0.03	0.11	0.12

SOURCE: CLI (1967c)

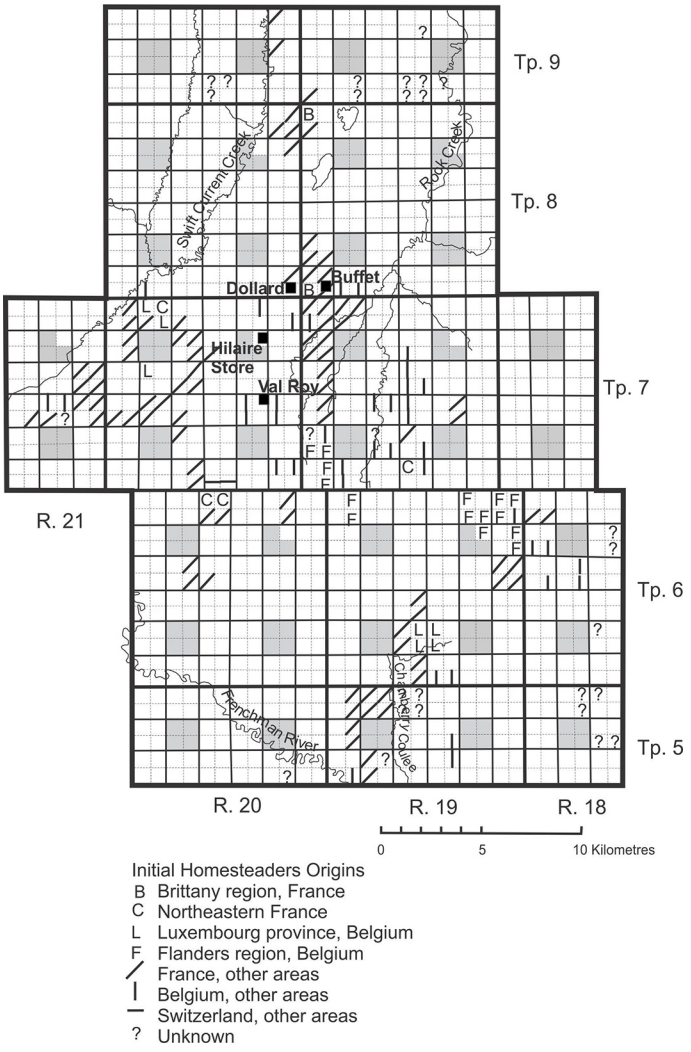


Figure 11
Homesteaders' origins and settlement at Dollard
SOURCE: Homestead files; CLI (1967c); Canada (1911); South Shaunavon History Book Club (1981); Eastend Historical Society (1982)

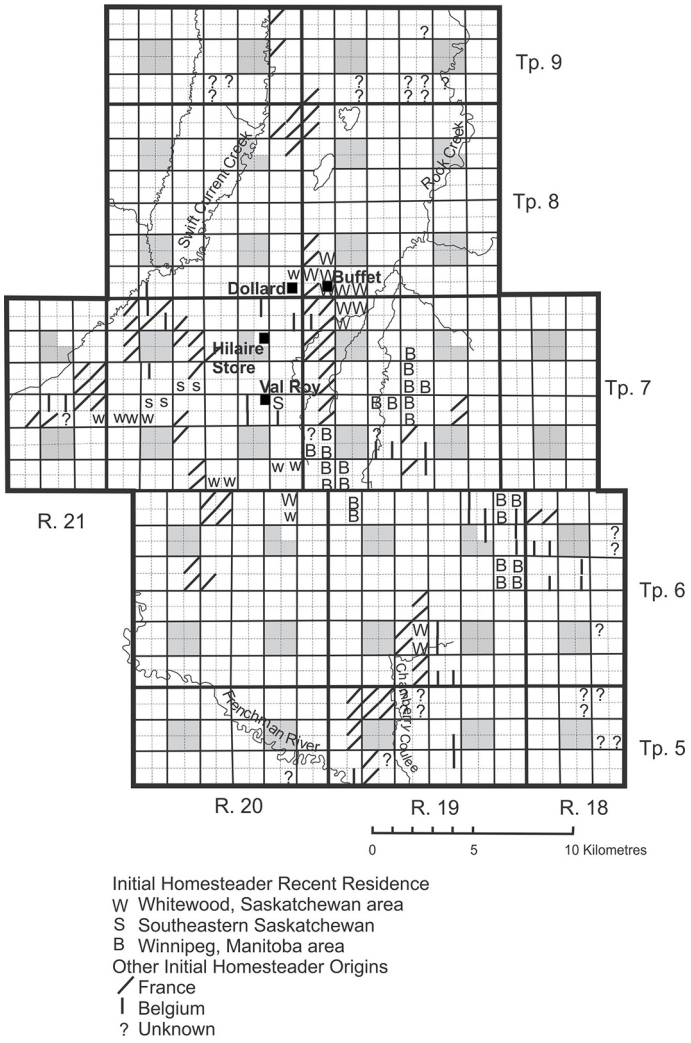


Figure 12
Homesteaders' recent residences and settlement at Dollard
SOURCE: Homestead files; CLI (1967c); Canada (1911); South Shaunavon History Book Club (1981); Eastend Historical Society (1982)

settlers further south and west of Rock Creek (Figure 13). Encounters with Léon Roy, along with family ties gathered a third group that settled southeast of Boutin's group and east of Rock Creek. This group included homesteaders recently resident near Winnipeg and French and Flemish Belgian settlers (SAR 1908i; Bleau n.d., 2; *Historique de la Paroisse Jeanne d'Arc* n.d., 2–3; Prince 1989, 45; Jaenen 1999).

Conclusion

The geographical location of the three settlements was discussed in terms of environmental, social, national, and religious affiliations. Their internal morphology was also examined. Priests were influential in the selection of sites for Note Dame d'Auvergne / Ponteix and Dollard / Buffet / Val Roy, thus their views about settlement sites were important. Instructed to look for particular features, priests toured and selected land with economic and cultural advantages such as good land, railways, water, ideally some wood, and sufficient vacant land to form large communities. The knowledge of early settlers in surrounding areas was important in the selection of Fife Lake. At Ponteix and Val Roy especially, priests may have assisted the many who would otherwise have selected land sight unseen.

While general areas for settlement were near proposed rail lines, railways did not have a significant effect on settlement patterns within blocks. The lack of knowledge of specific railway routes was key to this pattern—often communities were moved after railways were built in order to be closer to them. Instead, good soil and access to water appeared as the main economic features of interest within bloc settlements, rather than distance to railways and market towns. In all three settlements, French and Belgian homesteaders consistently chose the best quality land. They also gathered relatively close to towns for social ad-

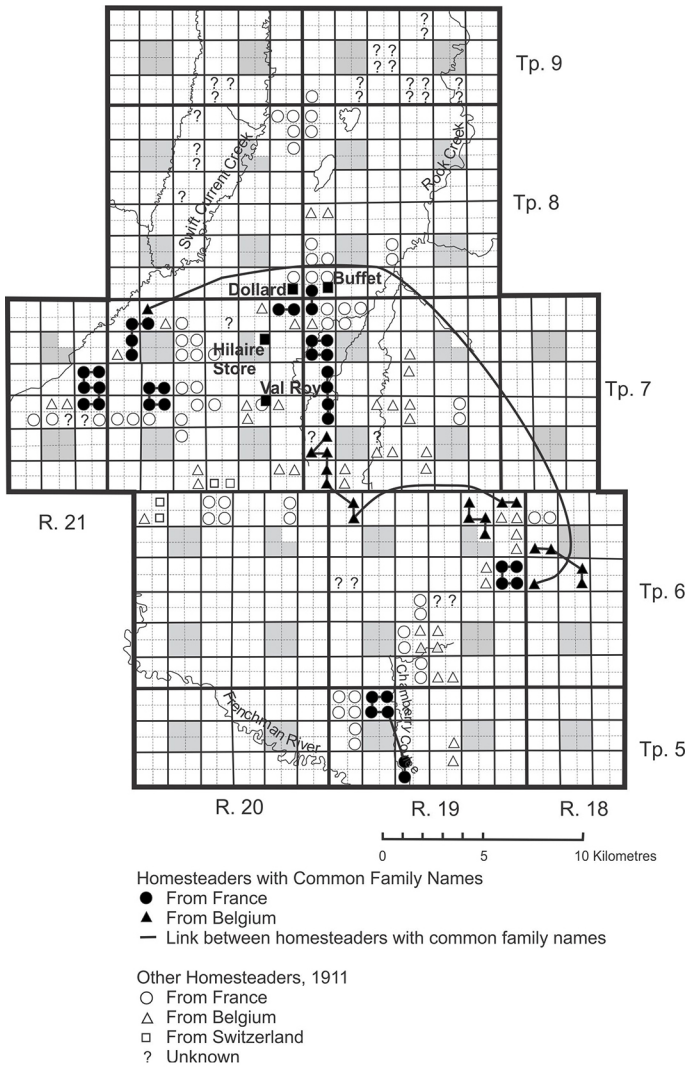


Figure 13
Family name groups at Dollard
SOURCE: Homestead files; CLI (1967c); Canada (1911); South Shaunavon History Book Club (1981); Eastend Historical Society (1982)

vantages, yet it was shown that settlement did not necessarily expand outward from towns. Hills, stones, wet areas, and sand made less fertile quarters obvious places to avoid. Water also influenced general settlement patterns here as elsewhere on the prairies (Lehr 1972, 1974; Ostergren 1998, 26), and homesteaders selected land near waterways in all three settlements. Low shrub that was sometimes associated with waterways in this dry region was an added attraction. Late-arriving settlers generally took poorer land that was further from waterways and central communities.

Finally, the clustered arrangement of family groups demonstrated that chain and step migration occurred through acquaintance ties and communication links. Origin-based clusters, where homesteaders came directly from home countries, were more significant in the settlements where the priest played a greater role in migration, as was the case in Ponteix. Conversely, at Fife Lake, family and recent residence groups were more important as the priest played a lesser role. Jerome Boutin and Léon Roy were important in the clusters of settlers who shared common recent residences at Val Roy. The significance of the church in the establishment of the French community at Ponteix is similar to Pyée's (2005) findings for Notre-Dame-de-Lourdes and Saint-Claude, Manitoba, where migrant channels based on church recruitment in Europe were particularly important in the establishment of communities of French migrants. In all three settlements, French and Belgian homesteaders were able to gather in origin, recent residence, acquaintance, and family groups without giving up economic advantages of good land, though they sometimes located away from water. Important social ties could thus be maintained without forgoing economic advantages.

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The politics of toponymy: Naming settlements, municipalities and school districts in Canada's Prairie provinces

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Place names reflect the political, military, economic, and social power of a group. When what are now the Canadian Prairie provinces of Manitoba, Saskatchewan, and Albertaa were settled by Europeans, the names they bestowed on places revealed the newcomers' power and the institutions that constituted the political fabric of the new society. Railway corporations, the churches, and the imperial government were the principal contributors to toponyms of settled places. At the local level, hundreds of rural municipalities were named by politicians and thousands of school districts were named by elected school trustees. Investigation of the naming process reveals how these newcomers negotiated their place in Canadian society and how they transferred their world views, history, and geography into western Canada.

Keywords: toponyms, school districts, rural municipalities, Canadian prairies

Introduction

Places are social constructs created by human societies who imbue them with meaning and values. Assigning a new name to a place is a powerful statement of political authority that may subsume religious beliefs, patterns of use, social values, a society's views of the past, and its expectations of the future. The old axiom that the victors write the history should carry a corollary that they also get to name—or rename—places. Place names carry emotional and cultural baggage and are socially and politically important as products of often conflicting ethnic, national, and community values.

The process of de-colonializing Canada's North testifies to the deep emotional bond of communities to place and the role of place names as a form of symbolic capital for both elite and marginalized groups. The acts of renaming Frobisher Bay to Iqaluit in 1987 and Eskimo Point to Arviat in 1989, for example, highlighted the semiotic relationship between toponyms, power, and identity. To the Inuit population, restoring the original names was a symbolic assertion of their presence and an affirmation of their political primacy in the newly created administrative territory that would eventually become Nunavut. The process continues. In Manitoba, the news media has begun to note the Cree community of Cross Lake is also known as Pimicikamak, which is Cree for where the lake crosses the river, though the band's website insists that the name describes the tribal territory rather than the community of Cross Lake itself (Cross Lake

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Band 2016; Robinson 2016). Such nuances are important, for the semiotics of renaming speak to the perpetuation of deeply entrenched power relationships between settler and Aboriginal societies.

Geographers and historians have long recognized the study of place names as a valuable aid in interpreting past landscapes. In Britain, the course of settlement by various invading groups can be determined through the distribution of Norse and Saxon place names, while surviving Celtic place names, often highly descriptive, when translated offer valuable insights into environmental conditions thousands of years ago (Readers Digest Association 1965, 124–5.) A series of publications by the British Place Name Society has examined the origins and meanings of place names in ever more detail, extending to the level of farms and individual fields offering new insights into the landscapes of bygone eras. Place name evidence was also used by Sousa and García-Murillo (2001) to reconstruct changes in past environments. Elsewhere, Cohen and Kliot (1992) and Katz (1995) studied place names as part of political processes aimed at legitimizing territorial claims; Guyot and Seethal (2007) argued they were expressions of social power; while Lester (1979) viewed place names as integral parts of the colonization and decolonization process. This final point is echoed by Yeoh (1996) and Tucker and Rose-Redwood (2015), who maintain toponyms are indicators of social attitudes and political thinking. Place names are also important to national governments. Radding and Weston (2010, 394) argue some nations are prepared to go to war over the naming of a place, believing recognition of a place name legitimizes a territorial claim.

In Canada, there has been increasing interest in the study of place names, sparked in part by Alan Rayburn's popular book, *Naming Canada*, which explored the history of Canadian place naming. In the Prairie provinces a series of publications have listed and, less often, given the etymology of prairie place names. In Manitoba, Rudnyc'kyj, (1970), Hamm (1980), and Buchner (2000) maintained a gazetteer-like approach that provided sophisticated and etymological analyses of provincial place names. Saskatchewan place names were inventoried and explained by Russell (1980) and Barry (1997). Marden (1973), Karamitsanis (1990), Harrison (1994), and Aubrey (1996) have listed and given the etymology of many Alberta place names. More recently however, Berg and Vuolteenaho (2009) and Rose-Redwood et al. (2010) have argued for a critical reformulation of the study of toponomy, urging a move beyond the traditional focus on etymology and taxonomy and re-examination of the politics of naming places.

The reformulated critical approach to toponymic enquiry argues that power, narrowly and simplistically defined as politics, misses all the other influences on place names and the effects they have on people. A critical, far broader, and more encompassing view, acknowledges that naming places is inextricably bound up with both governmental and societal power relations. Laura Bigon's (2016) edited volume on the colonial legacies embedded in African toponomys is an example. The contributors recognize that the relationship between governed and government as manifested in place names is complex and nuanced by the semiotics of place and agency. The critical approach to the examination of prairie toponymy, adopted here, emphasizes the nuances of naming rural municipalities and school districts by settlers. In so doing, it reveals something of the complexity surrounding place, toponymy, society, politics, and power. Thus the toponomys found on the prairies may be seen variously as statements of imperialism, settler appropriation, Aboriginal resistance, and ethnic resistance or acculturation.

Toponyms in the Prairie provinces

For millennia before the arrival of Europeans in the territory that now comprises the provinces of Manitoba, Saskatchewan, and Alberta, the land was occupied by Aboriginal peoples who assigned names to those features and points significant to them for religious, territorial, or economic reasons. As is common when invaders dispossess the original inhabitants and occupy a new territory, in those parts of the prairie provinces settled by European agriculturalists, the newcomers transplanted their political and social values and impressed their weltanschauung into the landscape by creating, naming, and renaming places. Today, relatively few original Aboriginal place names survive in their original form, though many "English" place names are simply the original Aboriginal names appropriated and translated into English. Head-Smashed-In and Swift Current are but two examples. Moose Jaw in Saskatchewan is actually a poor rendition of an Aboriginal name that had nothing to do with the animal or its jaw. For the most part those Aboriginal place names that have survived without being translated into English or French, or mangled in pronunciation, occur most frequently in areas that were settled only sparsely by Europeans, such as the northern shield areas unsuited to commercial agriculture.

Since western Canada was surveyed long before any significant settlement by Europeans, the Crown, represented by the Dominion Government, and later by provincial governments and their agencies, was a powerful institution that monitored and registered place names, thereby controlling the majority of the toponomy of the country. Government surveyors recorded names obtained from Aboriginal people or squatters who were present when the survey came through. At least in the early period of European exploration, the toponyms appearing on maps were the product of negotiation between pre-existing Aboriginal knowledge and cartographic expedience. The Canadian geologist J. B. Tyrrell explained the process of naming places in areas new to Europeans:

> … many of the names in use by the local tribes were obtained from them. Where such names did not conflict with similar names in use elsewhere, they were generally adopted in my reports and on maps. When no native Indian names were obtainable, I made use of such names as seemed appropriate at the time (Tyrrell 1915, 214).

Tyrrell listed some 230 Aboriginal place names in "Manitoba and vicinity," all of which referred to natural features: lakes, rivers, rapids, islands, portages, and so forth (Tyrrell 1915, 214–231). These names had been in use by local Aboriginal populations according to Tyrrell "from time immemorial." Some, he thought, were "evidently contractions or corruptions" with their original meanings lost. When he considered Aboriginal names too long or difficult for Europeans to pronounce, he shortened them to "about four syllables, retaining, as far as possible, the general character and sound of the words" as pronounced by the Aboriginal population (Tyrrell 1915, 215). Most surviving Aboriginal place names are descriptive. Some examples include Patemaykwan Lake [where beaver are put in a fire to burn the fur off], Pembina [summer berry], Pukatawagen [fishing place], Pisew Falls [lynx] and Manigotagen [bad throat] (Buchner 2000). Athabasca [grass and reeds here and there], Manitou [supernatural spirit or god], Ponoka [elk], Saskatchewan [swift flowing river], Wetaskiwin [the hills where peace was made] and Winnipeg [muddy waters] are among the relatively few Aboriginal names on the prairies that survived the inrush of European settlement (Russell 1980).

The Canadian government had no real presence in the region prior to 1870. Before then, corporations were the de facto European claim to power for all the territory that later became the Prairie provinces. Two fur-trading enterprises, the Northwest Company and the Hudson's Bay Company (HBC), maintained posts along the rivers that fed their respective trades. In northern Manitoba, along the rivers flowing into Hudson Bay, most of the permanent settlements were founded by the HBC. Virtually all promoted a particular vision of history and conflated corporate and national identities in their names. Oxford House and York Factory incorporated transferred toponyms, Churchill and the nearby Fort Prince of Wales suggested imperial designs, while Norway House simply recalled the ethnic origin of the Norwegians brought in to construct a road there in the early 1800s (Buchner 2000, 195). The Northwest Company, headquartered in Montreal, also penetrated into the region, leaving evidence of its Quebec roots in some of the forts it established in connection with the fur trade. Dauphin, Qu'Appelle, Fond du Lac, and Souris were all products of the company's French Canadian heritage, though its posts established by Anglophone employees were given British or Aboriginal names: Fort Chipewyan, Pembina, and Fort Gibraltar.

When the railway companies laid track across the prairies they located station halts at six to ten mile intervals. Thus, thousands of places were created along railway lines, most of which were named by railway executives and employees. Most of the former, and many of the latter, were drawn from an Anglo-Canadian elite thoroughly imbued with British imperial values. The names of major points along the lines reflected this. For example, Virden in western Manitoba was initially named Gopher Creek but was renamed Manchester after the Duke of Manchester, a Canadian Pacific Railway (CPR) director. When it was found that another Manitoba community was already named Manchester the name was switched to Virden after the name of the duke's county seat (Buchner 2000, 282.) Similarly, Cherry Creek was re-named by the CPR in honour of Adolph Boissevain who had introduced CPR shares to the European market in the railway's early years (Buchner 2000, 83). In later years, other large corporations also played roles. Early hydro-electric generating plants built by Winnipeg Hydro and Manitoba Hydro along the Winnipeg River mostly carried non-Aboriginal names. In the 1960s, as generating stations were built further north, and corporate attitudes towards the Aboriginal presence began to change, names of Aboriginal origin were adopted or appropriated.

In areas occupied by waves of European immigrants, Aboriginal toponyms, like the people who created them, generally were soon marginalized or eliminated. If settlers were already established, names of physical features and other landmarks were obtained from them and also became enshrined on topographic maps. Later, as embryonic settler communities grew, they were named by government-appointed postmasters who chose to celebrate their homeland places, British national heroes or honour early, mostly Anglophone, pioneer families.

The names of resource towns in the North tended to reflect the disconnection between the corporations that founded them and the Aboriginal peoples who occupied the area prior to the exploitation of the area's mineral resources. Thompson, Uranium City, Fort McMurray, and Lynn Lake are typical examples. One hydro dam near Norway House was named Jenpeg, a name often assumed to be of Aboriginal origin but was in fact an acronym of the names of two women in the Manitoba Hydro office in Winnipeg: Jennifer and Peggy (Buchner 2000, 123). The oddly named Flin Flon, Manitoba was named after Josiah Flintabbatey Flonatin—a fictional character in the novel, *The Sunless City*—by the prospector who discovered the deposit that fueled the town's growth (Buchner 2000, 82).

In areas where settlement preceded the arrival of the railway, churches exercised a crucial role. In French and Métis communities across the West a high proportion of place names celebrate Roman Catholic saints, members of the church hierarchy, or major donors to church building funds. In Manitoba, Ste. Agathe, St. Jean Baptiste, St. Pierre, and Ste. François Xavier all commemorated Catholic saints. St. Malo was named in honour of a Mr. Malo who was a major contributor to the settlement's church building fund and Fannystelle was named after Fanny Rives, a woman who worked among the poor of Paris (Rudnyc'kyj 1970, 67). Further west, Catholic influence and French and Métis presence was evident at such places as Gravelbourg, Batoche, St. Laurent, Prud'homme and Bonne-Madon in Saskatchewan and at St. Albert, Morinville, Girouxville, Lac la Biche and Grande Cache in Alberta (Russell 1980; Anderson 2013). Among Mennonite communities in Manitoba and Saskatchewan the pacific and bucolic values of their churches prevailed, expressed in names of settlements such as Waldheim [forest home], Hochfeld [high field], Schönfeld [good field], and Gnadenthal [grace valley] (Russell 1980; Epp 1974). Jewish settlers also named some of their settlements after religious leaders. Hirsch, Saskatchewan, celebrated Baron Maurice de Hirsch, the founder of the Jewish Colonization Association (Russell 1973, 140). The nearby railway halt of Narcisse was named after Narcisse Levin, sometime President of the same association (Buchner 2000, 23),

whereas Bender Hamlet in Manitoba's Interlake district was named after Jacob Bender who organized that colony in 1903.

Naming places on the prairies has been predominately an institutional process that continues today. In Manitoba, thousands of not yet officially-named lakes and physical features are being assigned names by the Provincial Geographical Branch that honour those men and women who gave their lives in the service of their country. For example, Kennedy Point on Crow Lake was named in 1995 after WWII casualty Flying Officer James C. Kennedy of 424 Wellington Squadron, while Lindal Lake, named in 1972, commemorates Lieutenant Harold E. Lindal of Winnipeg who was killed while serving with the Essex Scottish Regiment during the same war.

Individuals without institutional power played a less significant role in naming prairie places. Often those who did occupied an official position as a local postmaster or postmistress and were in a position to name their post office, from which the locality eventually took its name. There were exceptions, of course, when no one person named a place. The community of Ardill in Saskatchewan gained its name from a Cockney immigrant complaining that the road from the river to the settlement was a "damned 'ard 'ill" [hard hill] for his team to climb (Russell 1973, 11). Hoodoo, also in Saskatchewan, allegedly gained its name from an elderly French woman who never learned English and her rendition of "How do you do," came out as "Hoodoo." This captured the imagination of the community and everyone began using Hoodoo as a salutation. The school, post office and the church and, finally, the settlement were all named Hoodoo (Russell 1973, 143). When Indiana settlers, known as Hoosiers, settled south of Scott, Saskatchewan, their district became known colloquially as Hoosier Valley. In 1913, the Grand Trunk Pacific line arrived and proposed to name their station, around which a settlement was sure to form, "Fee" in accordance with its alphabetical naming practice. The Indiana settlers proposed Hoosier Valley but the railway settled on Hoosier (Russell 1973, 143). The district of Onefour in southern Alberta was so named by local settlers after its location, which they thought was in Township 1 Range 4, but actually lay in Township 2 Range 4. When the discrepancy was realized they elected to keep the original name (Karamitsanis 1991, 90).

Naming municipalities

Across the prairies local governance of rural areas is in the hands of rural municipalities (RMs).[1] Their names variously reveal the dominance of the Anglophone elite and the influence of the Roman Catholic Church in Métis and French communities. Less often, the presence of large numbers of settlers from specific ethnic groups is reflected in RM toponomy.

Rural municipalities were created at different times in the three Prairie provinces. The first RM was created in Manitoba in 1873 but it was not until 1909 that Saskatchewan organized its first. Alberta did not see RMs organized until it passed the Rural Municipality Act in 1912 (Hanson 1956, 24–25; Goldsborough 2008, 5). Whereas in Manitoba RMs were generally organized before the geographically smaller school districts, in Saskatchewan and Alberta organization of school districts often preceded the organization of local government at the level of the RM. This was to have an effect on the naming process.

There are presently 116 RMs in Manitoba. The great majority of their names are transferred toponyms from Anglophone eastern Canada or Britain or, if not, they bear the names of the British or Anglo-Canadian elite. Nine municipalities have French or French Roman Catholic names, three have Icelandic names: Bifrost, Gimli, and Siglunes. Surprisingly, seven RMs have names of Aboriginal origin: Miniota [plenty of water], Minnitonas [home of the little god], Saskatchewan [swift flowing river], Odanah [large camp], Pembina [summer berries], while Pipestone and Brokenhead are both translations of Aboriginal place names (Rudnyc'kyj 1970; Buchner 2000). Since Aboriginal peoples in western Canada were almost entirely disenfranchised until the 1950s, these Aboriginal toponyms suggest appropriation by incoming settlers rather than any Aboriginal political influence.

There are 296 existing and 21 former RMs in Saskatchewan. As in Manitoba the vast majority of these have names of British origin. Echoes of the original peoples survive directly in municipality names such as Piapot [an Aboriginal leader], Meota [a good place to camp], Nipawin [a place where one stands or viewpoint], and indirectly in translations into English as with Cut Knife and Indian Head municipalities. The RM of Mankota, whose name is of Aboriginal origin, is actually a transferred toponym from Minnesota. American settlers decided on the name in honour of their former residence in the United States (Russell 1980, 186). There are ten RMs of French origin, including Auvergne, Rocanville, Val Marie, Monet, and Coteau, although the Anglophone name Frenchman Butte RM recalls only the presence of early French travelers. Although German and Ukrainian immigrants made up a significant proportion of Saskatchewan settlers prior to 1914, there is only one municipality with a German name, Blucher, and none with a Ukrainian name. Even after some 20 years of settlement allophone immigrants carried little influence beyond the immediate confines of their communities.

Although there are presently only 64 municipal districts or counties (both analogous to the RMs of Saskatchewan and Manitoba) in Alberta, at one time or another there have been some 252 differently named local government entities in the province. Their toponymy demonstrates the hegemonic power of Anglo-Saxon culture in local governance. Most were either descriptive (e.g. Beaver Dam, Prairie Creek), transferred toponyms from Great Britain (e.g. Argyle, Dublin), or honorific appellations of imperial heroes (e.g. Haig, Kitchener). Although large tracts of the province were settled by people from central and eastern Europe, only four municipal districts carried Ukrainian names: Sobor, Ukraina, Wasel, and Wostok. All four were later subsumed by larger municipal districts.

Naming school districts

School districts were, and in some areas still are, important elements in prairie toponymy. Over 11,500 were established in what are now the provinces of Manitoba, Saskatchewan, and Alberta. School districts were smaller in area and more numerous than rural municipalities, rivalling only settled places—hamlets, villages, and towns—in sheer numbers of prairie toponyms. They provide insights into the attitudes and values of the ordinary newcomers who settled the West and the often complex power relationships that prevailed at the time of their organization.

Soon after the settlement of an area by Europeans schools were established and were assigned a number and name. The school's number was assigned by the provincial or territorial government but the name was chosen by members of each school board, who were drawn from the immediate locality. School names generally reflected the world view and values of the settlers in each district. In contrast to towns, which were typically named by the social and business elite, and rural municipalities that were mainly named by regionally influential elected officials, school districts were named by boards that drew their elected members from the common people in the community. Consequently, school districts reflect the world view of ordinary settlers: board members chose names after their own national heroes, places of origin in Europe and North America, or to celebrate qualities held in high esteem in their culture. A consideration of school district names thus offers further insights into the emotions and politics behind the creation of prairie toponymy.

Most frequently school boards chose names that described their district's topography, natural history, or agricultural qualities. Many of the latter type were unashamedly boosterist, extolling the agricultural potential of the district as in Eldorado, Goodsoil, and Richland in Saskatchewan. Manitoba also had an Eldorado, a Richland, and a Utopia, while Alberta, in addition to its own Eldorado, boasted a Fertile, a Peerless, and a Cornucopia. Often names brimmed with optimism, as with Superb, Saskatchewan, Up-to-Date, Alberta, and Beautiful Valley, Manitoba, reflecting the hopes of embryonic communities who saw their own districts as the best in the West and, presumably, thought the right name would enhance their appeal to further immigrants. On occasion, a tinge of realism crept in when less than enthusiastic emotions were incorporated into school district names. Even though vastly outnumbered by the positive, school names such as Skull Creek, Vindictive, and Dismal in Alberta, Hardscrabble, Survivance, and Rock Bottom in Saskatchewan, and Badthroat and Dry River in Manitoba, obviously were not selected with a positive image in mind. Topographic descriptors varied widely but embraced both native flora and fauna, with 25 references to buffalo (e.g. Buffalo Park, Buffalo Plain and Buffalo Hill) and one, more taxonomically correct, to Bison. There were 37 referring to beaver, as in Beaver Hills, Beaver Creek, and Beaver Heights.

The founders of new communities have long transferred the place names of their former regions to the areas they were pioneering. When selecting names for their prairie school districts, thoughts clearly turned to hometowns and homelands, and a score of newly minted school districts were assigned names that recalled the place of origin of most boards members or the place of origin of the most influential among them. In districts settled by Anglophones there were many school districts named after homeland places, including Marlborough, Beeston, York, Devonshire, Bristol, and Stratford. Ukrainians commemorated scores of places in their home country: Buczasz, a village in Galicia; Czernowitz, the capital of Bukovyna; Bridok, a Bukovynian village that provided many immigrants to Canada; and many other towns, districts, and rivers in Ukraine. Other Europeans shared the desire to transfer toponyms. There were Venice School Districts founded by Italian settlers in both Alberta and Saskatchewan while a Reykjavik School District served an Icelandic community in Saskatchewan.

Immigrants from western Ukraine named many of their schools after their national heroes and places in the old world with nationalistic connotations. Ukraine, which was then a geographical concept and not yet a nation state, had a school district named for it in each prairie province, although the spelling varied. Manitoba and Saskatchewan had Oukraina school districts while Alberta had Ukraina. The Zaparoze Sich, island fortress of the Cossacks, occupies a prominent place in Ukrainian history and national mythology. Not surprisingly there was a Zaparoze school district in Manitoba, Saskatchewan, and Alberta, and a Sich School District in Saskatchewan. Other school district names in Ukrainian districts were simply descriptive. Alberta's Chornohora translates as black mountain, Krazne as beautiful, Kraznahora, as beautiful mountain, Myrnam as our peace, and Dickiebush as wild bush. The latter name is an interesting hybridization of the Ukrainian word for wild and the Canadian-English word "bush." Several school districts were named Zorra or Zoriya or different renditions of the Ukrainian word for star (Baergen 2005).

During the time that western Canada was being settled by Europeans, Britain was involved in two major conflicts: the Boer War in South Africa (1899–1902) and the Great War in Europe (1914–1918). As the "mother country," Great Britain, along with many Anglophone Canadians, expected communities to demonstrate support for wartime policies and celebrate military victories. Thus, Victory and Mafeking School Districts commemorated battles won against the Boers in 1901 and 1902 respectively. Years later, the outbreak of war between Great Britain and its allies and the Central Powers in August 1914 not only terminated immigration into Canada but had a significant effect on the nation's toponymy. Allophone communities, especially those whose homeland governments sided with Germany, Austria-Hungary, and other members of the Central Powers, were naturally anxious to display their patriotism and demonstrate their commitment to British-Canadian values. In Manitoba, Bukovina School District became Lord Roberts, Svoboda became Beckett, Slowo became Strand, and Wisla became Prince of Wales (Perfect 1978; Province of Manitoba, School Formation Files). New school districts were less likely to reveal the ethnic origins of their founding communities and, in their choice of name, as likely as not celebrated an allied victory, an allied general, or an allied statesman. Each prairie province had a Foch, a

Haig, and a Mons school district. Saskatchewan had Vimy and Vimy Ridge school districts, Alberta had a Vimy Hill, and Manitoba a Vimy Ridge—all created in 1917 and 1918 to celebrate a decisive victory won by the Canadian Corps over the German Sixth Army in France. Even some already-established school districts changed their names to reflect their patriotic feelings. New Berlin changed to Verdun, Prussia to Leader, and Munster was renamed Cavell, after Edith Cavell, the British nurse shot for helping British prisoners escape from German-occupied Belgium. Some schools were renamed to express patriotic sentiments or dissociate the community from sympathies for the Central Powers.

Conclusion

When the western interior was being settled by Europeans, naming a place was a political and cultural act embodying the mood and aspirations of embryonic communities, revealing their ethnic composition, geographic origins, their connections to the past, and hopes for the future. For the most part, Aboriginal communities were marginalized and condemned to toponymic silence. When their toponymy survived in areas of European settlement it was frequently in an appropriated, translated or mangled form.

Corporate power was manifested in the naming of the prairies. Railway companies, and before them, the fur-trading companies created and named places. Although there were exceptions, corporations tended to honour their executives, stockholders, and the heroes and places of their Britannic culture when it came to bestowing names. Naming lower-order places such as RMs and school districts allowed for a greater degree of local input although, as the rash of school district name changes during the First World War showed, local sentiment was not immune from the greater cultural and political currents sweeping the globe. School districts in Alberta and Saskatchewan were also formed before rural municipalities or districts. As they were always geographically far smaller, a single ethnicity was far more likely to predominate and, more importantly, wield local political power, enabling small communities to inscribe their identity into the prairie landscape. The size of administrative areas also affected naming. Large areas were more likely to fall under the oversight of the Anglophone elite who manifested their influence through their naming practices. Relatively few RMs or districts were given "ethnic" or Aboriginal names, simply because minority or marginalized communities lacked an effective voice at the time when names were initially assigned. Although attitudes towards allophone peoples began to change with the advent of multiculturalism in the 1960s, the time for naming RMs had then long passed.

The toponymy of the Prairie provinces offers insights into the attitudes and origins of settler society in the Canadian west, its social and political diversity and the political currents within it. The emerging narratives of place parallel relationships between marginalized communities and the governing elite.

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Notes

[1] This study drew on different sources for information about rural municipalities and school districts in each province. Information on Manitoba RMs was drawn from Goldsborough (2008), Hanson (1956) provided information on Albert's rural districts, and information on Saskatchewan RMs came from Adamson (2014) and the Canada Revenue Agency (2016). Information on school districts was obtained from Perfect (1978) and the Records of School Formation at the Archives of Manitoba. Saskatchewan data was gleaned principally from the Saskatchewan One Room School Project (2013), and Alberta data was taken from Baergen (2005) and the online School District Catalogue at the Glenbow Museum.

Prairie Perspectives: Geographical Essays
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'How to live to be 100 … with Manitoba's help!' Nature and antimodern tourism in post-war Manitoba

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The Manitoba Travel and Publicity Bureau was established in 1945 with the aim of developing and promoting a provincial tourism industry. During the post-war period, the provincial government believed the expansion of tourism would help secure economic growth and prosperity, and thus promoted the rural countryside and wilderness areas as desirable sites to visit. I focus on the influence of antimodern sentiment—a belief that cities and technology had made life empty and meaningless—on the early development of tourism in the province. However, as tourism promoters sought out farm and wilderness spaces where people could recuperate from the hardships of the modern age, they simultaneously constructed these 'natural' spaces through a very modern tourist experience. This article elaborates on these ideas and explores how antimodern sentiments were incorporated into representations of Manitoba in materials produced by the bureau using films, photographs, and pamphlets they distributed across North America.

Keywords: antimodernism, social nature, wilderness, tourism, Manitoba

Introduction

In 1955, Manitoba's Bureau of Travel and Publicity (MBTP) produced a film and a booklet with the common title *How to live to be 100 ... with Manitoba's help!* (AM 1955a; MBTP 1955). Both promised potential tourists that antiaging treatments awaited them in the Manitoba wilderness. "TAKE A LOOK in your mirror, friend! See those wrinkles? Notice that tell-tale bulge around your middle?" the booklet asked (MBTP 1955). "Let's face it, my boy – it's age! The years are catching up with you … and you're offering no resistance. Well, here's good news. You can lick Old Man Time–with Manitoba's help!" (MBTP 1955) Tourists were thus told they could resist aging by visiting the province's pristine lakes, forests, and streams, where hunting and fishing would provide effective antidotes to wrinkles and bulges. To illustrate all of the fishing opportunities in the province, the booklet contained a map explaining where brook trout, northern pike, and a variety of other fish could be caught (Figure 1). In the map, the province is literally crowded with activities and outdoor opportunities. It also recommended other forms of outdoor recreation found in Manitoba: "Whatever your outdoor interests—be it fishing, hunting, canoeing, photography, or just the sheer novelty of breathing fresh air instead of carbon monoxide" (MBTP 1955). In so doing, the MBTP equated the province's wilderness with health and rejuvenation.

The film version of *How to live to be 100* also described a wilderness where tourists could temporarily escape the maladies of modern civilization and heal their weary bodies (AM 1955a). It featured an American tourist and his son on a fishing trip in the Whiteshell Forest Reserve in eastern Manitoba. According

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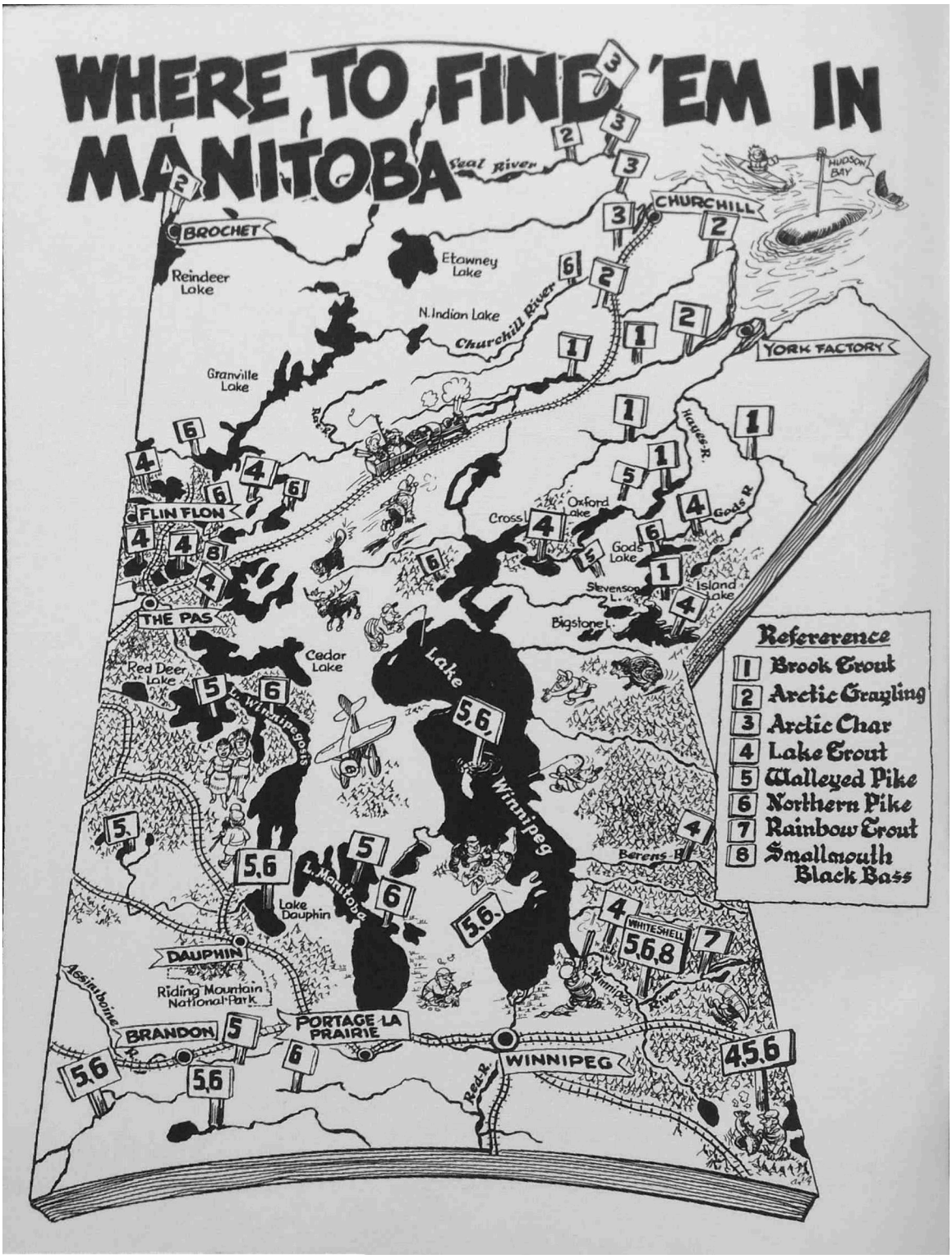


Figure 1
'Where to find 'em in Manitoba' illustrated map from *How to live to be 100 … with Manitoba's help!* (MBTP 1955)

to the film, the experience rejuvenated the pair, reasoning "[t]his is what's good for the tired businessman," to a scene showing video of the man and his son fishing in a boat. The film described both the logistics of planning a trip and the challenges a fisherman could anticipate. "Manitoba bass are real fighters," it stated, "[y]ou won't see them come to the boat without a struggle." The father and son were rewarded for their efforts with fresh fish cooked in the clean Manitoba air. Viewers were assured that the benefits of a trip extended beyond fish and that "The surroundings will be good for the inner man, and we don't mean your stomach." Explaining how the scenery in the Whiteshell Forest Reserve was rugged, unsurpassed, and untouched, the film promised fishermen would find the lakes "just as nature made them." Together, the booklet and film targeted the modern businessman, equating the patriarchal responsibility to provide for his family with a wholesome and healthful experience outside the city that would simultaneously relieve him of the strains of bureaucratic life.

This article explores how MBTP's publications constructed the province's 'natural' landscapes as antithetical to the increasingly structured social and economic world of post-war Canada. Essentially, Manitoba promised technocratic workers relief in antimodern spaces. *The How to live to be 100* publications were part of a larger effort by the MBTP to attract American tourists by presenting the province's natural areas as a kind of antidote to worries about over-civilization associated with modern urban life. They relied on modern anxieties that cities and technology made people weak and effeminate, and that the only remedy was to escape the city and seek cure by facing the wilderness. In publications and advertisements, the bureau constructed Manitoba's wild geography as the binary opposite of modern towns and cities by assuring tourists these spaces could cleanse them of modern ills. However, despite the dominance of this idea in post-war publications, and despite the idea that Manitoba's wilderness spaces offered a retreat or antidote to the stifling city life in the 1940s and 1950s, the spaces available to tourists in Manitoba were presented within the mould of modern society (Wall 2010).

In the post-war era, the narrative of escape from modernity fitted within larger provincial efforts to expand the economy, which both the federal and provincial governments sought to do through the expansion of the tourist industry (Wilson 1991). To accomplish this, the MBTP made advertising the province's tourist destinations a priority (AM 1943; 1946). They produced and distributed promotional material across North America with titles such as *Manitoba: Inside the Rim of Adventure, Manitoba's Romantic Northland,* and *Fishing and Hunting in Magnificent Manitoba!* (MBTP 1948; 1950; n.d.-a). They hoped to sway Americans and Canadians alike into believing that Manitoba, once "simply known and regarded as one of the prairie provinces—a province with no individuality," was a special wilderness where tourists could rejuvenate (AM 1943). However, these escapist ideas were used to both support and expand the very modern society the movement purportedly critiqued.

This paradox, whereof the desire to escape modernity actually deepens its influence, has been described by cultural historians. The foremost thinker here is T. J. Jackson Lears, who termed this phenomenon 'antimodernism.' Lears noted how beginning in the late-nineteenth century, a broad movement developed in response to the rapid urbanization and industrialization occurring in Europe and North America. For many, the rationalization and acceleration of modern society was causing 'over-civilization' which they associated with moral degeneracy, the breakdown of traditional family structure, and—for many men who worked teller jobs or spent their days in offices—the waning of manliness and masculinity they associated with the 'rougher' lifestyles of their ancestors. To avoid these afflictions, people sought to recover a humbler pre urban past doing things with their hands, improving their bodies, and seeking out self-sufficiency. Many of these experiences were sought through escaping the conveniences of the city for a wilderness devoid of modern comforts. However, their understanding of nature was significantly different from earlier ideas which had associated 'wilderness' with waste and danger. Moreover, despite the obvious physical differences between 'the city' and 'the wilderness', the latter was not distinct from, or outside of, the former (Williams 1973). Rather, as Lears and other scholars have demonstrated, the wilderness was often paradoxically the place where modern values became most apparent (Lears 1981; Wilson 1991).

The concept of antimodernism has been employed usefully in Canada. Kathryn Morse's book on the 'nature' of gold in the Klondike as a liberating escape from modern corporatism demonstrated how the gold rush in fact brought capitalism to the Yukon (Morse 2003). In another example, Ian McKay's study of historical culture in Nova Scotia demonstrated how the region's past was rewritten to promote the idea of 'folk' tourism in the province at the very same time industrial modernity was transforming society (McKay 1994). Sharon Wall explored a similar phenomenon in her study of antimodern sentiments at Ontario summer camps in the early to mid-twentieth century. Wall argued that the purportedly natural spaces associated with the camps were not outside of modernity, but rather were influenced by and in turn reinforced many modern ideas (Wall 2010). Yet despite these important contributions, no studies have explored the experience of antimodernism in Manitoba.

Nature and modernity

The power of antimodernism in reshaping ideas about Manitoba's wilderness may be examined from the perspective that ideas about nature are socially constructed by society. 'Social nature' emphasizes how discourses about 'nature' are shaped by social ideas which exist in certain times and places. For example, prior to the nineteenth century, nature was largely understood to be hostile and alien (Williams 1973). For European colonizers who sought to subdue and survive in it on a daily basis, the wilderness was not a place of benevolence and spirituality in the way it is commonly thought of today. Rather, as environmental historian William Cronon demonstrated, "to be a wilderness was to be 'deserted,' 'savage,' 'desolate,' 'barren,'—in short, a 'waste,' the word's nearest synonym" (Cronon 1995, 70). These ideas stand

in stark contrast to contemporary perspectives, demonstrating that 'nature' changes across time and space. For instance, it was this understanding of nature which led writer Anna Jameson to declare in 1839 that a "Canadian settler hates a tree, regards it as his natural enemy, as something to be destroyed, eradicated, annihilated, by all and any means" (quoted in Wall 2010, 6).

Like nature, the concept of modernity has also been subject to human molding. It is a multi-faceted and contested term, but I use Stuart Hall's definition for it here to refer to the rise of capitalism, liberalism, secularism, and science as the primary social and economic relations used to organize daily life during the mid-nineteenth century (Hall et al. 1996). During this period, rapid urbanization and industrialization transformed the lives of many individuals as the former patterns of rural life were traded in for factory work in the cities of Europe. As Raymond Williams (1973) has shown, these upheavals of social and economic life changed the cultural meanings that many associated with city and wilderness respectively. As cities grew and the majority of people began to think of themselves as urban and modern, a romantic concept of rural life and the countryside as separate from or outside the modern urban experience took shape. Williams showed that ideas about nature reflected less about the real countryside and more about anxieties about modern urban life. The MBTP's publications revolved around this polarization of the city and the wilderness. At the same time that people invented modern society and saw themselves stepping into a new period in history, they also imagined a new concept for nature as somewhere to flee from those changes that were occurring.

Both nature and modernity developed out of and in opposition to one another in industrialized countries, resulting in a series of cultural expressions across the landscapes of Europe and North America. T. J. Jackson Lears studied these expressions, arguing that in the mid-nineteenth century "many beneficiaries of modern culture began to feel they were its secret victims" (1981, 4). Rather than embracing newness, educated and affluent individuals critiqued its focus on a "cult of science and technical rationality" and disliked its focus on material progress and expansion (Lears 1981, 4). To counter these effects, antimodernists sought 'authentic' and 'real' experiences which they believed came in natural spaces and parks—antimodern areas where recreational activities including hunting, fishing, and canoeing could take place. Yet in presenting the idea of a return to nature as a respite from the modern, antimodernists were actually deepening a modern romanticizing of it. Moreover, the wilderness was rationalized, industrialized, and transformed by capitalism as cars and camping created a small economy based around the consumption of natural recreation.

Antimodernity in the bureau's publications

Looking closer at the MBTP promotional pamphlets and films in the post-war period shows how they employed antimodern understandings of nature to attract tourists to the province. One example of this is the short film called *To Catch a Fish* which highlighted fishing opportunities in the Whiteshell Forest Reserve and featured an American couple, Joe and Ella, on a trip to the area. According to the narrator, the hundreds of lakes and rivers in the region made it a fisherman's haven, full of beautiful sites that were "just as natural as when the Indians had it," employing the trope of the 'noble savage' as often expressed in antimodern rhetoric (AM 1955; Wright 1997; Wall 2010). In 1954, the bureau produced a pamphlet called *Manitoba's Northland* (MBTP 1954). It described a wilderness waiting for tourists north of the 53rd parallel where "Manitoba's northland has all the mystery, romance, and rugged beauty of a landscape unspoiled by man and machine." The pamphlet explained that the enterprising traveler would find "an adventure land for the sportsman who wants to fish in virgin water, hunt in silent forest or travel through uncharted country by canoe." To illustrate this claim, it featured images of lakes, forests, rustic cabins, and men fishing. According to the pamphlet, fishermen would find walleye, lake trout, and firm, fighting northern pike in most northern lakes. Additionally, the pamphlet claimed, the most skilled and adventurous fishermen could challenge themselves to catch Arctic grayling and brook trout in the waters flowing into Hudson Bay. In this way, the wilderness of northern Manitoba could provide men with the type of 'authentic' and antimodern experience that urban environments could not.

The MBTP's films and pamphlets are an example of the paradox of antimodernism. In seeking to escape modernity and find rejuvenation in the wilderness, people actually carried with them modern ideas about the power of nature that arose in the city. One of the most powerful narratives in the antimodern idea of nature is the romantic notion of an empty space inhabited only by ostensibly pre-modern 'noble savages.' Of course, this was complicated by the fact that in many cases modern Indigenous groups lived in the purportedly empty spaces of the north. John Sandlos (2008) has described how Manitoba's Riding Mountain National Park forcibly removed Cree people from their ancestral spaces to in order to create a 'natural' environment for the pleasure of urban tourists. This allowed the park to be understood as a raw and rugged landscape, where men relied on physical strength to conquer the land (Phillips 1997). To further this idea of the park, the MBTP produced a booklet titled *Manitoba's Romantic Northland* featuring the region as "a land of romance, adventure and history" (MBTP 1948). An article titled *The Trout are Here…* invited tourists to fish and hunt in the region, claiming that the trout in northern areas were considerably larger than those in eastern streams. The booklet also contained six pages with poetic verses accompanied by photographs of lakes, forests, and wildlife. "Ageless Rocks and Unchanging Evergreens … Cormorant Lake," as one verse accompanied an image read (Figure 2). Another read "White Waters of the North … Churchill River." Ironically, the same white waters would be diverted in the next two decades to create Manitoba's hydro regime (Hoffman 2008). Alongside this, a third verse read "Mighty Waters Roll Toward Hudson Bay … Kettle Rapids." Through the booklet's images and descriptions, tourists across North America were taught that Manitoba's northern lakes and forests were a romantic and antimodern wilderness (MBTP 1950). Even though the MBTP presented the landscapes

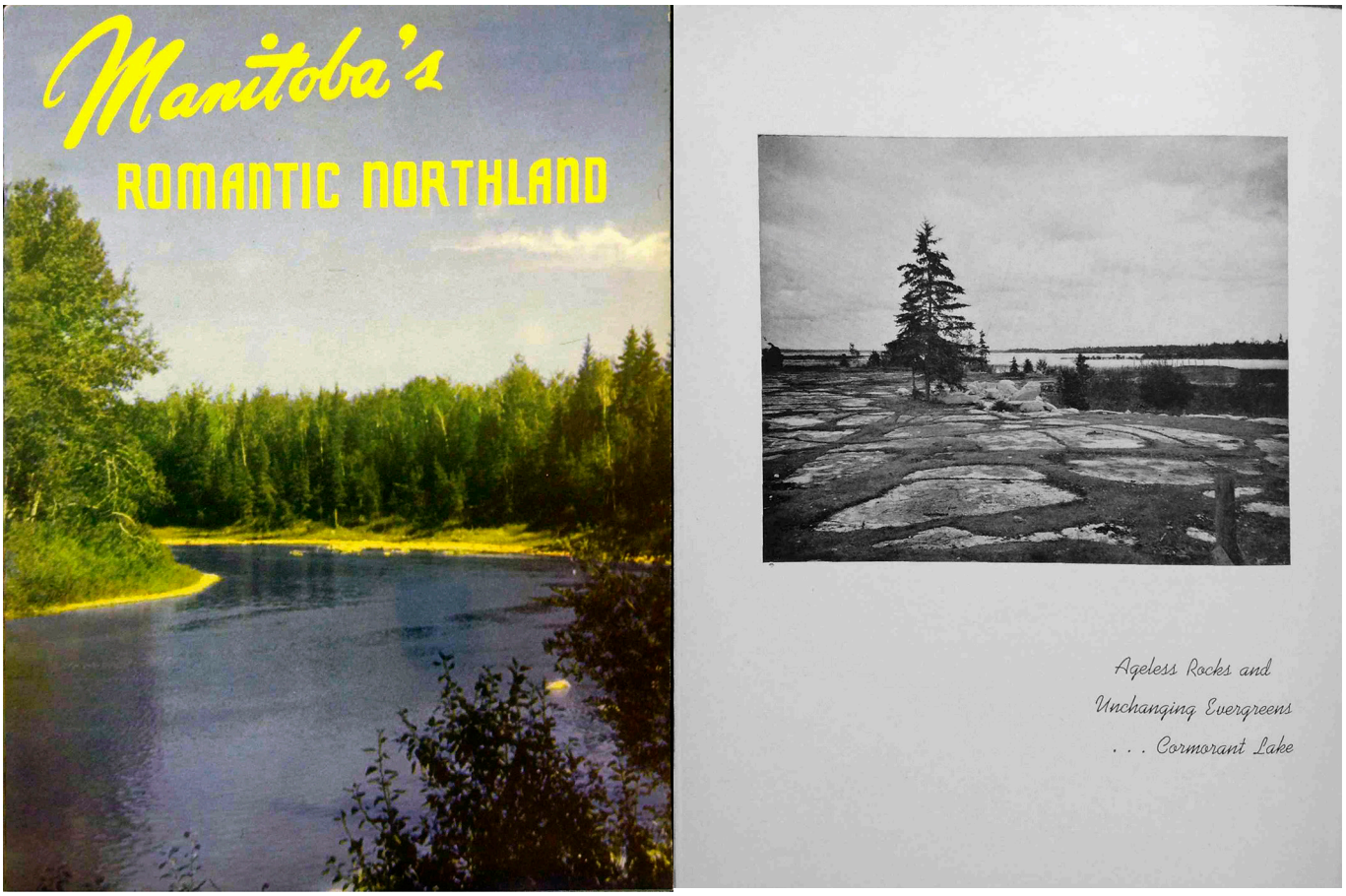


Figure 2
Cover and page featuring 'Ageless rocks and unchanging evergreens' from *Manitoba's romantic northland* (MBTP 1948)

at Riding Mountain as empty and pristine, they were only 'unoccupied' because of the expulsion of Indigenous peoples from the park (Sandlos 2008). Indeed, the tourism bureau was housed within the larger Manitoba Department of Industry and Commerce also responsible for mines and natural resources. Hence, while the booklets on Riding Mountain highlighted the area's protected lakes and forests, they also contained articles on northern resource extraction in surrounding areas. These indications reveal that antimodern nature appreciation had no apparent conflict with the industrial transformation of the same environment users were told to respect.

Treating nature as social reveals that antimodernism was a key driver in associating the idea of wilderness with, ironically, both adventure and tranquility. In their publications, the MBTP contrasted the hectic and stressful pace of city life with two distinct, yet complimentary, portrayals of the wilderness. On one hand, it was represented as an adventurous antidote to the bureaucratic boredom so often associated with modern life. On the other, the wilderness was represented as a slow and quiet space. One example of this is the bureau's booklet Mid-Eastern Manitoba, wherein an article titled *Wilderness Wonderland* discussed opportunities to fish, canoe, and hunt in tranquility. "Some of the peace and quiet of the wilderness is slivered only by the careful footsteps of wild game, or the sounds of the adventure seeker fishing, canoeing and hunting" (MBTP [n.d.-b]) the article explained. Alongside more general tourist fare, the MBTP also produced material specifically for sportsmen, including the booklet *Fishing and hunting in magnificent Manitoba!* (n.d.-a). It invited "fellow sportsmen" to experience adventure in the province, where "[t]he fish fight furiously." It advised sportsmen about how to travel with their family, in case the 'bride and bairns" planned to join them. Trips would be more difficult to arrange, but not impossible to manage. Further, "instead of being led by the hand by a guide whose boss has set up his camp on the best waters, now you have to prove you're a real fisherman." Sportsmen were assured that it was both possible and enjoyable to fish with their family. This was because the province was full of breath-taking beauty. The latter was poetically described in purple prose, stating "Forests and rocky shores touch the azure sky above and slope down to the rich blue of deep lakes or the foamy spray of cascading rivers." In this way, the book assured sportsmen that Manitoba would test their strength and vitality while also providing them with a beautiful view.

Modern and antimodern contradictions

Though the MBTP promoted Manitoba's natural spaces as a retreat from modernity, their advertisements reified many of the modern ideas and values that tourists purportedly sought to escape, reinforcing modern ideas about gender, domesticity, and rationality. The film *To Catch a Fish* featuring the husband and wife, Joe and Ella, on a fishing trip exemplifies how the MBTP's advertisements relied on modern ideas about gender and domesticity. "Ella likes fishing, but she doesn't have to face the boys at the office with her record" the film explained, showing both Ella and Joe casting a line. Shortly after this, Ella catches a walleye. "And really a beauty!" the film commented before sympathizing with her husband "Poor Joe! This is one set-back he hadn't imagined" (AM 1955b). The film equates Joe's essential manliness with his ability to fish, suggesting that his experience in nature is something that will be measured in the modern office. The humour of Joe's 'set-back' is also a subtle reminder that without these types of experiences, he is in danger of becoming effeminate. Similarly, the booklet *Fishing and hunting in magnificent Manitoba!* reinforced the idea that women were first and foremost concerned with housekeeping and children. If fishermen had to bring along their wives and children, there were "substantial compensations" to make up for the burden. "Have you ever eaten a mess of fresh caught perch for breakfast—the first fish Bobby ever caught and cooked as mother cooks it?" the booklet asked, continuing "[t]hese things the family can share, and it makes fishing better, not worse" (MBTP n.d.-a). In both examples, the MBTP's publications reinforced the modern domestic structure of the 1950s by imposing it onto life at the lake in Manitoba. Although the settings were markedly different when women entered natural spaces, with fishing boats replacing grocery stores and camping sites replacing kitchens, women were still expected to fulfill their modern familial and societal role as caregiver.

Manitoba's natural spaces offered tourists a way to escape the over-rationalization they associated with modern life on one hand, while supporting and reinforcing the value of rationality on the other hand. For example, Manitoba's purportedly antimodern spaces were ordered and experienced primarily through the emerging tourist economy. This was most evident in the prepackaged plans fishing lodges began offering to tourists in the early 1950s. For $100, a fisherman could experience a six-day trip on the Winnipeg River complete with food, guide service, accommodation, equipment, and boats. The wealthier fisherman could partake in a week trip through God's River Lodge for $400. The package included meals and lodging, round-trip transportation, two guides, and a freighter canoe with a motor. Throughout the 1950s, these packages, which planned and ordered tourists' experiences of nature, became increasingly popular. According to the MBTP, "the ardent angler who looks to virgin waters for his fighting fish jumps at the chance for a 'package holiday' that offers comfortable accommodation, transportation, guides, food, camp equipment, boats and all the trimmings of a backwoods vacation" (MBTP 1953). Although modern citizens attempted to leave behind the routines and rationality they associated with the city, it followed them into these purportedly natural spaces through the modern practices of structuring leisure time and hiring expert services.

In addition to reinforcing ideas about gender, domesticity, and rationality, Manitoba's antimodern spaces offered tourists no fundamental critique or alternative to modernity. Their tourist experiences were primarily a way for the modern citizen to temporarily 'escape' civilization and return as a more productive worker. As such, antimodern ideas very often actively supported modernity, claiming to rejuvenate the technocratic worker, allowing him to return to society as a more productive and efficient employee. Thus Manitoba`s experience echoes Lears and confirms others studies of antimodernism, which sought to understand why critics of modernization had continuously failed to challenge the phenomenon throughout the late-nineteenth and early-twentieth century. According to Lears, antimodernism shows that when "[p]reoccupied with authentic experience as a means of revitalizing a fragmented personal identity, dissenters have often been unable to sustain larger loyalties outside the self" (Lears 1981, xix). Likewise, in Manitoba, the antimodern tourist experiences offered no collective alternative to modernity's focus on individuality and rationality; visitors would find only a temporary fix in Manitoba's pristine forests and lakes, preparing them to go back to society as a more productive worker. Rather, they actively supported it, as antimodern experiences claimed to rejuvenate the modern worker, allowing him to return to society as a more productive efficient employee. In this way, although antimodernists rejected modernity's focus on individual achievement, their response was framed in individual rather than collective terms.

Conclusion

A look at the dawn of nature tourism in Manitoba confirms Lears' argument that modernity's greatest critics essentially failed to challenge it because they were "easily accommodated to the dominant culture of our bureaucratic corporate state" (Lears 1981, xix). Ultimately, this dichotomy at the heart of antimodern sentiments about wilderness led to remarkably unnatural ways of encountering nature. One illustrative example comes from the June 1953 issue of *Tourist Topics*, the MBTP's circular magazine for tourism entrepreneurs. Titled 'Clean-Up Clues for Campers,' it featured instructions for how best to deal with garbage produced at campsites. Whether in a campground or "on his own" in the backcountry, it recommended visitors be told to "properly dispose of all camp litter, garbage and waste so the ground will remain clean and sanitary." In order to keep their campsites pristine, campers were to use "three of nature's best purifiers: fire, boiling water, and burying." Small quantities of paper, animal bones, and food scraps could be burned in the campfire. However, to dispose of large quantities of waste, the article advised burying. In fact, the article advised visitors that the camp-making job was not complete until they dug a garbage pit 50 to 100 feet behind their tent. In order to dispose of cans, a combination of burning and burying was advised, while dish-

water was simply buried. In short, in order to maintain the appearance of pristine wilderness, the article encouraged tourists to bury all signs of modernity beneath their campsite (MBTP 1953). While this article was only a single page in length, it serves as an appropriate metaphor for the dichotomous relationship between modern ideas and antimodern spaces in the MBTP's publications. The article essentially recommends bringing the cans and plastics that are the material evidence of modernity into nature, but also burying them out of sight, so as to be out of mind in the pure and natural environment. However, underneath the surface in the article and in the antimodern spaces there were signs of modernity, whether tin cans and domestic gender roles, glass bottles and rationalized leisure time, or dishwater and economic growth. These modern materials and ideas accompanied tourists into nature, shaping how they interacted both with and in that space. In this way, the spaces did not exist outside of civilization as the bureau's publications suggest. Rather, as this article demonstrates, Manitoba's antimodern tourist spaces were constituted in the very making of modern Manitoba.

A study of the province shows that through their influence on MBTP publications, antimodern ideas paradoxically supported the expansion of modern society in the province. They did so by using the concept of 'nature' as a timeless, unchanging space to distribute new ideas of gender, domesticity, and rationality appearing in the 1950s. Further, antimodern ideas supported the growth of society by rejuvenating the individual worker and allowing him to return to society as a productive worker. Overall, the antimodern spaces presented in MBTP's publications were not outside of modernity, but rather were implicated in the very making of modern Manitoba.

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Prairie Perspectives: Geographical Essays
Prairie Division
Canadian Association of Geographers
Association Canadienne des Géographes

Field trip: Historic Minnedosa

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A synopsis of historic Minnedosa

In 1948, the Minnedosa Women's Institute published *A History of Minnedosa 1878–1948* (MWI 1948). It is from this document that the following synopsis is compiled.

Minnedosa, Manitoba was founded in late 1879 with the construction of H.G. Henderson's log house and store on the south side of John Tanner's crossing over the Little Saskatchewan River. Tanner's ferry crossing and ford was located at the junction of the middle branch of the Carlton Trail going west, the Audy or Riding Mountain trail to the north, and the Little Saskatchewan River. Today this site is found just east of Main Street at Centennial Park on Beach Road. Henderson partnered with an Irish salesman, Patrick (Paddy) Joseph McDermott, who arrived with a Red River cart full of goods in the fall of 1879. McDermott would become one of the most prominent and active businessmen and entrepreneurs in the Minnedosa area over the next 50 years.

Joseph Samuel Armitage came to Tanner's Crossing in 1877, registered a homestead and returned to Port Colborne, Ontario. The following summer, accompanied by his wife Mary Minetta, he returned to Tanner's Crossing and purchased two quarter sections of land from John Tanner. In 1880, Armitage opened a sawmill and grist mill and together with Tanner laid out the initial plans for the town (Figure 1). Armitage also suggested the settlement be named 'Minnedosa,' borrowing the Sioux word for 'swift flowing water.' By 1881, the Jermyn-McLellan survey created streets and lots west of present day Main Street as shown in Figure 1. Businesses soon followed such that six years after the Jermyn-McLellan survey, Minnedosa boasted a butcher, law office, sawmill, brickyard, two lime kilns, a grist mill, creamery, cheese factory, three grain elevators, four hotels, a tailor, hardware merchant, as well as a number of dry goods and grocery stores.

Commerce and industry were not the only aspects of early Minnedosa. In December of 1880, a Dominion Meteorological Survey site was established with the aim of collecting weather and climate information. Initially located two miles southeast of town, in 1884 the station was moved to its present site at Climate ID 5011760, 50.27o N, 99.83o W, 521.2 m ASL. Today, as a result of the station, a relatively continuous record of daily temperatures and precipitation amounts are available from Meteorological Service of Canada.

Minnedosa was officially incorporated on March 2, 1883. A month later the first council meeting of the new town was held in a local saloon named the Saskatchewan House. Later that year the town council passed a by-law granting the Manitoba and North-Western (M&NW) Company a $30,000 bonus to run their railway through the town. By the end of the year, the railroad from Gladstone (formerly Palestine) to Minnedosa was complete. Two years later the line was extended to Harrowby, Manitoba. Minnedosa became a divisional point and shops, yards and other facilities were constructed. The Consolidated Dominion Lands Act of 1879 further opened up surrounding land to settlement and rail transportation drastically reduced the cost and difficulty of overland movement across the prairies. As a result, Minnedosa doubled in size during the next 15 years

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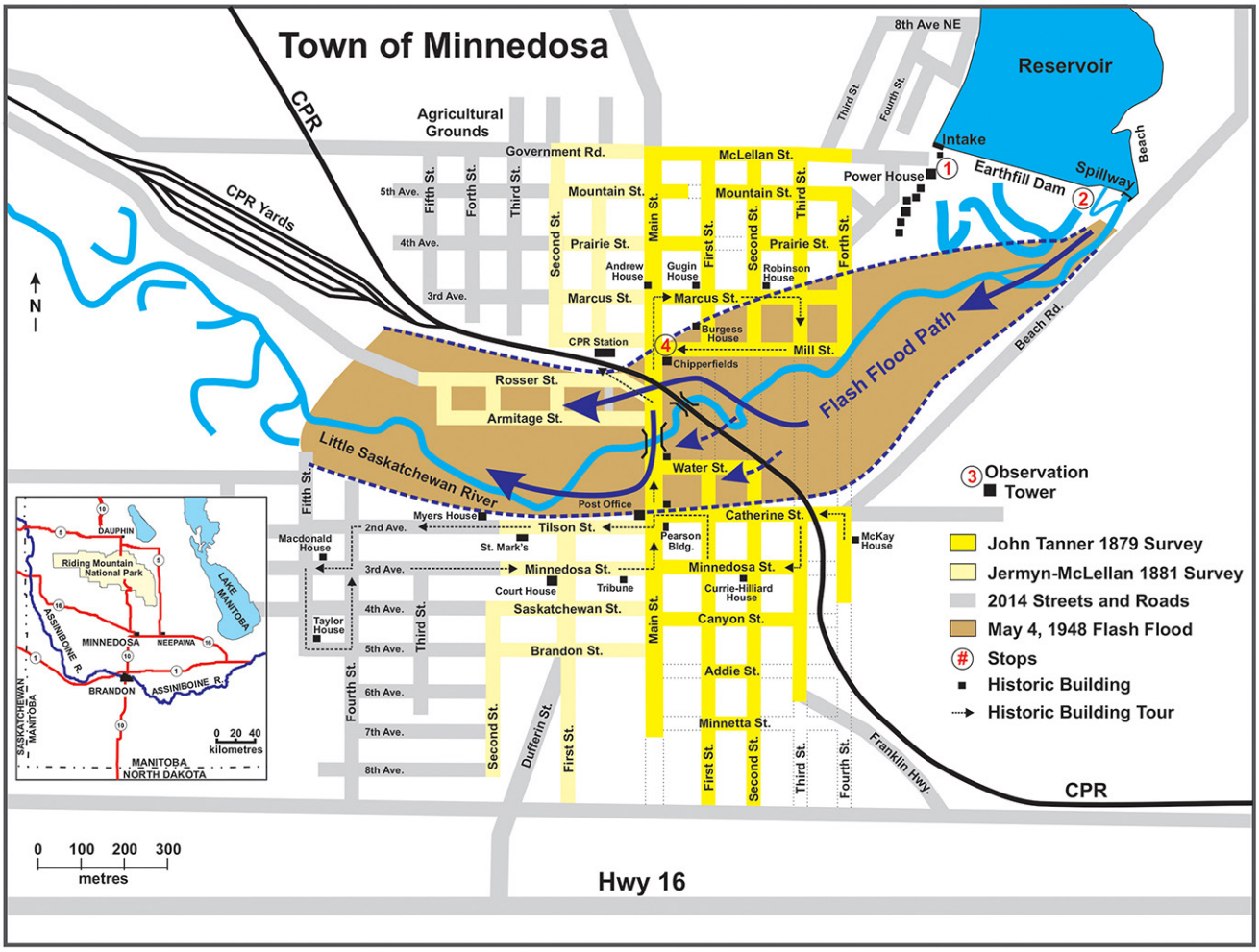


Figure 1
The town of Minnedosa

from approximately 500 people in 1886 to 1052 registered inhabitants in 1901.

In 1900, the Canadian Pacific Railway (CPR) signed a 99-year lease for the track, yard, and facilities of the M&NW Company. The historic CPR station, boasting a standardized architectural design, was constructed in 1910 and can be viewed today at its current locale on 2nd Avenue NW (Figure 1). With rail lines in place, the telegraph followed and by 1900, the Minnedosa Board of Works supervised the erection of telephone poles throughout the town. By June of that year there were 33 Bell Telephone Company (BTC) subscribers. Long distance service, connections to nearby towns and rural service were established in 1908. In 1909, Manitoba Telephone System (MTS) acquired the BTC.

Electricity brought changes to the urban geography of Minnedosa. In 1903, the town's four street lights, powered by a generator housed in a nearby sash and door factory, were turned on. Before long, Minnedosa's power needs grew beyond the ability of the small generators and in 1907 a group of local businessmen formed the Minnedosa Power Company (MPC) with the intention of building a hydroelectric power generation station on the Little Saskatchewan River. Construction of a dam, reservoir and two spillways began in 1910 and was completed in the spring of 1912. At 550 m long and ranging between 27.4–36.6 m wide, the earth-filled dam was designed to hold back water to a depth of 7.6 m. The massive amount of earth and shale fill was extracted from 'Devil's Pit,' a site the early settlers imagined was the site of an ancient Sioux battle with the Assiniboine. There were many construction delays including a partial dam collapse that required pile-driven reinforcing. The engineers prevailed and today the Minnedosa reservoir is 6.1 m deep, 940 m long, and stores 2,120,000 m^3 of water. Prior to flooding, the area was cleared of fence lines, bush and debris, and a large reservoir storage pit excavated in front of the gate house water intake segment of the dam, located on the western edge on the structure.

The gate house was constructed on top of a 4.9 m wide concrete segment on the west side of the dam. Two gated intake sluiceways controlled by stop-logs, metered water into 61 m long wooden flumes resting in concrete cradles. By 1912, only one flume was constructed. It transported water to the turbine wheel housed in the tailrace building. Here, a single turbine was

installed capable of generating approximately 336 kW of electrical energy. In 1920, the tailrace building was replaced by the present-day brick structure known by the inauspicious name of Manitoba Power Commission Power House No. 2. At that time, two diesel powered generators were installed to supplement the hydroelectric power generation. No. 2 was phased out of service in 1933.

The primary spillway was built into the east side of the dam. Three stop-log gated sluices controlled reservoir discharge, providing protection against dam over topping and dam catastrophic failure. The two-year construction of the entire generating infrastructure ended up costing the MPC $140,000, approximately four times the original estimate. Later, in 1921, the CPR constructed a water pipeline and two pumphouses to transport water from the Minnedosa reservoir to the company's water tower, station, roundhouse, and yards located in the town. Fire protection hydrants were installed along the route servicing the northeast quarter of town. The pipeline was closed in 1961 following construction of a controversial water supply and sewer system.

The field trip

This field trip was conducted in September 2014 as part of the annual meeting of the Prairie Division of the Canadian Association of Geographers. The historic Minnedosa tour begins at Stop 1, located on the east end of 6th Avenue NE on the west side of the Minnedosa dam at the entrance to the Minnedosa Heritage Village (Figure 1). The following list of stops and accompanying maps are intended to allow the reader to recreate and complete the field trip in approximately four hours. At each stop in the guide, sites of interest are discussed.

Stop 1: Minnedosa Heritage Village (Figure 2) 6th Avenue NE, Minnedosa, Manitoba
NTS 62J/5 Clanwilliam 14 U 440845.5 E, 5567371.0 N



Figure 2
Minnedosa Heritage Village. (Photo credit: R.A. McGinn, 2014)

This stop focused on nine historic buildings in Minnedosa and the local area. A two-hour tour and explanation of the buildings with historical anecdotes was given by local members of the Minnedosa District Heritage Foundation. The tour is available to the public on weekends from the Canada Day long weekend in July until the Labour Day long weekend in September. Additional photographs and further information for each of the buildings is available on the Discover Minnedosa website (MACDC 2016).

Manley House

Constructed in 1880 by Edmund Manley. In 2004, the Manley House was dismantled by the Minnedosa and District Museum Committee and reassembled two years later on a cement pad at the Minnedosa Heritage Village (MACDC 2016).

Hunterville Presbyterian Church

Opened in 1904 on an acre of land donated by Mrs. W. Hunter, it was moved to the Heritage Village in 1996. Service is held once each year and the Hunterville Church is available for weddings. Figure 2 shows the yellow church in the foreground and the Agricultural Display Building with the flag on the dome in the background.

Minnedosa Agricultural Display Building

Constructed in 1904 on the Minnedosa agricultural grounds as a display building, the Agricultural Display Building was moved to the Minnedosa Heritage Village and restored in 2007–2009 (Parks Canada 2016a).

Havelock School

Built in 1910 and opened in April 1911, the Havelock School and its contents represent an early nineteenth-century rural multi-grade one room school. Closed in 1966, the school was thereafter sold to the Minnedosa Museum and moved into the town where it sits adjacent to the Museum on 2nd Avenue NW. In 1997, the building was relocated to the Minnedosa Heritage Village.

Sprague House (Figure 3)

Also known as Cadurcis House, the original part of the two-storey wood-frame farmhouse was built in 1910. In 1999, the Sprague House was relocated to the Minnedosa Heritage Village, furnished with period pieces, and completely restored (Parks Canada 2016b).

Manitoba Power Commission Power House No. 2

Constructed in 1920, Power House No. 2 replaced the original wooden tailrace building. Two diesel generators supplemented the hydroelectric power capacity. The building was decommis-



Figure 3
Sprague (Cadurcis) Farmhouse. (Photo credit: R.A. McGinn, 2014)

sioned in 1930 when a 33,000-volt transmission line linked Minnedosa with Brandon. The town assumed ownership of the building in 1980 and it was designated a Municipal Heritage Building in 1993, eventually becoming the Minnedosa and District Museum in 1995.

Canadian Pacific Railway pumphouse

The CPR built two pumphouses and a waterline in 1921 to supply reservoir water to the roundhouse and water tower. Hydrants were also installed along the line and provided fire protection for northeast Minnedosa. In 1953, the town purchased the pumphouses and waterline to supply their water treatment plant but in 1961 they switched to well water and the pumphouses were no longer needed (Manitoba Historical Society 2009).

Hopkins Barn

Built in 1930 by Ben Hopkins, the two-storey barn is constructed of poplar logs. In 2003, the barn was moved to the Minnedosa Heritage Village and placed on a cement foundation. It is currently used for storage but eventually will be renovated to house livestock stalls and pens.

Blacksmith Shop

This building was constructed in 1935 as a temporary replacement for the Crocus Hill School, which had burnt down the year before. It was sold to Roy Munroe in 1936 and skidded by horse team to the Munroe farm where it was converted to a blacksmith shop. The fully equipped shop was donated to the Minnedosa Agricultural Society in 1989, and in 1997 was relocated to the Minnedosa Heritage Village. It is fully operational for special events.

From the Minnedosa Heritage Village, proceed across the 940 m long earth-filled dam to the east spillway structure to reach Stop 2.



Figure 4
Minnedosa dam and fishway. (Photo credit: R.A. McGinn, 2014)

Stop 2: Minnedosa reservoir, dam, and spillway (Figure 4)
Beach Road, Minnedosa, Manitoba
NTS 62J/5 Clanwilliam 14 U 441355.0E, 5567243.9N

The initial project was designed to provide hydroelectric power to the town of Minnedosa. Completed April 10, 1912, the 550 m long dam maintains a reservoir holding 2,120,000 m^3 of water (Mummery 1998). Modifications include an overflow spillway completed in 1950 and a fishway installed in 1999 to allow pike game fish to migrate into upper reaches of Little Saskatchewan River system. The 192 m fish ladder consists of 22 pool riffle structures and is the longest in Manitoba, with a vertical rise of 5.5 m KGS Group 2016). Walleye pike, northern pike, white sucker, and redhorse sucker are common fish seen here in the spring.

The 1948 dam failure and flash flood

A design flaw in the slope of the 1910 spillway apron resulted in significant backwash erosion over the years, undercutting it such that in the late winter of 1948 one could 'walk right under the spillway' (Mummery 1998) That spring, a large crack appeared between the concrete spillway apron and the western wing wall followed by a smaller crack in the eastern wall. Without the sup-

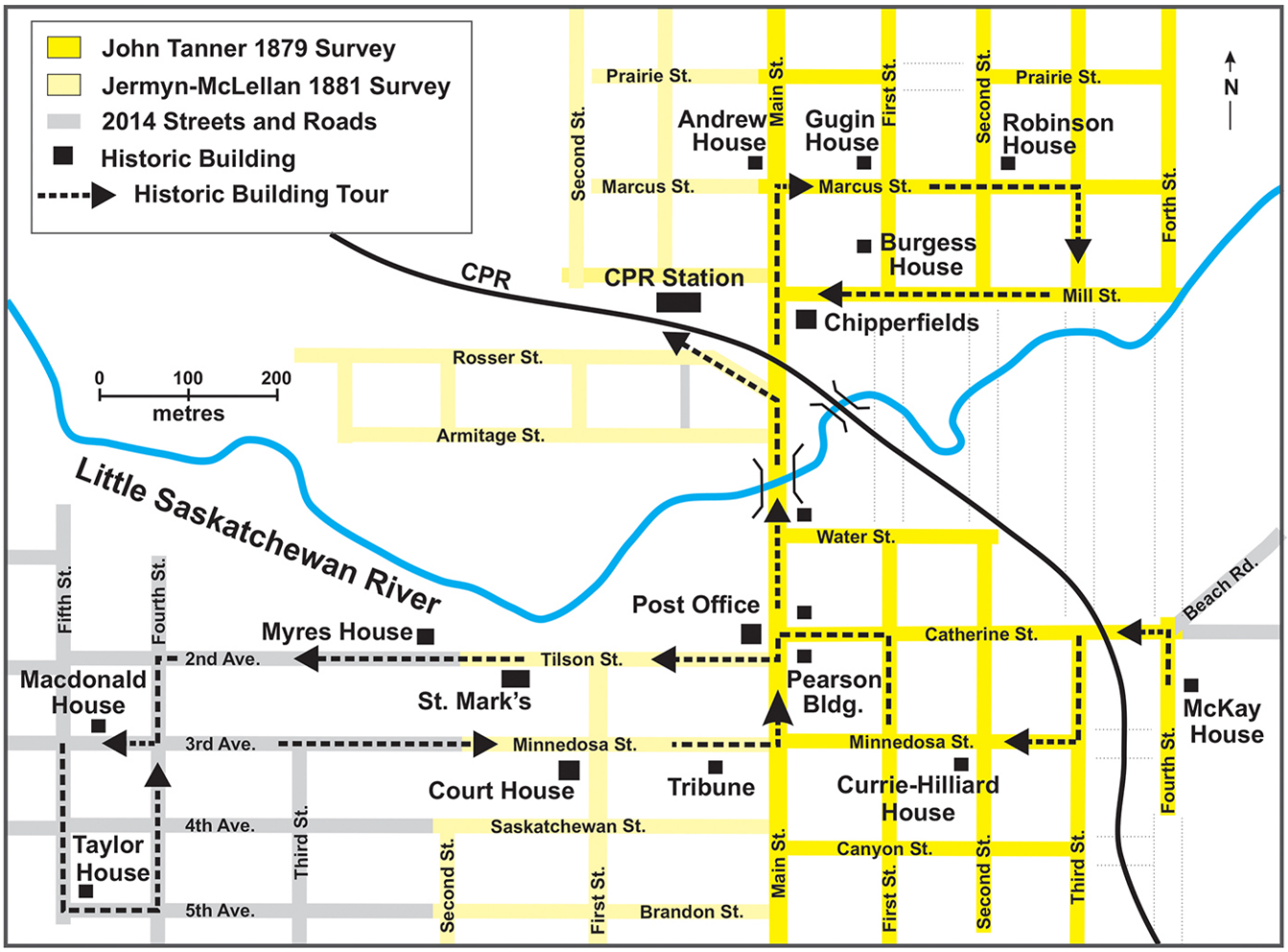


Figure 5
Historic buildings in Minnedosa

port of the concrete, the structure was in danger of imminent failure. Within an hour of discovering the cracks, volunteer workmen were on the site. For three days, approximately 800 men worked in the cold and rain to shore up the spillway structure by supporting the wing walls. Thousands of field stones, some transported from great distances were placed in the spillway along the wing walls. The work was to no avail and the spillway collapsed with a 'woosh' at 7 PM on May 4, 1948 followed by a flash flood that descended upon the town. Fortunately, a warning system of a prolonged steam whistle blast had been put in place to alert the town citizens of the dam failure (Mummery 1998).

The reservoir emptied in three hours, cascading thousands of cubic metres of water down the valley and across the town. Between 1 and 1.5 m of muddy water surged into unprotected basements and first floors causing substantial damage to businesses located along Main Street from the CPR Bridge to the Post Office, and approximately 240 m of CPR roadbed were washed out. Fortunately, thanks to the emergency warning system no one died and there were no injuries. Surface floodwaters had drained away by morning. The catastrophic event had lasted only five hours (Mummery 1998).

Stop 3: Minnedosa lookout platform 2nd Avenue SE, Minnedosa, Manitoba
NTS 62J/5 Clanwilliam 14 U 440894.5E, 5566502.4N

Looking north from the platform are the Minnedosa dam, reservoir, overflow spillway, and the historic buildings of the Minnedosa Heritage Village. Turning northwest, the observer can see the valley of the Little Saskatchewan River, Tanner's Crossing, and a bison enclosure. Further to the west is the town of Minnedosa where one can see the CPR railway rising up the north side of the valley towards Odanah Pass. From here a view down 2nd Avenue SE reveals the historic Dominion Post Office and the iconic clock tower.

Proceeding from Stop 3, the field trip route passes 15 historic buildings in the town (Figure 5).

McKay House (Figure 6)
Located at 120 4th Street SE, McKay House was built in 1892 by stonemason James McKay for his family. This L-shaped variation of the southern Ontario Gothic Revival design is enhanced with gingerbread bargeboard trim beneath the gables. An inset



Figure 6
The Gothic Revival style McKay House. (Photo credit: R.A. McGinn, 2014)



Figure 7
The Second Empire style Currie-Hilliard House. (Photo credit: R.A. McGinn, 2014)

front porch is placed in the crook of the L-shaped footprint. Also known as Wind Manor, the house was designated as a municipal heritage site in 1995 (MRHC 2006).

Currie-Hilliard House (Figure 7)

Located at 66 Minnedosa Street (today 3rd Avenue SW), its Second Empire architectural style is more commonly used for government buildings and schools but occasionally for house design. Built in 1900, of special interest are the mansard roof, elaborate dormer windows, and projecting bay windows. Charles Henry Currie is listed as the initial owner of the property, which was sold in 1904 to Herbert William Hilliard, a veteran of the Riel Rebellion (MRCH 2006).



Figure 8
Minnedosa Dominion Post Office. (Photo credit: R.A. McGinn, 2014)

Minnedosa Dominion Post Office (Figure 8)

Located at 103 Main Street S, this building is an example of a multi-purpose federal building commonly constructed in medium size towns prior to the First World War. The red brick building with a prominent five-storey corner clock tower was designed by the chief architect of the Department of Public Works, David Ewart and built by the Brown Construction Company of Winnipeg in 1913–1914. The Romanesque Revival architectural style tower presents a clock face on all sides. In addition to a post office, the building also housed offices of Customs, Inland Revenue and, more recently, the Royal Canadian Mounted Police. Its federal functions ended in 1970 and, in 1987, the building was designated a municipal heritage site (Parks Canada 2016c). Today it is used as a civic centre.

St. Mark's Anglican Church (Figure 9)

Located at 108 Tilson Street (today 2nd Avenue SW), this 1903 fieldstone structure replaced the 1885 wood-frame building. The Gothic Revival architectural style and a 'transept' (cross-shaped) footprint are characteristic of Protestant churches in the early 1900s. Anecdotal stories recall that the church rector re-



Figure 9
The Gothic Revival style St. Mark's Anglican church. (Photo credit: R.A. McGinn, 2014)



Figure 10
The Queen Anne Revival style Myers House. (Photo credit: R.A. McGinn, 2014)

cruited local farmers to haul fieldstone to the church building site. One of the unique features of the church's striking stone masonry is the use of pink mortar which compliments the red trim around the single, paired, and trios of multi-paned windows (MRHC 2006).

Myers House (Figure 10)

Located at 149 Tilson Street (today 2nd Avenue SW), built in 1901, and designated a municipal heritage site in 1986, this Queen Anne Revival style house was built for Judge Robert Hill Myers in 1901. Also known as The Castle or Tilson Place, key design elements of architectural interest are the rusticated stone foundation, the two three-storied towers, the verandah, and the variety of fenestration. The polygonal form of the tower on the southwest corner has a corresponding roof, whereas the rounded east tower is capped with a conical roof. On the southeast corner an angled verandah together with half-Tuscan columns support



Figure 11
Minnedosa Court House. (Photo credit: R.A. McGinn, 2014)

a second-storey balcony. Today, Tilson Place provides bed and breakfast accommodation (MRHC 2006; Manitoba 2016).

Taylor House

Located at 353 5th Avenue SW, this classic southern Ontario Gothic Revival-style farmhouse was built in 1894 by stonemason Thomas Dawson Taylor. The architectural style is characterized by the central tall pointed gable. An addition has modified the rectangular footprint and the large front verandah has been removed. Other prominent fieldstone buildings designed and built by Taylor, who was mayor of Minnedosa in 1909, include the commercial Pearson Building and Burges Building, both located on Main Street (MRHC 2006).

Minnedosa Court House (Figure 11)

Located at 70 Minnedosa Street (today 3rd Avenue SW), Gordon Goldsborough of the Manitoba Historical Society explains, 'In 1908, the Town of Minnedosa became the headquarters of the North-West Judicial District and over the next two years, an impressive two story brick and stone building was erected at the corner of First Street and Third Avenue. Designed by Provincial Architect Samuel Hooper and constructed by Charles Jeffrey of Portage la Prairie, it housed a jail, courtrooms and clerk's office (Goldsborough 2016).

Minnedosa Tribune

Located at 14 Minnedosa Street (today 3rd Avenue SW) and constructed over 1909–1910 to house the local paper. The story of the press is that newspaperman William Gibbens and typesetter David Cannon came to southwestern Manitoba in 1881. In 1883, Gibbens founded the Minnedosa Tribune. At first, the printing office operated out of a log structure. However, Cannon soon purchased the paper and in 1884 constructed a two-storey wood frame building to house the publishing operation.



Figure 12
The Gothic Revival/Italianate style Pearson Building. (Photo credit: R.A. McGinn, 2014)



Figure 13
Canadian Pacific Railway Station. (Photo credit: R.A. McGinn, 2014)

Adam Crossley succeeded Cannon and published the paper in 1919. In 1930, it was sold to Robert Sanderson who replaced the storefront with the present façade. Sanderson was followed by a series of publishers: Earle Gordon, Ruth Spencer, Robert Mummery, Jennifer Muth, and Darryl Holyk. Through its 131-year history the Minnedosa Tribune has undergone many physical and technical changes while continuing to print local content (Minnedosa Tribune 2016).

Pearson Building (Figure 12)

Located at 110 Main Street S and also known as the Setter or Bruce Building, this structure was constructed by local stonemason Thomas Dawson Taylor in the late 1870s. The Pearson Building combines the Gothic Revival architectural style of steeped gables and the Italianate-style paired rounded windows and an intricate wooden cornice, both fashionable in the late-nineteenth century. Over 140 years the building has housed several stores, offices, and meeting rooms and in 1910 was home to a movie theatre. Local legend states that Sir John A. Macdonald once spoke in the second floor meeting room (MRHC 2006).

Canadian Pacific Railway Station (Figure 13)

Located on Railway Avenue (today 2nd Avenue NW), this building was constructed in 1910 and designated as a municipal heritage site in 2001. The rectangular red brick structure exhibits the conventional station layout with a central ticket, freight, and telegraph office flanked by storage on one side and a passenger waiting room and office space for traffic supervisors and shop managers on the other side. Characterized by a gabled central hexagonal dormer, hip dormers, and tall rectangular windows set in pairs and trios with limestone trim, the station is the only surviving example in western Canada of the CPR standardized architectural design Special Plan H-1-20-6 (Parks Canada 2016d).

Andrew House (Figure 14)

Located at 125 Main Street N, this house, employing an American Four Square or Prairie Box-style architectural style, is characterized by its box footprint and pyramidal roof. Normally 'Prairie Box' houses are constructed of wood or brick, rarely fieldstone. Built around 1898, the house was sold to Dr. J. N. Andrew shortly after construction. 'Doc Andrew' served the community of Minnedosa and region from 1895 to 1953 (MRHC 2006).

Gugin House (Figure 15)

Found at 27 Marcus Street (today 3rd Avenue NE), this house was probably constructed by stonemason Robert Gugin circa 1892. It exhibits similarly sized and coloured fieldstones, while the tall peaked centrally positioned gable and a broad-front verandah are characteristic of the southern Ontario Gothic Revival architectural style (MRHC 2006).

Robinson House

Located at 101 Marcus Street (today 3rd Avenue NE), this L-shaped variation of the southern Ontario Gothic Revival was built in 1895 or 1896. It is uncertain as to whether the builder was Jackson Whiteside Brown or Frank Mashen. The architectural style has the characteristic Gothic gable and an inset porch similar to the McKay House (MRHC 2006).

Burgess House

Located at 77 First Street NE and built for Joseph and Edith Burgess in the southern Ontario Gothic Revival style, the house exhibits the classic rectangular footprint with a central pointed gable, pinnacles, and roofline bargeboards. A relatively small but elegant porch highlights the entrance. Joseph Burgess found-



Figure 14
The Four Square style Andrew House. (Photo credit: R.A. McGinn, 2014)



Figure 15
The Gothic Revival style Gugin House. (Photo credit: R.A. McGinn, 2014)

ed a store in 1896 that continues to serve Minnedosans in its original location on Main Street His son, Jack was mayor of Minnedosa during the devastating flash flood on May 4, 1948 (MRHC 2006).

Stop 4: Chipperfield Coffee Company (Figure 16) 50 Main Street N, Minnedosa, Manitoba
NTS 62J/5 Clanwilliam 14 U 440214.57E, 5566832.66N

In 1948, following service in the Second World War, James and Eric Chipperfield moved to Minnedosa where they established the Chipperfield Brothers general store. In 1969, Jim and his wife Irene Chipperfield (nee Gugin) renamed the family business the Chipperfield Clothing Centre. The store was purchased in 2004 by the Mackling family and the Chipperfield Coffee Company was established. Many cups of coffee, hot chocolate, and an occasional 'chipperdoodle' cookie have warmed the authors' glacial geomorphological students early on Thursday mornings.



Figure 16
Chipperfields Coffee Company. (Photo credit: R.A. McGinn, 2014)

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Prairie Perspectives: Geographical Essays
Prairie Division
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Field trip: Ice-shoved hills and related glaciotectonic features in the Glacial Lake Proven Basin

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Introduction

Constructional glaciotectonic landforms include a variety of hills, ridges and plains composed wholly or partly of soft bedrock or drift masses deformed or dislocated by glacier-ice movement (Aber 1985). Aber (1989) classified constructional glaciotectonic landforms into five types, comprising hill-hole pairs, large composite ridges, small composite ridges, cupola-hills, and flat lying mega blocks. These classes represent the ideal generic types within a continuum of glaciotectonic landforms. Intermediate, transitional, and mixed features also can be described.

Benn and Evans (2010) employ Aber's 1989 classification in their textbook and include descriptive examples of each constructional glaciotectonic landform. The hill-hole pair is described as a discrete hill of ice thrust material situated a short distance down-glacier from a depression of similar size and shape. Aber et al. (1993) illustrate an example of multiple hill-hole pairs from the Devils Lake area in North Dakota. Composite ridges are composed of multiple slices of upthrust and contorted bedrock and/or unconsolidated sediments which are often interlayered and overlain with glacigenic material (Benn and Evans 2010). Aber (1989) subdivides these constructional glaciotectonic landforms into small composite ridges (<100 m relative relief) and large composite ridges (>100 m relative relief and arcuate in form). Large composite thrust ridges in North Dakota are described by (Moran et al. 1980). The Brandon Hills in southwestern Manitoba are an example of a small composite linear ridge (Welsted and Young 1980; Aber 1989). Cupola-hills are glaciotectonic hills lacking a hill-hole relationship and or transverse ridge morphology (Bluemle and Clayton 1984). They have a dome-like morphology, circular to oval to elongated oval shape, and are composed of deformed floes of Quaternary sediments or older bedrock overlain by a thin carapace of till (Benn and Evans 2010). Finally, megablocks or rafts are dislocated slabs of rock and unconsolidated material transported from their original position by glacial action (Benn and Evans 2010). The Qu'appelle Valley megablock located near Esterhazy Saskatchewan is a local example and demonstrates the susceptibility of the Cretaceous Pierre Shale Formation to glaciotectonism (Christianson 1971).

Two, perhaps three, of these types of constructional glaciotectonic landforms have been found in the Glacial Lake Proven Basin, Riding Mountain Uplands, Manitoba. Other concealed structures including bedrock folds, faults and contortions have been recognized in Cretaceous exposures along the Manitoba Escarpment (McGinn 2000).

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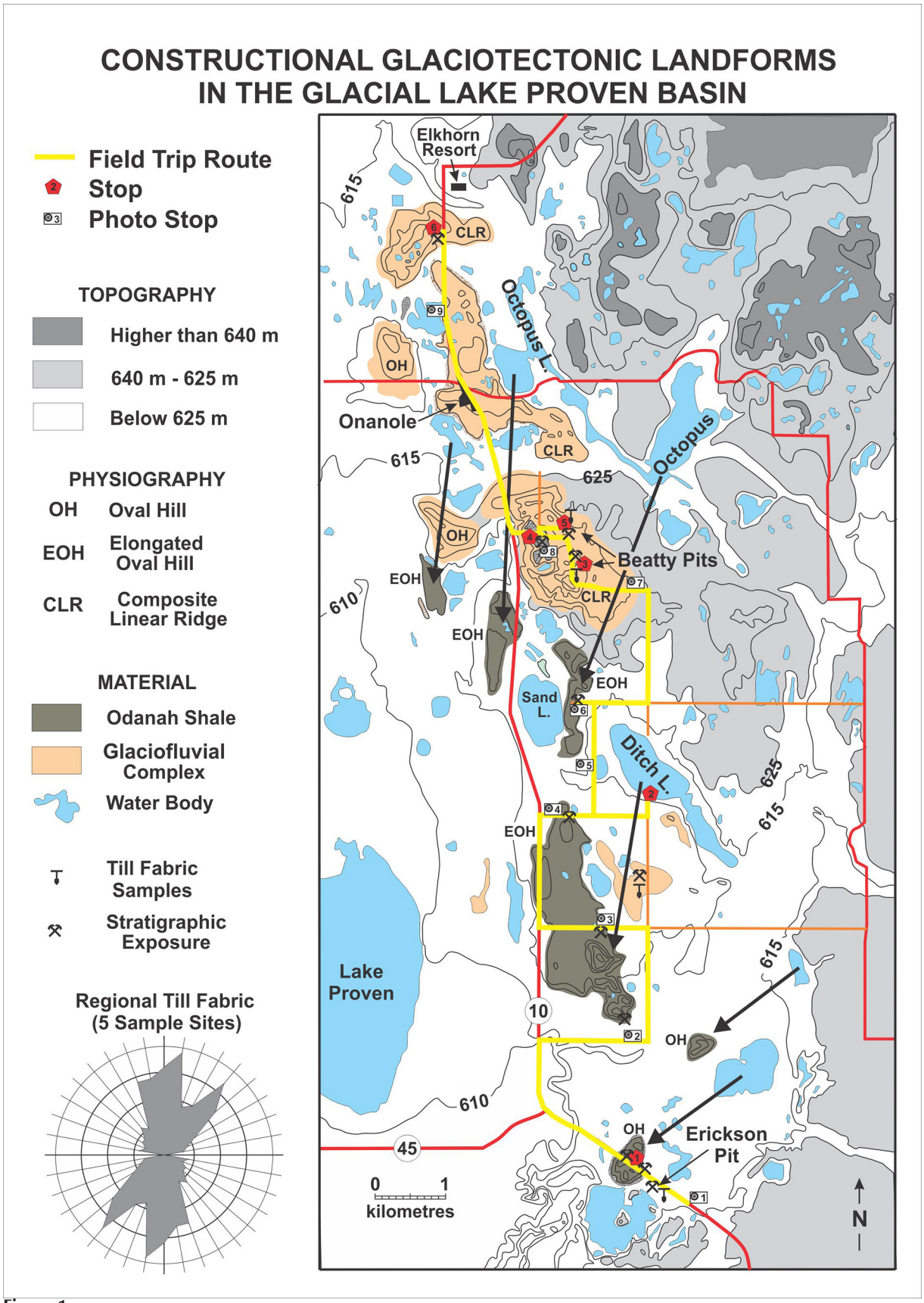


Figure 1
Constructional glaciotectonic landforms in the Glacial Lake Proven Basin

Field trip excursion and description of stops

The following field trip was part of the 2014 Annual Meeting of the Prairie Division of the Canadian Association of Geographers held in Wasagaming, Manitoba. The field trip was designed to provide examples of ice-shoved hills and related glaciotectonic features and consisted of driving excursions traversing the glaciogenic landscape, accompanied by brief photo stops for photography and presentation stops where there was a short descriptive presentation and discussion. The field trip begins on Provincial Highway 10 just north of Erickson, Manitoba. The route, photo stops and presentation stops are indicated on Figure 1.

Photo stop 1: A cupola-hill
Provincial Highway 10, 2.7 km northwest of Erickson, Manitoba; NTS 62J/12 Wasagaming; 14 U 434111.00 E, 5596472.00 N; Approximate elevation 620 m ASL

Cupola-hills have a dome-like morphology, circular to oval shape and are composed of deformed Quaternary sediments or bedrock overlain by a thin veneer of till (Benn and Evans 2010). Provincial Highway 10 bisects the feature.



Figure 2
Cupola-hill. (Photo credit: R.A. McGinn, 2014)

Presentation stop 1: Road cut into an oval-shaped ice-shoved hill on Provincial Highway 10
Provincial Highway 10, 2.8 km northwest of Erickson, Manitoba; NTS 62J/12 Wasagaming; 14 U 433745.55 E, 5596777.27 N; Approximate elevation 632 m ASL

The ice-shoved hill is oval in form, approximately 0.75 km in diameter and 10–15 m high. The cupola-hill and a second similar hill located 1.5 km towards the northeast of this site appear to be associated with small depression lakes located approximately 2.0 km upstream of ice flow directions (40°–50° azimuth). Consequently they may be speculatively classified as hill-hole pairs although Glacial Lake Proven deposits certainly have modified the bedrock extracted depressions.

These cupola-hills/hill-hole pairs are composed of the Odanah Shale member of the Pierre Formation. Odanah Shale is described as hard olive-grey siliceous shale with soft interbeds of darker olive-grey shale (McNeil et al. 1981). The shales are composed of clay sized siliceous particles which show no sign of biogenic origin. The mineralogy is described as amorphous silica and illite with traces of quartz and organic carbon (Bannatyne 1970). Odanah Shale is jointed. Joints stain reddish to purplish-brown and ironstone concretions are common. Roadcut exposures in the small oval hill just north of Erickson (Figure 2) indicate that while the strike is generally as expected, the dip appears to be disrupted and plunges opposite the acknowledged western trend.

Approximately 0.5 m of Zelena Till overlies the shale core. The Zelena Formation, on average, is 0.5 m–5.0 m thick in the region and represents the uppermost tills and intertill sediments on the Riding Mountain Uplands (Klassen 1979). The Zelena Formation was deposited during the final stages of glacial stagnation during the Late Wisconsinan. Oxidized Zelena Till is usually yellowish-brown or very dark grey-brown in colour. Fresh (unoxidized) exposures are dark olive-grey or very dark grey. The till is shale rich but since Pierre Shale clasts tend to disintegrate when removed from the matrix, it is difficult to determine a percentage composition. Carbonates constitute approximately 26%–36% of the clasts (Klassen 1979).

Stratigraphic exposures in the Erickson pit (see Figure 1) located adjacent to the southernmost hill-hole pair reveal two tills overlying deformed sands and gravel. The upper diamict, described as a supraglacial meltout complex, overlies a slightly more compact supraglacial ablation till. The meltout complex is usually a typical diamict, massive in appearance but with occasional concentrations of relatively coarse or fine material forming vague lenses. The ablation till is massive and slightly more compact. The prominent clasts are typically Interlake carbonates as the local Odanah Shale clasts quickly achieve terminal grade during transport. Larger shale clasts are evident but difficult to remove without fracture. The underlying fluvial facies (proglacial outwash) contains shearing flexures and small thrust faults; features supporting a glaciotectonic modification hypothesis. Pebble clast fabric analysis from the till exposures towards the north support the hill-hole hypothesis illustrated in Figure 1.

The Glacial Lake Proven Plain, large ice-shoved ridge and Odanah Shale exposures

In the Ditch Lake area (Figure 1), Wisconsinan glacial ice moving from the north-northeast to the south-southwest over the Riding Mountains Uplands excavated a large body of shale bedrock. The block of shale froze to the base of the glacier and was transported 2.5 km south-southwest where it was deposited as an elongated oval-shaped ridge. The large elongated oval ridge



Figure 3
Microwave Tower Hill. (Photo credit: R.A. McGinn, 2014)



Figure 4
Glacial Lake Proven lacustrine sands over Odanah Shale. (Photo credit: R.A. McGinn, 2014)

is situated north of Erickson, east of Provincial Highway 10 and approximately half way between the southern ice-shoved oval hills and the more northern elongated oval hills (Figure 1). This ice-shoved elongated oval ridge (EOH) is 3.5 km long and 1.0 km wide. The feature is approximately 15 m in relative relief except for a prominent dome-shaped hill located near the southern end, which stands 45 m above the Glacial Lake Proven plain shown in Figure 3. On the Glacial Lake Proven plain, meltwaters from stagnating glacial ice flooded into the region depositing lacustrine sands and silt in low lying areas surrounding the constructional glaciotectonic hills. Klassen (1966) named the associated lake, Glacial Lake Proven. Detailed mapping (Klassen 1966, 1979; McGinn 1991, 1997, 2002; Zaniewski et al. 2007, 2009) has determined that Glacial Lake Proven deposits occur at elevations below 625 m.

Photo stop 2: Microwave Tower Hill
1.4 km east of Provincial Highway 10 and 1.65 km northeast of the intersection of Provincial Highways 45 and 10; NTS 62J/12 Wasagaming; 14 U 433791.50 E, 5598552.70 N; Approximate elevation 614 m ASL

Microwave Tower Hill is 3.5 km long and 1.0 km wide. The feature is approximately 15 m in relative relief except for a this prominent dome shaped hill located at the southern end, which stands 45 m above the Glacial Lake Proven plain.

Photo stop 3: Odanah Shale exposure
Roadcut, 1.0 km east of Provincial Highway 10, approximately 6.0 km north-northwest of Erickson, Manitoba; NTS 62J/12 Wasagaming; 14 U 433460.56 E, 5600200.90 N; Approximate elevation 628 m ASL

The ice-shoved ridge is composed of displaced Odanah Shale overlain by a thin veneer of Zelena Till. Light coloured carbonates, derived from the Interlake Region, constitute approximately 26%–36% of the clasts. Large glacial erratics (field stones) are found along fence lines.

Photo stop 4: Odanah Shale exposure
Roadcut, 0.4 km east of Provincial Highway 10 on the Ditch Lake Road, approximately 6.6 km south-southeast of Onanole, Manitoba; NTS 62J/12 Wasagaming; 14 U 432865.25 E, 5601872.70 N; Approximate elevation 639 m ASL

In some locales, Glacial Lake Proven fine sands overlie the glacially disturbed Odanah Shale. In this location, lacustrine fine sand shave settled into wider surface fractures in the glaciotectonically disturbed Odanah Shale (Figure 4).

Presentation stop 2: Ditch Lake view point
9.2 km east of Provincial Highway 10 on the Ditch Lake Road, approximately 6.9 km southeast of Onanole, Manitoba; NTS 62J/12 Wasagaming; 14 U 434520.57 E, 5602218 N; Approximate elevation 615 m ASL

Ditch Lake covers an area of 941,000 m^2 and has a maximum depth of approximately 11 m. It is estimated that Ditch Lake holds approximately 3,711 dam^3 of stored water. The mean depth, calculated as total volume/surface area, is 3.94 m. Ditch Lake is very elongated in shape having a northwest to southeast orientation. The water body is approximately 2,780 m in length along a mid-lake line. The maximum width normal to this mid-lake line is approximately 631 m. The local name is not related to the ditch-like form of the lake but named after a late 1870s settler in the area, W.H Ditch. On topographic maps the lake is



Figure 5
Ditch Lake, 178 resident/cottage lots. (Photo credit: T. Sallows)

referred to as Gertrude Lake. Ditch Lake is the up glacier basin associated with Microwave Tower Hill (McGinn 2000).

Ditch Lake hydrology and limnology[1]

Snowmelt and summer rainfall runoff are the primary surface water inputs into Ditch Lake. Groundwater is also a significant contributor to the storage volume. Summer evapotranspiration and outflow discharge through a shallow outlet channel represent the primary water losses. Annual outflow is approximately 458 dam^3 and the flushing period is estimated to be 8.1 years. Consequently, nutrient and sediment build-up in the lake is expected.

Ditch Lake fisheries included northern pike (*Esox lucius*), white sucker (*Catostomus commersoni*), yellow perch (*Percea flavescens*) a variety of smaller fish species and is annually stocked with young walleye pike (*Sander vitreus*) (Bruderlin 2011). It is also a significant recreation setting. The Ditch Lake Cottage Association includes 178 resident/cottage lots (Figure 5). Seventy-four of the cottages are located in the Ditch Lake community while there are 104 residents/cottages fronting on the 3630 m long north basin shore. Of these, approximately 20–25 are permanent residents. All new residences/cottages require a septic tank ("pump-out") for wastewater treatment and disposal. However, not all of the 178 units employ pump-outs; some have septic fields and a few older units drain grey water into the lake (Hall 2011). All resident and cottage units have a well to obtain potable water. Most shore frontage units have a seasonal dock and a variety of watercraft including pontoon boats, power boats, personal watercraft, punts and canoes. There are three public boat launches and a community swimming beach.

In 1985, A.E. Beck authored a Water Standards and Studies Report which focused on 12 recreational "pothole" lakes in the South Riding Mountain Planning District. Ditch Lake was one of the 12 lakes studied. The primary objective of the study was to develop recommendations regarding cottage carrying capacity with respect to environmental quality, public safety and aesthetic considerations. A rigorous water sampling program was implemented to assess the trophic status, phosphorus budget and cottage carrying and boating capacity of each lake. Beck found that Ditch Lake was eutrophic. The water was considered suitable for recreational purposes, except during major algae blooms. Excessive phosphorus loading due at least in part to over development was responsible for the deterioration in water quality. He estimated that the development capacity had been exceeded by about 500%. Not surprisingly, the boating capacity also had been exceeded, exacerbating the water quality problems and increasing the risk of physical injury to individuals due to boating accidents. He also recommended that further development of Ditch Lake not be permitted, and that restrictions be applied to the number of powerboats allowed on the lake. The study also recommended that local residents install wastewater holding tanks and plant tree and shrub buffer zones to improve the water quality of the lake (Beck 1985).

Twenty six years later, the limnology and water chemistry of Ditch Lake were monitored from spring thaw to freeze-up (Hamilton et al. 2011). Limnological measurements included: temperature, pH, conductivity, specific conductance, total dissolved solids concentration (TDS), salinity and dissolved oxygen concentration (DO). Total ammonia nitrogen, nitrate nitrogen, nitrite nitrogen and reactive phosphate phosphorus concentrations were chemically determined. Today Ditch Lake is more alkaline than in 1985. The mean seasonal pH is 4.2% greater than Beck's July–August mean. Lake water conductivity has increased by approximately 13%. However mean seasonal dissolved oxygen concentration has not changed significantly since 1985.

The total ammonia nitrogen concentration in Ditch Lake is 54% greater than Beck's 1985 July–August mean and seasonal nitrate nitrogen concentration is 51% greater than Beck's 1985 values for Ditch Lake. The measured mean seasonal reactive phosphate phosphorus concentration of 0.193 mg L^{-1} represents a 98% increase the estimated derived by Beck, 1985 and is eight times the Manitoba Conservation guideline of 0.025 mg L^{-1}.

Beck's 1985 Trophic State Index (TSI) for Ditch Lake indicated a moderately eutrophic water body; very productive and subject to frequent summertime algal blooms. Water quality was considered suitable for recreational purposes except during toxic cyanophyte algal blooms. The 2011 calculated TSI falls in the hypereutrophic range suggesting a significant deterioration in water quality. The lake is subject to annual blue-green algal blooms, excessive macrophyte growth and both summer and winter fish kills. Nuisance macrophytes, algal scum, high turbidity and low light transparency can discourage aquatic activities. Severe taste and odour may occur at times and during these times water contact is not recommended.

The Sand Lake ice-shoved hill to the Beatty pits in a small composite linear ridge

Photo stop 5: The Sand Lake ice-shoved hill
1.1 km northeast of the intersection of Provincial Highway 10 and the Ditch Lake Road, approximately 5.8 km south-south-



Figure 6
Sand Lake ice-shoved hill. (Photo credit: R.A. McGinn, 2014)

east of Onanole, Manitoba; NTS 62J/12 Wasagaming; 14 U 433199.80 E, 5602692.32 N; Approximate elevation 618m ASL

This elongated ice-shoved hill is approximately 2.0 km long, 300 m wide and lies 15 m above the Glacial Lake Proven lacustrine plain (Figure 6).

Photo stop 6: Weathered Odanah Shale exposure
1.0 km east of Provincial Highway 10 on the Sand Lake cottages access road; NTS 62J/12 Wasagaming; 14 U 433085.71 E, 5603499.95 N; Approximate elevation 630 m ASL

Dried out and weathered Odanah Shale is usually light olive-grey in colour, non-calcareous, sub fissile, siliceous and hard (McNeil et al. 1981). Light-brown to dark-yellowish-orange patches are common on some weathered fracture surfaces. Odanah Shales have high moisture absorption rates (approximately 20%) and air dry shrinkage rates of 4–8% (Bannatyne 1970). Consequently, theses shales are susceptible to hydration weathering, rapidly breaking down into small blade like shapes over two to three wet/dry cycles. Mean ASCE (Corey) Shape Factor ($c/ab^{0.5}$) equals 0.296 ± 0.064. Mean relative density (specific gravity) is measured to be 1.8 (Blais and McGinn 2011).

Photo stop 7: A small composite linear ridge
1.8 km east of Provincial Highway 10, approximately 4.0 km southeast of Onanole, Manitoba; NTS 62J/12 Wasagaming; 14 U 434011.50 E, 5189.80 N; Approximate elevation 641 m ASL

Associated with the ice-shoved hill-hole pairs is a low relief ridge, centred on Onanole, Manitoba (Figure 1). This small composite linear ridge is described as a broken series of hills 8.0 km long, 2.0 km wide and 15–30 m high. The gaps appear to be generated by a combination of ice stagnation drainage and Holocene fluvial erosion (McGinn 2002). The ridge may be divided into a north-northwest–south-southwest orientation (335°) tri-sectional ridge (CLR) and two distal outlier hills (OH) (Figure 1). The tri-sectional ridge is slightly arcuate, suggesting an ice advance from the northeast. However, an alternate interpretation employs a natural drainage channel to divide the landform into a northern suite (two sections of the ridge and a northern outlier) and a southern unit composed of a contiguous ridge section and outlier (Figure 1). The northern hills typically exhibit 15–20 m relative relief. The southern unit is higher (up to 45 m relative relief) and broader.

Composite ridges are composed of multiple slices of upthrust and contorted bedrock and or unconsolidated sediments which are often interlayered and overlain with glacigenic material (Benn and Evans 2010). Beatty pits in the foreground, displaced Odanah Shale crest in background.

Presentation stop 3: Beatty pit 1
1.2 km east of Provincial Highway 10 on Beatty Road, approximately 3.3 km southeast of Onanole, Manitoba; NTS 62J/12 Wasagaming; 14U 433346.95 E, 5605689.17 N; Approximate elevation 656 m ASL

Ice proximal sections in the Beatty pit (Figure 1) expose about 2.0 m of Zelena Till overlying a deformation diamict and/or distorted sands and gravels. The fluvial facies contains dragfolds, overfolds and small thrust faults. The deformation diamict, in places, is predominantly reworked coarse glaciofluvial material. When this is the case, dragfolds, overfolds and crenulations are common. When the deformation diamict is reworked till, shear flexures and small thrust faults occur. Pebble clast fabric analysis (Figure 1) from the upper till suggests a northern ice flow vector (5° azimuth). A secondary vector (40° azimuth), however, supports the northeastern ice flow theory.

Presentation stop 4 and Photo stop 8: Shale pit outlook
0.75 km east of Provincial Highway 10 on the south side of Beatty Road; NTS 62J/12 Wasagaming; 14 U 432919.18 E, 5605830 N; Approximate elevation 670 m ASL

South of Onanole, discordant shale bedrock is exposed in a small borrow pit on the crest of the ridge. At this site the strike appears to be as expected, apparent dips seem to be disrupted, plunging opposite the acknowledged western trend. The eastward view from the crest of the composite linear ridge overlooks the proximal Beatty pits.

Presentation stop 5: Beatty pit 2
1.2 km east of Provincial Highway 10 on Beatty Road, approximately 3.0 km southeast of Onanole, Manitoba; NTS 62J/12 Wasagaming; 14U 433298.99 E, 5606092.22 N; Approximate elevation 651 m ASL

Deformed sand and gravel under Zelena Till (Figure 7). This ablation or melt-out till is 9% gravel, 34% sand, and 57% silt and clay (Klassen 1979). Clasts are predominantly Paleozoic carbonates (60%), local Odonah Shale (Pierre Formation) and



Figure 7
Beatty pit 2 showing glaciotectonically deformed sands and gravels. (Photo credit: R.A. McGinn, 2014)

metasedimentary shield rocks. The preferred orientation of the clasts tends towards the southwest suggesting a northeast ice advance (McGinn 2000).

Omars are distinctive glacial erratics composed of massive siliceous greywacke, characterized by buff-weathering calcareous concretions rare but have been found in the Beatty pits (Figure 8). Omars are derived from the Omarolluk Formation, a thick Proterozoic turbidite-flysch deposit outcropping in the Belcher Islands, southeastern Hudson Bay (Ricketts and Donaldson 1981). Omars found in southern Manitoba have experienced two episodes of Late Wisconsinan glacial dispersal; an early northwest to westward flow from the Belcher Islands source region (Labrador Sector ice flow), followed by the southward dispersal by the Keewatin Sector ice flow (Prest et al. 2000).

Photo stop 9: A small composite linear ridge
West side of Provincial Highway 10, 1.0 km north-northwest of Onanole, Manitoba, North across the pothole lake; NTS 62J/12 Wasagaming; 14U 431128.3 E, 5609354.0 N; Approximate elevation 621 m ASL

Presentation stop 6: Onanole Borrow Pit
NTS 62J/12 Wasagaming; 14 U 431113.23 E, 5610142.85 N; Approximate elevation 631m ASL

A recumbent fold in glaciotectonically deformed sand and gravel (see Figure 9).

Conclusions

One might suggest that these hypothesized ice shoved hills are in fact shale bedrock subcrops. Perhaps subsurface drilling could resolve the conflict, but that is unlikely to occur. The stratigraphic evidence (tills over deformed glaciofluvial material) in both the surrounding ice stagnation plain and the Small



Figure 8
An Omar. The Omarolluk Formation greywacke. (Photo credit: R.A. McGinn, 2013)



Figure 9
Onanole borrow pit, showing a recumbent fold in glaciotectonically deformed sand and gravels. (Photo credit: R.A. McGinn, 2014)

Composite Linear Ridge support the conclusion that these features are Cupola-Hills and perhaps Hill-Hole Pairs. All appear to have formed during the Falconer Advance of the Lostwood Glaciation and are surrounded by Glacial Lake Proven sediments. The fluvial facies appears to be outwash suggesting the

glacier advanced south-southwest over its outwash plain. Subglacial shear and folding were probably aided by variations in porewater pressure and frictional drag.

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Notes

[1] This section on 'Ditch Lake Hydrology and Limnology' is reproduced in edited form from the executive summary of the Gertrude 'Ditch' Lake limnology and water quality study conducted by the Ditch Lake Cottage Association and Riding Mountain National Park (Hamilton et al. 2011).

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Introduction

The Experimental Lakes Area (ELA) began as a Government of Canada research station in 1968 tasked with investigating the causes of and controls on nutrient pollution in lakes. It was established largely in response to growing public awareness of nuisance algal blooms in lakes located close to cities. Throughout the 1960s, the algal blooms and fish kills in lakes such as Lake Erie became a major indicator of human influence on lake ecosystems (Schindler 2009). These changes are evidence of a process called eutrophication, whereby excess nutrients boost the productivity of plants and algae in lakes, but ultimately consume dissolved oxygen, leading to poor water quality and fish death. In order to understand this problem, federal scientists in the late 1960s sought out a remote site where lakes could be purposefully manipulated to assess their responses to environmental stressors. The ELA is located on the Precambrian shield of northwestern Ontario, 35 km southeast of Kenora, Ontario. It encompasses 58 lakes designated solely for research and monitoring (Blanchfield et al. 2009). This remote setting was chosen such that the lakes and their watersheds are distant from human-induced environmental pressures, including air pollution

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and impacts from industrial or urban development (Johnson and Vallentyne 1971). While there are several long-term research stations scattered across Canada, ELA is perhaps the best known for two reasons. First, its mandate to perform whole-ecosystem manipulation experiments to investigate the response of lakes and watersheds to stressors has produced striking results. These field test results have often stood in direct opposition to lab-based or smaller scale studies. Most notably, the experimental fertilization of Lake 227 in the 1970s demonstrated that algae in these systems are limited by phosphorus. This suggested that controlling phosphorus pollution to lakes would help them recover from eutrophication (Schindler 1974). These scientific results, accompanied by aerial photographs of emerald green, eutrophic lakes clearly altered by the addition of phosphorus, led to widespread policy changes that included banning phosphates in detergents (Schindler 2006). Research conducted at the ELA still informs efforts to control algal blooms in water bodies across Canada today (Lake Winnipeg Stewardship Board 2006). The second reason that ELA is well-known is that in 2012, the federal government announced they intended to cut all funding to the research station, prompting an outcry from scientists across North America (Orihel et al. 2013). A campaign to save the ELA was launched, consisting of petitions, newspaper ads and rallies putting the research station and its long track record of policy-relevant science in the public eye. Responsibility for the operations of ELA was transferred to the International Institute for Sustainable Development, and the station became known formally as IISD-ELA (Xenopolous and Frost 2015).

This photo essay provides an overview of a tour of the IISD-ELA camp and surrounding area given by current staff to attendees of the 38th annual meeting of the Prairie Division of the Canadian Association of Geographers (PCAG). The meeting and field trip were held in Kenora, Ontario in September, 2015. Participants boarded a bus in Kenora and headed east on the TransCanada Highway, taking a southward turnoff to follow a long, bumpy road to the main IISD-ELA facilities.



Figure 1
The group gathers for a briefing by IISD-ELA staff at the dining hall before heading out on the tour. Although the camp was empty on the Saturday we visited, it can accommodate more than 50 people at a time. Much of the activity and interactions between researchers, students and staff is focused around meals, eaten communally in this building. (Photo credit: N. Casson, 2015)



Figure 2

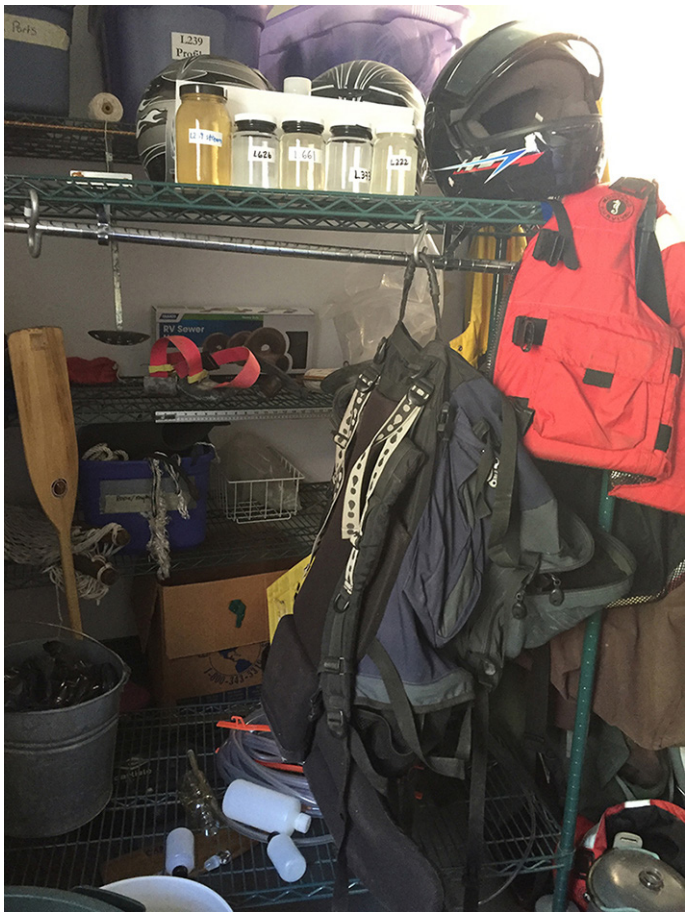


Figure 3
Figures 2 and 3 show scenes inside the lab facilities. Long-term monitoring of physical, chemical and biological parameters of several lakes and streams has been ongoing since the early 1970s. These records set the context for many of the manipulative experiments which are carried out by researchers. They are also valuable for detecting the effects of drivers like climate change, which act over years or decades. (Photo credit: Figure 2, N. Casson, 2015; Figure 3, A. Ducharme, 2015)



Figure 4



Figure 5



Figure 6
Figures 4, 5 and 6 show views of the meteorological station located near the camp. The equipment here is operated by both IISD-ELA and Environment Canada and used to measure parameters including precipitation, temperature, windspeed and chemical deposition. As one of only a few stations in the region measuring airborne pollutants such as mercury, sulphur and nitrogen deposition, the data from this station provide an important measure of these chemicals which can be carried thousands of kilometres from their sources. (Photo credit: Figure 4, K. Thomson, 2015; Figure 5, N. Casson, 2015; Figure 6, J. Piwowar, 2015)



Figure 7



Figure 8
Figures 7 and 8 show views of the landscape at ELA. The boreal forest at this site is mostly dominated by jack pine (*Pinus banksiana*) and black spruce (*Picea mariana*), with thin and discontinuous soils (<1m in depth), underlain by granite-dominated Precambrian Shield geology (Schindler et al. 1996). (Photo credit: Figure 7, G. Vandeberg, 2015; Figure 8, N. Wilson, 2015)



Figure 9
Lake 240 located near the camp. This lake was originally considered for eutrophication experiments, but it was decided to leave it for recreation and study by researchers, students and staff staying at the camp (Schindler 2009). (Photo credit: M. Burke, 2015)



Figure 10
A flume capturing the outflow of Lake 239 into Lake 240. The inflows and outflows of several lakes are gauged and water level is measured continuously by dataloggers. Water chemistry samples are taken weekly. These records are more than 40 years long and allow researchers to calculate water and chemical budgets for the lakes. (Photo credit: B. McGregor, 2015)



Figure 11



Figure 12



Figure 13
Plates 11, 12 and 13 show field trip participants deploying a seine net. This vertical net with floats on the top and weights on the bottom is spooled out from a boat in a semicircle and dragged onto shore. (Photo credit: Figure 11, B. McGregor, 2015; Figure 12, J. Paterson, 2015; Figure 13, B. McGregor, 2015)

Conclusion

This field trip provided students and geographers a glimpse into how field research is carried out at one of the most important long-term ecological research sites in Canada. For some, the sunny afternoon trip inspired ideas of future research questions around ecosystem processes or ways in which science informs national and international environmental policy. The participants are grateful to the IISD-ELA staff and scientists, who facilitated the visit, led the tour and participated in lively discussions.

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