

PRAIRIE PERSPECTIVES

GEOGRAPHICAL ESSAYS

Edited by
Bernard D. Thraves

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Preface

The 31st Annual Meeting of Prairie Division, Canadian Association of Geographers was hosted by University of Regina on the weekend of September 28 to 30, 2007. In keeping with PCAG tradition, the Meeting was conducted off campus with the community of Weyburn serving as the venue. Facilities and accommodation were provided at Weyburn Inn. Seventy delegates including Alison Gill, President of CAG, and geographers from as far afield as Halifax, Nova Scotia and White River Junction, Vermont, attended the Meeting.

Friday evening was assigned mostly to social gathering. An informal walking tour of Weyburn's CBD required interpretation of its architectural heritage and close inspection of several hostelries. On Saturday morning, 35 papers were presented in a series of four concurrent sessions. Eighteen of the 35 papers were presented by students each of whom received a Paul Simpson-Housley/CAG Student Travel Award.

Two field trips were conducted on Saturday afternoon. In the first of these, Ulrike Hardenbicker and Bernie Thraves guided a group of 52 delegates on a tour of the Missouri Coteau in the vicinity of the Big Muddy Badlands. Notes from the field trip are included in this volume. A second field trip for 10 delegates was led by Alec and Linda Paul. They investigated the cultural and recreational landscapes of Weyburn and visited the Weyburn Inland Terminal.

At the Saturday night banquet, John Everitt of Brandon University delivered a warmly received keynote address and slide presentation entitled *My Story of Life in a* 2 *Black Hole*.2 Apparently, somewhere along life's highway John got off a London Routemaster bus at the wrong stop (*i.e.*, in Brandon). He has now rectified this situation by retiring to the British Virgin Islands. John intends to remain active academically during his retirement. We wish him well. Saturday night's activities concluded with the ever popular Annual Slide Competition. Three of five categories including 'best human' and 'best prairie' were won by entries from University of Regina.

Of the 35 conference papers, eight are presented in this volume. Beckey Hamilton draws on archival data from the Hudson's Bay Company and Saskatchewan Land Titles to provide a detailed explanation of land sale patterns and agricultural settlement in the francophone bloc of

southwestern Saskatchewan. Two papers focus on railways. In the first of these, Charles Bohi and Leslie Kozma challenge the conventional view that the extensive construction of prairie branch lines in the Interwar period was a 'disastrous' mistake. Shifting to the present and moving south of the border, Alec Paul interprets the 'grailscape' of the Northern Plains Railroad. He describes the railroad's challenging operating environment in providing service to local grain farmers. Remaining south of the border, Tina Billups, Devon Hansen and Doug Munski examine aging-in-place in Larimore, North Dakota. They establish that aging-in-place is related to an array of social and economic factors including nearness to family and friends, and loyalty place. Moving back across the border to Winnipeg, Parnali Chowdhury and Emdad Haque investigate residents' knowledge of and preparedness to deal with climate change-induced heat wave hazards. Their paper focuses on improving risk communication between experts and the public. Weather and climate is also the focus of the paper by Zhaoqin Li, Xulin Guo, Paul Dixon and Yuhong He. They report on the utility of using temperature data from satellite images to augment the sparse data available from weather stations in northern Canada. The physical environment is also to the fore in the paper by Andrew Burton and Rod McGinn. They report on the limnological and nutrient regimes of four pothole lakes in the Riding Mountain Uplands to determine their suitability for fish stocking and sports fishery. Last, but not least, John Selwood flies Southern Cross to team up with George Curry, Niels Fold and Roy Jones to investigate the role of social and cultural capital in the growth of local fairs and markets in the Great Southern district of Western Australia.

The editorial process has been a lengthy one. I would like to thank the many reviewers from Australia, Canada, Poland and United States for providing their critical assessments of the papers. I thank the authors for their attention to scholarship and their patience in responding to my many e-mails. Finally, publication of this volume would have been impossible without the technical and production assistance of Weldon Hiebert at University of Winnipeg and the cartographical skills of Rob Knox at University of Regina.

Bernard D. Thraves
Department of Geography
University of Regina

PCAG Delegates at Castle Butte, Big Muddy Badlands, September 29, 2007



Front row crouching left to right: Gina Sylvestre, Elaine Walker, Tom Carter, Bill Rannie, Xulin Guo, Anne Krahnen, Dan Zhao, Stacey Lowe, Alison Gill, Chris Malcolm

Back row standing left to right: Joe Piwowar, Reiko Liermann, John Welsted, Keith Knox, Ben Cecil, Bernie Thraves, Dion Wiseman, Sheena Gordon, Rod McGinn, Rodrigo (Bori) Arrobo, Kyle Hodder, Suzan Lapp, Dirk deBoer, Christina Canart, Cesar Perez-Valdivia, Wenonah van Heyst, Jessica Henderson, John Osborne, Julia Siemer, Brad Forsyth, Jessica Vanstone, Marija Krestyanska, Dave Sauchyn, Jonathan Barichivich, Brian Phillips, Becky Sernick, Derrek Eberts, RaeAnn Brenner, Fortune Ogbebo, Mark Coté, Alex Gunn, Doug Munski, Ulrike Hardenbicker, Laura Munski, Mary Vetter, Weldon Hiebert, Kyle Muirhead, Stephanie Fortier, Lynn Bohi, Brian McGregor, Chuck Bohi, Peter Bush

The sale of Hudson's Bay Company farm lands: an example from the Francophone bloc in southwestern Saskatchewan, 1909–1930

Beckey R. Hamilton, University of Regina (*hamiltob@uregina.ca*)

***Abstract*:** This paper adds to the literature on the role of the Hudson's Bay Company (HBC) on the prairie settlement frontier. It focuses on the sale of farm lands that the Company was granted under the Deed of Surrender of 1870. While several studies have documented sales of HBC land in urban areas, less work has been conducted on rural land sales. Using data collected from HBC's Farm Land Records and Saskatchewan Land Titles, the paper analyses land sales in southwestern Saskatchewan in terms of time of sale, the price paid, land quality, land location and HBC policies. The possibility of speculation is also considered. Results of regression analysis suggest that better HBC land near railways and railway service centres sold before other, more distant and lower quality land. Distances to railways and railway service centres, and land quality also affected selling prices, though the importance of each factor varied over time. Collectively, they explained only 50 percent of the patterns of sales and selling prices, suggesting a need for additional, detailed study of HBC land sales and sales policies. Due to limits inherent in the sources used, the results relating to speculation were less clear. Purchasers left all categories of land with departures linked to the economic cycle, HBC policies and the personal characteristics of purchasers.

Key words: *Saskatchewan, Hudson's Bay Company, land grants, land sales, settlement frontier*

Introduction: The Hudson's Bay Land Grant

On July 15 1870, the Hudson's Bay Company (HBC) sold Rupert's Land, the land that it had been granted under charter in 1670, to Canada. In return for Rupert's Land, the HBC received £300,000, one-twentieth of the land in fertile areas to be opened for settlement, and title to the land on which it had trading establishments (Ray 1988, 1022). Moreover, the HBC

was allowed to select an additional 50,000 acres of land in blocks adjoining its trading posts (Selwood and Baril 1977). The fertile belt was defined as an area bound to the south by the American border, to the north by the northern branch of the Saskatchewan River, to the east by Lake Winnipeg, Lake of the Woods and the waters connecting them, and to the west by the Rocky Mountains (Ross 1986). One-twentieth of the land meant that the HBC was allocated all of sections 8 and 26 in every fifth township and all of sections 8 and three-quarters of sections 26 (consisting of the northwest quarter and southern half) in all other townships (McKercher and Wolfe 1986, 11). The grant totalled nearly seven million acres (Ross 1986).

The Hudson's Bay Company Lands and the Prairie Settlement Frontier

Early commentators on the settlement frontier in North America, notably Frederick Jackson Turner (1893) and Canadians, including Sage (1928), described the frontier in terms of a linear advance across the continent. From their perspective, this wave involved not only geographic advance, but also integration, as migrants came into contact with the North American environment and were liberated from the constraints of their homelands. Later, this view was questioned as others saw more complex patterns of migration, settlement and integration (Stanley 1940; Hudson 1976, 1986; Dick 1987, 4–7). In contrast with the apparent freedom of the American frontier, Canadianists, especially historians of the Laurentian school, observed that central and metropolitan cores and their agents exerted substantial power over Canada's frontier (MacKintosh 1923; Innis 1937; Careless 1954; Cross 1970). In particular, the Dominion Government, a main agent of the central core, established the National Policy to settle the West (Fowke 1957) and controlled land policies and surveys. Together, these instruments established the context and framework of prairie settlement and set its basic pattern, notably through the township survey. This was accomplished in advance of settlement and regulated settlers' experience of the frontier (Stanley 1940; Breen 1976, 15). The Dominion Government's decision to grant land to schools and to central institutions, railways and the HBC further affected settlement patterns.[1] Grants to land companies, and the policies that these central institutions adopted, also influenced prairie land settlement and landscapes (Hedges 1939; Warkentin 1961; Weir 1961; Lalonde 1971; Cutting 1975; McKercher and Wolfe 1986).

Certain aspects of the HBC's role in the western settlement frontier have been examined. Galbraith (1951), for example, provided an early

appraisal of HBC land sale policies while Selwood (2000) continued the study of HBC leadership with an elaboration on the Company directors' role in the interconnections with other companies. Other studies have documented the sale of HBC lands adjacent to former trading posts that became part of urban areas; both these sales and the sales of farm lands represented part of the Company's role as a geographical agent in western Canada after 1870 (Moodie 1977). In this context, Selwood and Baril (1977) described the HBC reserve at Upper Fort Garry. They related the effects of HBC policies on land sales and observed the impact of the HBC reserve on the layout of land in Winnipeg. Selwood (1980) discussed the Company's involvement and influence on the development of Fort Qu'Appelle, Saskatchewan through its land sales. Cerkow *et al*. (1997) described land purchase and forfeiture patterns at Edmonton. Selwood and Baril (1981) conducted a more comprehensive study of HBC policies and their effect on several western urban centres between 1870 and 1888. However, the final component of the HBC role in western Canada, namely its "influential [role] in the disposition of homestead lands throughout the areas of pioneer agricultural settlement" has received less attention (Moodie 1977, 269). Similarly, limited research has been conducted using the HBC Land Department records (Ross 1986). Selwood and Richtik's (2003) study of a HBC and Canadian Pacific Railway (CPR) settlement scheme at Vermillion, Alberta is one exception to the lack of research on the sale of farm lands that were part of every prairie township.

Problem

The current study examines one aspect of the prairie frontier that the HBC affected, namely the sale of HBC farm lands. It considers: first, the pattern of purchase of farm lands; second, the pattern of selling prices; third, the potential influence of speculation on land sales; and fourth, the pattern of purchaser persistence on HBC farm land. These patterns are viewed within the context of HBC policies and land settlement. How did purchase patterns, patterns of speculation and selling prices reflect HBC policies? This paper presents an exploratory investigation of this question. Although only a partial answer is obtained, the paper sheds further light on how the HBC influenced the Canadian prairie settlement frontier.

Basis of Analysis

Pattern of farm land acquisition:

Research has shown that various factors have affected settlement patterns in frontier areas. At a broad scale, wheat prices and farm technology influenced the potential for returns from agriculture and have been implicated in the spread of settlement (Lewis 1981). At a local level, land first had to be made available for settlement to proceed (Schlichtmann 1977). Within regions, an early commentator, Bylund (1960), recognized a pattern of diffusion into new areas that involved the selection of favourable climates and land. Hudson (1969) continued in the same vein, envisioning a three-step process of settlement involving: 'colonization,' an initial period of entry, where pioneers selected land with suitable conditions, namely good soil and reasonable proximity to railways; 'spread' where settlement density increased and towns formed; and 'competition' where 'stronger elements' acquired land and markets from 'weaker elements.'

Over time, researchers increasingly recognized the role of perceived, as opposed to actual, favourability of the land for returns from farming in the timing and pattern of settlement on frontiers (Schlichtmann 1977; Richtik 1983). Thus, studies have interpreted settlement patterns so as to compare the importance of a wide variety of economic and other variables that affected pioneers' perceptions and choices of land. Lewis (1981), for example, has shown the importance of the distance that grain had to be hauled in the spread of settlement, while Dick (1985) and Weisinger (1985) studied many factors: land type, soil quality, access to wood and water, proximity to settlers' points of entry, trails, railways and grain handling facilities, and proximity to supply centres. The importance of human characteristics, including culture, family and acquaintances in the direction and pattern of land alienation on the frontier has also been widely studied.[2]

This study, unlike several studies discussed above, describes expansion and infill of a partially settled area through sales by a company, rather than selection of relatively free homestead land and movement into a new area. This expansion, as elsewhere, could occur via the arrival of new settlers, or with settlers, previously in the area, expanding their holdings (Hudson 1969). The processes of mechanization and the extension of railways often played an important role in the expansion of farms and infill of existing settlement areas (Schmidt 1934; Norton and Guelke 1977; Thomas 1985). More importantly, as land was sold by a company, company policies had to be considered in explaining the settlement of this land (Weisinger 1985).

Even so, this study assumes that several of the locational factors that applied to frontier land settlement, notably soil quality, and access to railways and railway service centres,[3] may have some applicability to early HBC land sales. Other studies of land that was sold by companies have suggested that purchasers looked for similar land characteristics as those who settled on 'free' Dominion grants. For example, those who bought railway land in Nebraska generally looked for economic advantages, particularly proximity to railways and the availability of water, although some other purchasers sought the social advantages of group settlement (Kinbacher and Thomas 2008). Notably, too, and underlining their importance, the potential advantages of these characteristics affected HBC land pricing schemes (HBC *c*1920).

Potential of speculation:

Speculation was not unknown on the Canadian prairie frontier (Adelman 1994, 222). Americans pioneers, who had speculated in their home country, also speculated at Vulcan, Alberta (Voisey 1988, 41–42). According to Voisey (1988, 46–47), 'professional pioneers,' or people who homesteaded in multiple places as a speculative venture, were not uncommon on the prairies. In southwestern Saskatchewan, there were instances where individuals cheaply acquired large tracts of land (Hamilton 2007, 211). Also, speculation was influential in at least some sales of HBC land (Cerkow *et al*. 1997). As such, speculation was considered as potentially important in the purchase pattern of HBC lands in the study area.

Speculators are generally characterized as individuals who purchased unimproved land with the intention of selling out once land values had risen sufficiently (Park 1984). Frequently, speculators have been associated with large tracts of land, and often with absentee landownership (*e.g*., Heller and Moore 1972; Clarke 1978; Bloom 1983). In this regard, this study differs from many others since HBC parcels were scattered, limiting the acquisition of large tracts of land.[4] Speculators have also been associated with rapid turnover (Heller and Moore 1972). This study assumes that this aspect of speculation may have affected HBC land. Moreover, it was considered probable that those who speculated in HBC land would have had at least some of the same characteristics as other speculators. Studies have shown that speculators came from varied backgrounds. Park (1984), for example, found that speculators on the frontier have included: first, frontiersmen hoping to sell for a profit as settlement expanded; second, small farmers who purchased more land than they were able to farm profitably; third, land agents; and fourth, officials who invested as a sideline activity.

Pattern of selling prices:

In a study of southern Ontario, Norton and Conkling (1974) proposed that land values were affected principally by distance to a central market, but were altered by distance to nearby markets, to arterial transportation routes and by soil quality. While they confirmed their hypotheses, their results did not fully explain variation in land prices. Thus, they proposed that human characteristics, including limited knowledge of the area, were also influential in land prices. A similar study by Clarke and Brown (1982) found that, among other things, access to a major urban centre was significant in land prices. Lindert (1988, 47) also described the price for each parcel of land as a function of climate, soil conditions, "other dimensions of nature," human investment, and the economic environment, including transportation costs, taxes, liens and property entitlements. At the same time, broad scale factors, including markets for farm products, asset markets, input markets and government policies, affected land pricing at a larger scale. Furthermore, Norton and Conkling (1974) suggested that within the pioneer period, land sold by a company at planned prices may not have exhibited the same pricing patterns as other land. Cotroneo (1987), for example, showed the effects of one company's pricing policies in a detailed study of the Northern Pacific Railway's role in land sales in Montana.

Many of the factors mentioned above were explicitly part of the HBC's policies in the pricing of Company lands. Land quality, proximity to market and potential for immediate cultivation influenced land prices (HBC *c*1920). The HBC also sold land for higher prices where it would likely increase in value, such as along projected railway lines (Galbraith 1951). Thus, in this study, since the land was not forested and did not need to be cleared prior to cultivation, the analysis of selling prices considers distance to a railway, distance to a railway service centre, land quality and timing of land sales.

Persistence patterns:

Persistence over time has been widely studied in frontier areas. Many reasons have been suggested for persistence or lack thereof. They include farm size (Boyd 1989, 158; Hamilton 2007, 200), soil quality (Mallet 1971, 41; Dick 1985; Boyd 1989, 106, 118), farmers' age (Mallet 1971, 98–99; Vogelsang 1972, 54; Mackintosh 1991; Hamilton 2007, 202) birthplace, ethnic background (Mallett 1971; Vogelsang 1972; Boyd 1989), family situation (Mackintosh 1991), location within ethnic settlements (McQuillan 1979), proximity to kin (Lewry 1986, 217), and personal characteristics and expectations (Bennett and Kohl 1995, 74). This study is restricted to providing a brief overview of persistence among HBC

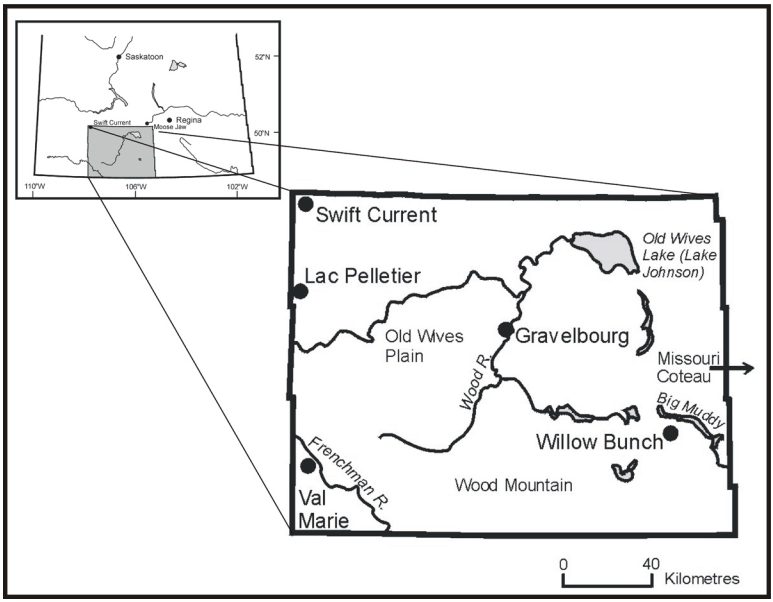


Figure 1: *Study area.*

purchasers and concentrates on describing the link between persistence and a limited number of characteristics of land quality for farming.

The Study Area

An area in southwestern Saskatchewan, located approximately between and to the south of Moose Jaw and Swift Current, was selected for study (Figure 1). The area includes a variety of soils, land at diverse distances from railways and a multitude of ethnic groups. However, the author's previous studies in this area were key in its selection.

The study area lies to the west of the Missouri Coteau, a 150 m escarpment that separates the Saskatchewan plains from the higher Alberta plains to the west (Abrahamsson 1972, 153). Old Wives Plain characterizes the northern part of the study area. Here, lakes and rivers have deposited lacustrine material on top of some 15 to 40 m of glacial drift. This has left fairly flat land, interrupted occasionally by glacial landforms, including moraines. Wood Mountain, a 150 m, flat-topped plateau, dominates the southern part of the study area (Loveridge and Potyondi 1983, 35–37). Big Muddy Valley, a former meltwater channel, punctuates the eastern

part of the area. The land between the Missouri Coteau, Old Wives Plain and Big Muddy Valley is often more rolling than Old Wives Plain, but changes in elevation are much less dramatic than along the Missouri Coteau or Wood Mountain uplands (Gauthier *et al*. 1993, 14).

The study area lies in southwestern Saskatchewan's arid belt and is characterized as a mid-latitude steppe within the Köppen climate classification system. Less than 400 mm of precipitation are received annually in all parts of the study area, though precipitation is highest in the northeast. Precipitation peaks during the summer, often as thunderstorms, enabling crop growth (Longley 1972, 25). Unpredictability, especially drought, also characterizes the area (Loveridge and Potyondi 1983, 12). Summer temperatures are elevated, reaching daily averages of about 19°C in July, but dipping to "14°C in January. Temperatures tend to be slightly higher in the western and southern parts of the area (Fung 1999, 95–100) and high summer temperatures combined with limited precipitation can result in significant moisture deficits at times reaching 350 mm in some areas (Gauthier *et al*. 1993, 26).

Water bodies are limited in the study area. Wood River and Frenchman River provide the key drainage. Most other creeks are ephemeral, flowing only in the spring after snowmelt. Saline sloughs are common though most, with the exception of the largest lakes, dry up during the summer months (Abrahamsson 1972, 153; Loveridge and Potyondi 1983, 39).

Chernozemic soils predominate in the area. However, topography is irregular and vegetation that would increase organic material is limited. Consequently, large tracts of land are relatively poor (Abrahamsson 1972, 153; Loveridge and Potyondi 1983, 42). The best soils are found on the most level land, particularly along Wood River near Gravelbourg (Figure 2). Soils between Old Wives Plain and the Wood Mountain uplands are reasonably fertile where the land is flat, though stones are common and present a problem to farmers. In addition, these Haverhill and Hatton soils are more susceptible to drifting during drought periods than soils in the Wood River floodplain. Poorly developed, light loams of the Wood Mountain association lie further south. Poor quality, coarsely textured Chaplin soil surrounds Old Wives Lake. Other soils in the northern part of the study area are of the Cypress, Haverhill and Wood Mountain associations. In addition to coverage with soils of lesser fertility than in the Gravelbourg area, these northern lands are rolling (Mitchell *et al*. 1944; Loveridge and Potyondi 1983, 42).

The natural vegetation of the study area, a quality that may have influenced patterns of land purchase (Tracie 1970; Richtik 1983), is characterized as mixed prairie in the east and dry mixed prairie in the west (Fung 1999, 133). At the time HBC land was taken, grasses, including

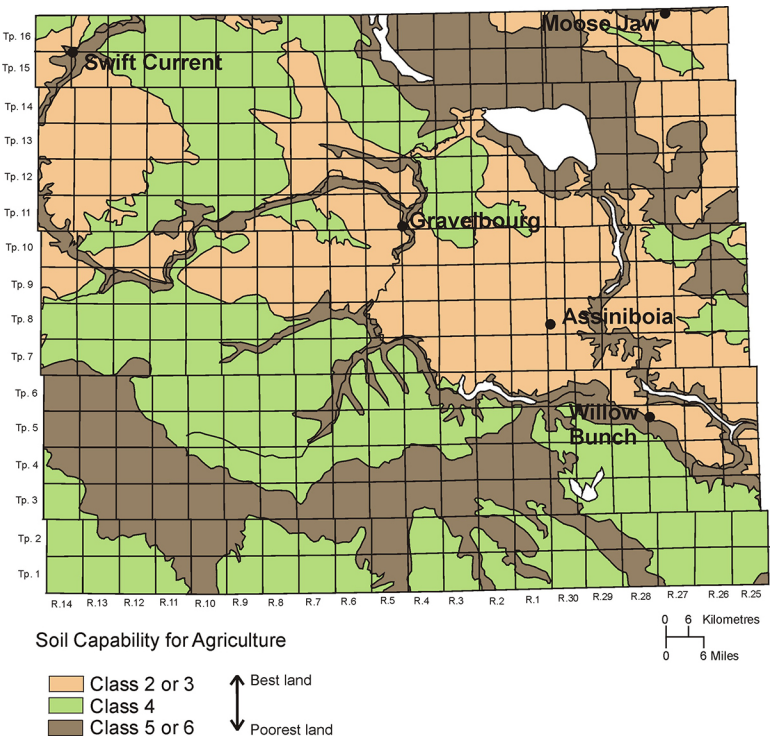


Figure 2: *Soils in the study area.*
Source: Fung (1999)

blue gamma grass (*Bouteloua gracilis*) and spear grass (*Stipa comata*), would have covered most of the land that had not been broken for farming. Bush, often wolf-willow (*Elaeagnus commutata*), buffaloberry (*Sheperdia argentea*) and cottonwood (*Populus deltoids*), would have been limited to valleys, while prickly pear cacti (*Opuntia polyacantha*) and pasture sage (*Artemisia frigida*) would have inhabited dry areas (Department of the Interior *Township Plans*; Watts 1959).

Land settlement in the area began with Métis and Francophones at Willow Bunch, Val Marie and Lac Pelletier. A few ranchers also established themselves in the late 1800s and early 1900s. During the first years, the region was isolated from markets with only the distant CPR mainline approaching the area. After 1906, Francophones much expanded land settlement as they sought to establish colonies before others arrived (Loveridge and Potyondi 1983, 121–152, 166–176; Fung 1999, 56–57). Other homesteaders, of varied nationality and culture, including

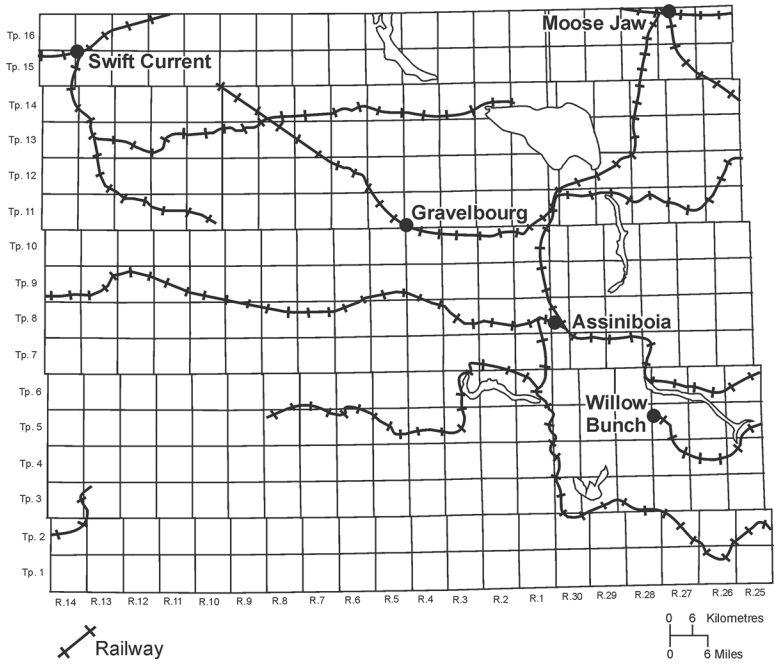


Figure 3: *Railways in the study area.*
Source: Drake (1950)

Mennonites, Romanians, British, Scandinavians and Germans, arrived subsequently; many formed bloc settlements (Fung 1999, 56–57).

Settlement initially spread outward from the clusters in Wood River Valley as homesteaders skipped poor land south of the CPR mainline and opted instead for better land. Over the ensuing years, settlers filled into more marginal areas, expanding south towards Wood Mountain and around Lake Johnson (Department of the Interior 1909, 1910a, 1911, 1915, 1918). Despite land alienation, many portions of the study area lacked railways for years. The parts which were homesteaded first and best suited for agriculture received rail service first. Settlers in poorer regions, particularly at Willow Bunch, waited until 1926 for rail service (Drake 1950) (Figure 3).

Time Period

The study begins with the first purchases of HBC land in southwestern Saskatchewan, in 1909. It ends in 1930 at the start of the Great Depression,

a period of tremendous change in prairie agriculture typified by extensive drought, decreased demand for farm products and declining prices (Schmidt 1934; Lindert 1988).

Sources and Method

The HBC's Farm Land Records are the main source material for the study. The farm land agreements and registers of sales provide information on the year of sale, the selling price, the address and occupation of the purchaser, and the year of transfer of the agreement, cancellation or reception of title to HBC farm land. Locating information about the sale of HBC land is a two-step process. Land sale agreement numbers, assigned to each quarter section sold, were first searched in the *Record of HBC Lands* (HBC Series 21). Next, the appropriate land sales were located by number in the *HBC Farm Lands Registers of Sales* (HBC Series 25), the *HBC Farm Lands Agreements* (HBC Series 26), and the *HBC Farm Lands Registers of Transfers* (HBC Series 29).

While HBC documents provided the information needed about patterns of land sales, purchase prices and completion of contracts, they included less information about speculation. For this reason, the information provided by HBC documents was supplemented with data from Saskatchewan Land Titles to show how purchase, cancellation, forfeiture, transmission and selling patterns may have involved speculation. Even so, the limits of these sources for identifying speculators are many. Like most sources, they do not explicitly identify speculators (Clarke and Brown 1987). However, some studies have used various methods to identify them. Clarke (1978), for example, considered all large landholders as potential speculators whereas Widdis (1979) developed more specific criteria. He typified speculators as large landholders, who cleared and invested little in their land and who either sold or persisted 'sitting' on their land. Combinations of lack of residence, limited development and large holdings have also been used as criteria to identify speculators (Clarke and Brown 1987), and it has been shown that prairie speculators, too, did little to improve their holdings (Voisey 1988, 45). Unfortunately, most of these methods require information that could not be gathered from the sources that were available in the present study. In particular, information about residence and improvements to land was not available.

Mostly, the sources available for this study only showed sales patterns. Although sales patterns, especially rapid turnover (Bogue and Bogue 1957; Hartnett 1991), may be suggestive of speculation, they certainly do not provide full information on speculative intent. First, while some speculators

bought and sold land quickly, others purchased large tracts of land and persisted as landowners, though they occasionally leased land (Bogue and Bogue 1957; Widdis 1979; Hartnett 1991). These speculators would not have appeared among those who sold out soon after acquiring title to HBC land. Second, farmers also speculated, though sometimes only on a small scale. This group of speculators often purchased only a few additional quarter sections that could be sold for a profit, though they could keep the land if sales conditions were unfavourable and it was useful for their operations (Park 1984; Adelman 1994, 222). According to Voisey (1988, 46–47), the latter form of speculation was common on the prairies as some purchased land in addition to a homestead. These speculators, too, may not have been identified by the pattern of land sales. Third, a variety of factors, other than speculation, including closing of the settlement frontier, availability of capital in the local area, land fertility, size of the tract of land held, perceptions of land value, family geographical and generational propinquity, and the land owner's occupation have been shown to influence land sale patterns (Schmidt 1934; Bogue and Bogue 1957; Hartnett 1991). These factors would have affected land sale patterns irrespective of speculative intent.

Analysis of the effects of soil characteristics on the sale of land was based on soil classes described by the Canada Land Inventory (CLI) maps (CLI 1967a, 1967b, 1967c, 1967d). The CLI grouped land into seven classes based on its capability for agriculture. HBC land within the study area included quarter sections with one class of land and quarter sections with two or more classes of land. Where quarter sections contained more than one class of land, a general class was assigned either by attributing the class that described the most land, if there were two adjacent classes of land (*e.g.*, Class 2 and 3 land), or by determining an average quality class for the quarter section, if it contained more than two classes of land or non-adjacent classes of land.

The expansion of railways in the area was described by Drake (1950); his maps were used for discussion relating to railways. The analysis of land sales and distance to railways and railway service centres was based on straight line distances to a railway that existed at the time of purchase. This provided a simplified approximation of the trip settlers would have had to make to haul their grain to a railway or railway service centre. This method was used since the actual routes taken were unknown (SAR 1973).

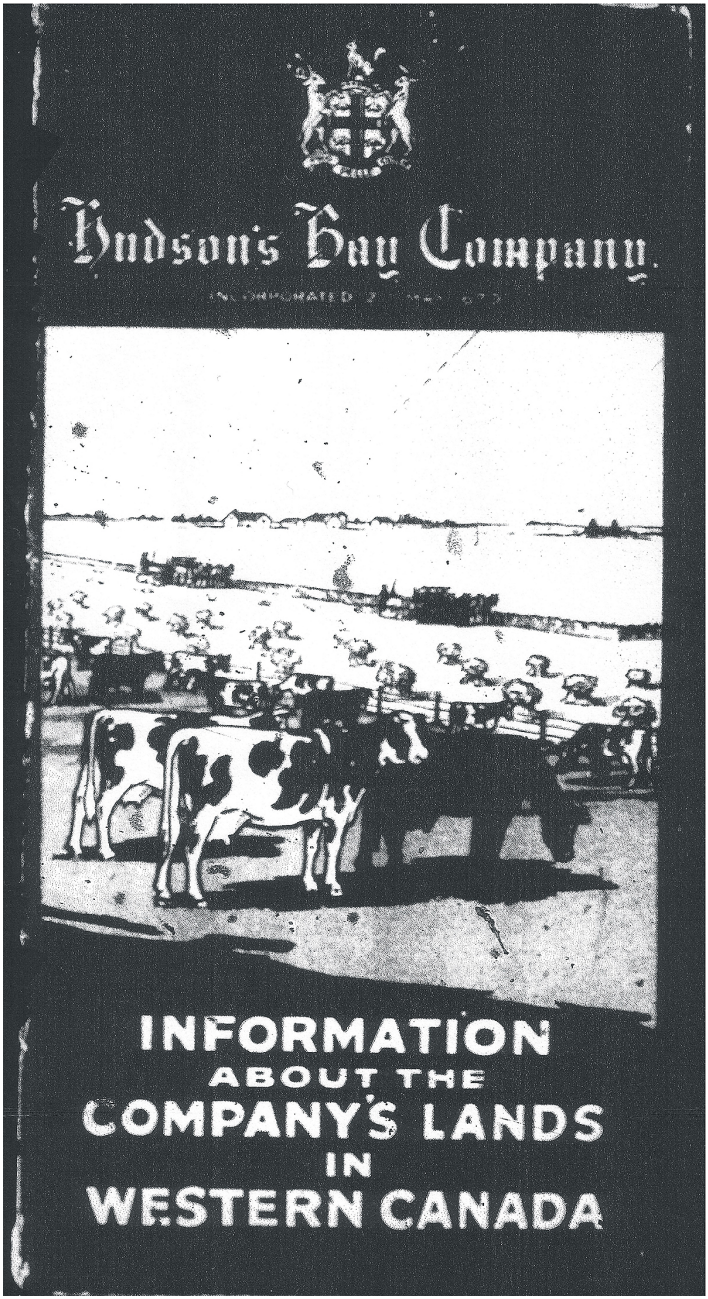


Figure 4: *Hudson's Bay Company advertising.*
Source: HBC (*c*1920)

The Hudson's Bay Company's Rural Land Sale Policies

As a holder of land in all townships, the HBC participated in the settlement of western Canada. During the early 20th century it advertised in newspapers and published a series of brochures explaining the advantages of purchasing Company land (Figure 4). Acquiring Company land, it suggested, would allow homesteaders to select land of proven fertility, in an established district, with the advantages of proximity to other people, communities and facilities (HBC *c*1920). The Company also advertised the assistance its agents provided in helping potential settlers to secure reduced rates on Canadian railways and in accompanying them to HBC land (HBC *c*1920).

Nevertheless, while participating in western settlement, the HBC's motives differed from those of other agents. In particular, grain production and transportation by rail allowed both the Dominion Government and railways to continue benefitting following the sale of their lands. The HBC, on the other hand, would not reap long-term benefits from the sale of its land; its land was a diminishing asset that, once sold, would no longer benefit the Company (MacKay 1949, 304). To this end, the HBC devised sales policies aimed at maximizing profits from land sales. Generally, it attempted to hold land until the most profitable deal could be obtained. Yet since it could not risk resentment from settlers and Canadians, and because holding land did not provide its shareholders with returns, and since taxes drained resources, the HBC sold land, though it demanded higher prices than other land holders (Galbraith 1951). Homestead quarters were free of charge except for the $10 registration fee and completion of homestead duties, pre-emption quarters sold for $3.20 per acre, and railway land sold for $8.55 per acre. In contrast, HBC land sold for an average of $12.10 per acre between 1906 and 1927 (Martin 1938). Furthermore, the HBC adopted policies of selling land for higher prices in locations where it would likely increase in value, such as along projected railways (Galbraith 1951). Land quality, proximity to market and potential for immediate cultivation also influenced land prices (HBC *c*1920).

Other HBC land sale policies reflected the Company's goal of maximizing profits. When Lord Strathcona became governor in 1906, he envisioned that land prices in western Canada would increase until they were approximately equal to those in eastern Canada. Thus he implemented a policy of disposing of no more than one-half section of HBC land to each purchaser and he did not allow more than part of the land in every township to be sold to individual buyers (Galbraith 1951). As he expressed in 1910, the quarter sections that were not sold immediately would most certainly increase in price in later years:

> … there is no difficulty in reserving for a higher price such sections (or parts of sections) as it may appear desirable to deal with, the actual fact being that while a portion of any section has been sold, let us say for eight or ten dollars per acre, in a couple of years or so later twenty dollars per acre have been received for the other portion of the section of precisely the same quality (HBC *Hudson's Bay Company Proceedings* 1910).

This policy, he maintained, was consistent with Company goals. It did not pose hardship to Canadians. On the contrary, it was beneficial as it would discourage speculation, while increasing revenue for the Company (HBC *Hudson's Bay Company Proceedings* 1909). Furthermore, the loss of revenue, because of taxation and fewer sales, would be made up through leases of HBC land for grazing (HBC *Hudson's Bay Company Proceedings* 1910).

By the mid-1910s, the burden of taxation on HBC land increased because of the expansion of settlement and school districts, the Finance Act, and the judicial decision that municipalities had the right to levy taxes. Thus, the Company, now under the governorship of R.M. Kindersley, adopted a policy of reducing sales prices, particularly for poor land (HBC *Hudson's Bay Company Proceedings* 1916, 1920, 1926; *The Regina Leader* 1918). Also, it actively campaigned to sell its land in 1919, 1925 and 1928 (HBC *Hudson's Bay Company Proceedings* 1919, 1928; *The Regina Leader* 1925). Still, despite the sales and the leasing of land that provided income and some tax exemptions, the burden of taxation increased over succeeding years as the Saskatchewan government imposed a surtax and a wild lands tax (HBC *Hudson's Bay Company Proceedings* 1920, 1921).

Once settled, purchasers were subject to fulfillment of HBC land sale policy. The terms of sale for farm land required a down payment of one-eighth of the purchase price with the remaining payments to be made in seven annual instalments at 7 percent annual interest. Purchasers were also to erect fences and buildings though this provision was not enforced (Galbraith 1951).

Moreover, the Company instituted policies to aid purchasers of HBC land, though the aid policies were also designed to provide longer term revenue to the Company. These policies allowed farmers to convert sales agreements into loan agreements. This was intended to enable them to invest in developing their land rather than making payments, and to pay dividends to the Company (HBC *Hudson's Bay Company Proceedings* 1913). Policies of leniency relative to payments were adopted during difficult years between 1918 and 1922, though the HBC's directors also

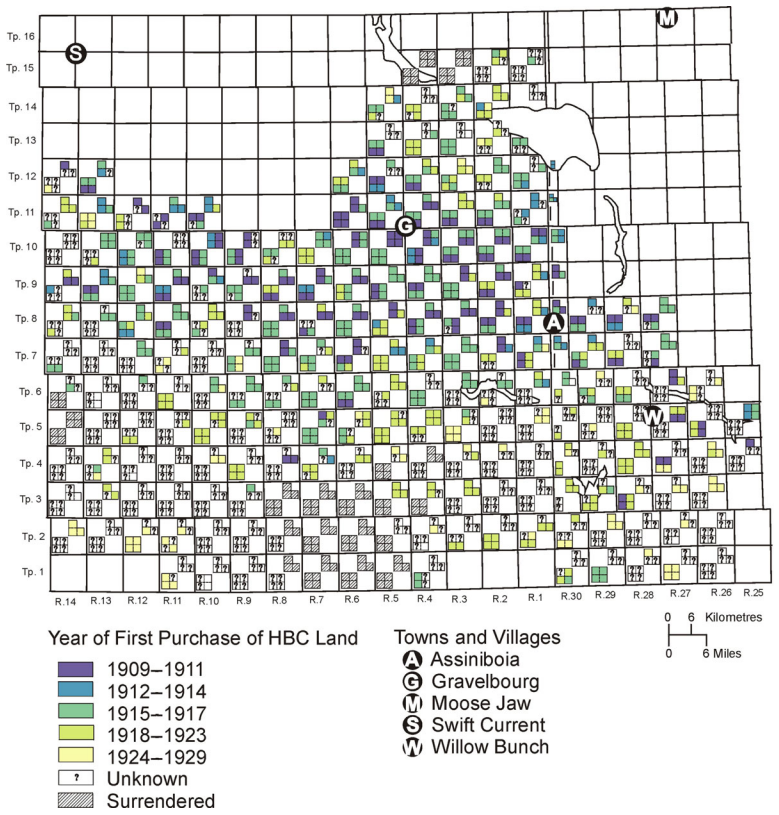


Figure 5: *Year of Hudson's Bay Company land sales.*
Source: HBC Farm Land Records

believed that these policies would pay in the long run (HBC *Hudson's Bay Company Proceedings* 1922). Purchasers who began to develop the land could, after making their second payment, postpone further payments on the principal for six years, provided they continued to develop the land and paid interest and taxes. This policy, too, was to pay longer term dividends to the Company (HBC *c*1920; HBC *Map of Lands for Sale*).

Despite enforcing its desire to have its land settled, by 1923–1924, the Company's directors began to have contracts on lands cancelled where they felt they would not recover payments. Although this policy was aimed more at townsites than at farm lands, the Company endeavoured to cancel all speculative contracts and contracts where farmers had left the land but had not cancelled their contracts (HBC *Hudson's Bay Company Proceedings* 1923, 1924).

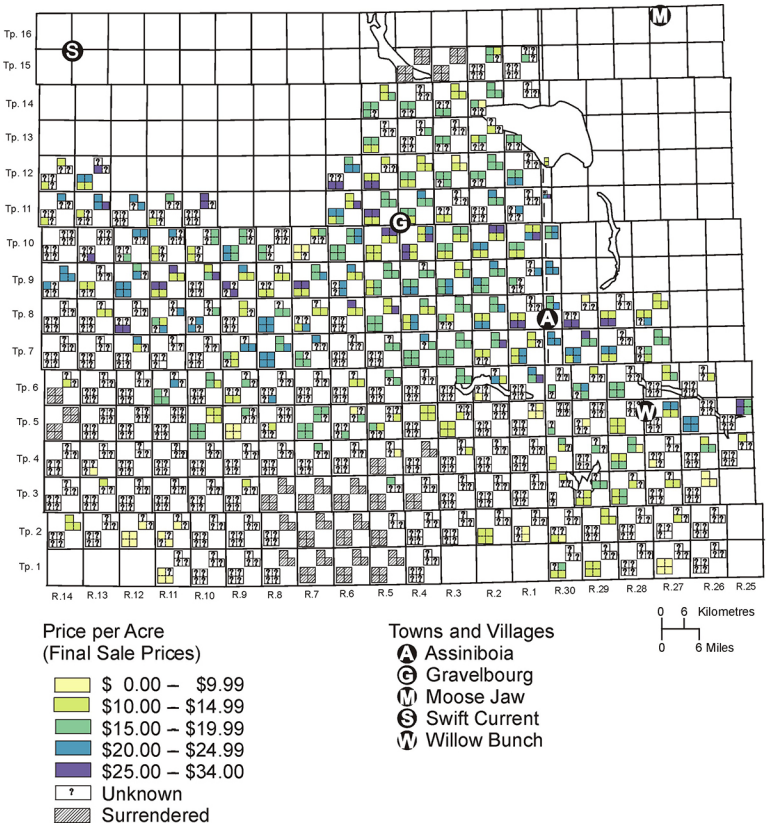


Figure 6: *Selling price of Hudson's Bay Company land.*
Source: HBC Farm Land Records

Patterns of Hudson Bay Land Sales in Southwestern Saskatchewan: An Overview

As elsewhere, settlers in the study area began purchasing HBC lands a few years after they entered for homesteads (Galbraith 1951). They made their first purchases of HBC land in 1909 (Figure 5). Land was sold in the Assiniboia-Gravelbourg area first. Next, sales extended to the immediate south and to the north. Only later were quarter sections purchased in the southern part of the study area. In fact, much of the land in the southernmost region remained unsold in 1930.

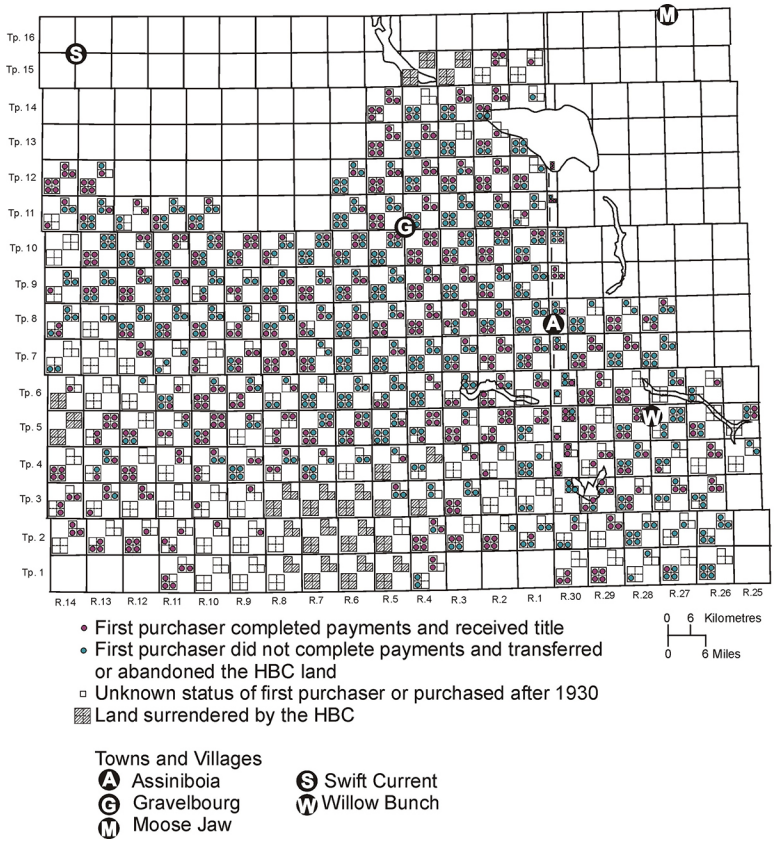


Figure 7: *Persistence to completion of the contract among those who purchased Hudson's Bay Company land.*
Source: HBC Farm Land Records

Figure 6 shows the spatial distribution of the final selling price for HBC land. Although selling prices appear mixed at first glance, the Company received the best prices for land in the Assiniboia-Gravelbourg area, where it sold for between $15 and $34 per acre. Prices were lower for land to the north, south and west. Land in the southern part of the study area often sold for much less, typically earning the Company between $5 and $19 per acre.

Many first purchasers of HBC land did not complete the purchase (Figure 7). Sales contracts were cancelled on 33.6 percent of the land sold in the study area. This rate of non-completion was greater than the rate of reinvestment of HBC land elsewhere. Between 1906 and 1927, the HBC

sold 2,851,502 acres. Of this, 607,129 acres (21.3 percent), were reinvested or cancelled (Martin 1938). In addition, many other purchasers transferred their title, so that 46.3 percent of purchasers in the study area did not complete the purchase or transferred the contract rather than obtain title. Relatively poor land and adverse weather and farm conditions during the study period likely contributed to the high rate of turnover. Examination of Figure 7 suggests that local circumstances were less important in turnover than were broad scale conditions; purchasers throughout the study area cancelled or transferred their contracts.

Analysis

Timing of land sales:

Both the timing of settlement and economic influences affected the numeric pattern of land sales. The earliest sales, during the first decade of the 20th century, occurred during a general period of expansion as economic recovery and demand for food contributed to increasing prices for foodstuffs. But environmental conditions varied (Schmidt 1934). The sales in 1909 largely followed the arrival of settlers at Gravelbourg. In contrast, settlers at Willow Bunch, who had begun entering for homestead land as early as 1902, and had been in the area for several years before that, had faced both favourable and poor years since the turn of the century. This may explain why most did not purchase land until later years. Although crops were good in 1905, devastating storms had struck Willow Bunch during the winter of 1903, and some settlers had lost most of their herds. Besides, dry weather had resulted in light crops in 1906 and failures in

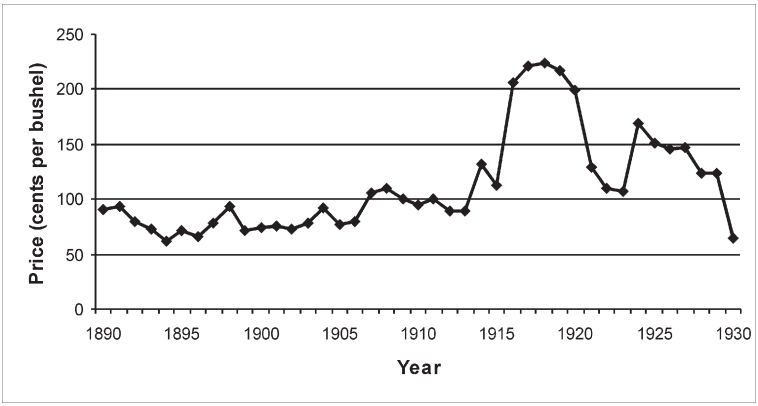


Figure 8: *Wheat prices.*
Source: Based on Urquhart and Buckley (1965)

some areas in 1907 and 1908. Conversely, better crops in 1909 and the end of financial difficulties in the United States appeared to contribute to the peak in HBC land sales in the study area in 1910 (Saskatchewan Department of Agriculture 1905–1909; HBC *Hudson's Bay Company Proceedings* 1909; Department of the Interior 1910b; Rondeau 1923, 164).

A succession of years followed when sales were limited. Weather and price conditions seem to have played a role. Harvests in 1910 and 1911 were marginal. In 1910, some farmers harvested less than half of what they had sown. 1911 was dry, with yields about half of those of previous years. Better crops followed in 1912 and 1913, but large crops in other wheat producing countries contributed to low prices for wheat (Figure 8). The decline in world financial conditions in 1913 further affected HBC land sales (HBC *Hudson's Bay Company Proceedings* 1911, 1913; Saskatchewan Department of Agriculture 1911, 1912, 1913). 1914 witnessed continuation of the depression that again generally reduced HBC land sales. Renewed drought conditions in parts of southwestern Saskatchewan only exacerbated this situation. In fact, areas around Swift Current were "said to be drier than it had been within the memory of the oldest settler. Many fields were badly scorched and some fields were being ploughed under" (Saskatchewan Department of Agriculture 1914, 108). Large numbers of farmers were unable to meet financial obligations (Saskatchewan Department of Agriculture 1914, 111–112; HBC *Hudson's Bay Company Proceedings* 1914; Peel 1946, 198–199).

Although fires devastated a few parts of the study area in 1915, many farmers had an outstanding year as better weather conditions returned and wheat prices increased, spurred by the need to supply the Allies during World War I. Following these improvements, HBC land sales began to increase (Saskatchewan Department of Agriculture 1915, 10–11, 122–123; HBC *Hudson's Bay Company Proceedings* 1918; Peel 1946, 201; Urquhart and Buckley 1965, 359–360). In 1916, reasonable crops, high prices and declining availability of homestead land appeared to contribute to a peak in land sales (HBC *Hudson's Bay Company Proceedings* 1916, 1918; Saskatchewan Department of Agriculture 1917, 12–13, 108–115; Urquhart and Buckley 1965, 359–360). Land sales remained high in 1917, again spurred on by high prices, in spite of the dry weather and decline in yields (Saskatchewan Department of Agriculture 1918, 107–112; Urquhart and Buckley 1965, 359–360).

1918 marked the end of this period of relative prosperity and the start of a period of decline in HBC land sales. Although wheat prices were high in 1918 as Europeans continued to need food, the drought that began that year hindered farmers. Weather conditions in 1918 were so poor that the Dominion Government, in cooperation with the railways, arranged for the

distribution of seed grain, reduction in costs for shipment of feed to drought areas, and shipment of livestock to areas where feed was plentiful. In 1919, the Dominion Government and railways, along with provincial and municipal governments, provided fuel, flour, seed grain and free transportation of feed. As in 1914, the Saskatchewan Department of Agriculture interceded between farmers and creditors. Poor conditions persisted in 1920: grasshoppers appeared, wheat prices declined as they were no longer inflated by the needs of the War, and continuing labour shortages increased production costs. The auction of school land by the Dominion Government further contributed to reduced HBC sales at this time (HBC *Hudson's Bay Company Proceedings* 1918, 1921, 1922; Saskatchewan Department of Agriculture 1919, 10, 86, 104–105, 1920, 9, 12–13, 17, 59, 255–257, 1921, 9–10, 22–23, 66, 69, 1922, 9, 11, 292–294, 1923, 168–169; Potyondi 1995, 93)

Crops began to improve in 1922. Even so, wheat prices were low and farmers encountered higher prices for other necessities. Better weather conditions continued in 1923, resulting in a reasonable crop but the price of wheat again declined and input costs remained high. Also, as the preceding drought years had contributed to increased debt loads, farmers had only achieved a moderate level of prosperity. Under these conditions, HBC land sales fell to a low in 1923 (Saskatchewan Department of Agriculture 1923, 9, 13, 168–169, 1924, 9–10, 261–262; HBC *Hudson's Bay Company Proceedings* 1923; Urquhart and Buckley 1965, 359–360).

Sales in the study area picked up in 1924 as prices improved, aided in part by the establishment of the Wheat Pool. Nevertheless, land sales did not increase substantially. In addition to the more limited availability of HBC land, this was likely associated with lower grain prices than during the War years, the continuing debt burden, and a renewal of poorer weather conditions (HBC *Hudson's Bay Company Proceedings* 1924; Saskatchewan Department of Agriculture 1925, 9, 238–240). Crops were better in 1925 and 1926, and prices were higher than they had been in the early 1920s; this corresponded with an increase in HBC land sales. However, conditions deteriorated after 1927, with lower yields in 1927 and much lower yields in 1929. Despite a good crop in 1928, wheat prices declined along with HBC land sales (Saskatchewan Department of Agriculture 1927, 258–269, 1928, 349–361, 1931, 451–462; HBC *Hudson's Bay Company Proceedings* 1929).

Broadly, the spatial pattern of HBC land sales in the study area paralleled the pattern of frontier expansion. Following the initial land alienation at Willow Bunch, Gravelbourg, Ponteix and Assiniboia in 1902 and from 1906 to 1908, settlement expanded northwest and southeast of these nodes, with homesteaders claiming the better land in the region. By

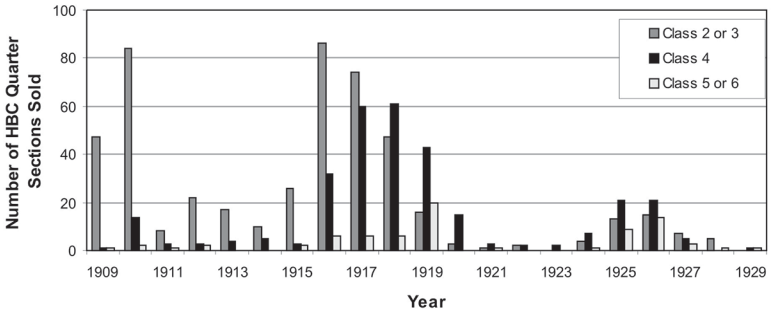


Figure 9: *Year of sale of Hudson's Bay Company land and land quality.*
Source: HBC Farm Land Records

1910, much of the land in Wood River Valley was claimed, along with the good land around Assiniboia and the best land in the Willow Bunch district. Settlement gradually expanded onto poorer land of the Wood Mountain uplands and in northern parts of the study area. Still, several quarter sections, particularly in the Wood Mountain uplands, remained open for entry in the late-1910s while other marginal land was leased for grazing (Department of the Interior *Township Registers*).

The pattern of HBC land purchases was similar, though HBC land was first purchased in the Gravelbourg-Assiniboia area, three years after this region was first settled. Purchases then extended northwards and southwards, following the homesteading frontier.

Soil capability for agriculture influenced the timing of land sales (Figure 9). First, this pattern appeared in the study area as a whole. Early sales were for Class 2 or 3 land. In 1909 and 1910, 95.9 and 84.0 percent of sales were for the best land (Class 2 or 3). By the late-1910s, sales of Class 2 or 3 land dropped relative to sales of poorer land. In 1917, 52.5 percent of the land sold was Class 2 or 3 while 42.9 percent of the land sold was Class 4, and 4.3 percent was Class 5 or 6. By the end of the period, Class 5 and 6 land made up a much larger portion of land sold, reaching 20.9 percent in 1925 and 28.0 percent by 1926. Second, this pattern of purchases of good land before poor land developed within townships. Even where townships were mostly settled, if some quarters of HBC land were better suited for farming, they were purchased before land that was less suited. This finding concurs with other studies of prairie settlement that have shown that most settlers preferred good land to poor land (*e.g.*, Lewry 1986, Boyd 1989).

As in the case of land quality, railways played an important role in prairie settlement. Studies have often considered distance to a railway as

a factor in the timing of prairie settlement (*e.g.*, Dick 1985; Weisinger 1985; Lewry 1986). Railways offered economic advantages of easier transport of crops to those settled nearby. Indeed, in 1911, the Saskatchewan Department of Agriculture estimated the cost of hauling grain at 0.5 cents per bushel per mile (Saskatchewan Department of Agriculture 1911, 54). The disadvantage of distance from a railway was amply expressed by homesteaders at Willow Bunch who lacked a railway for about two decades after they settled the area; some contended that hauling grain 'ate' one-third of their profits (*The Regina Leader* 1920). The location of railway service centres was even more important for farmers than the location of

Table 1: *Year of sale and distance to a railway.*

Distance to a railway (km)	Year									
	1909–1911		1912–1914		1915–1917		1918–1923		1924–1929	
	no.	(%)	no.	(%)	no.	(%)	no.	(%)	no.	(%)
0.00 – 5.00	2	1.2	24	38.1	74	25.0	17	7.7	24	18.9
5.01 – 15.00	2	1.2	18	28.6	126	42.6	54	24.3	36	28.3
15.01 – 25.00	0	0	12	19.0	60	20.3	48	21.6	28	22.0
25.01 – 35.00	7	4.3	3	4.8	25	8.4	46	20.7	18	14.2
35.01 – 45.00	8	4.9	1	1.6	2	0.7	32	14.4	11	8.7
45.01 – 60.00	28	17.2	3	4.8	6	2.0	19	8.6	4	3.1
> 60.00	116	71.2	2	3.2	3	1.0	6	2.7	6	4.7
Total	163	100	63	100	296	100	222	100	127	100

Source: Based on HBC Farm Land Records

Table 2: *Year of sale and distance to a railway service centre.*

Distance to a railway service centre (km)	Year									
	1909–1911		1912–1914		1915–1917		1918–1923		1924–1929	
	no.	(%)	no.	(%)	no.	(%)	no.	(%)	no.	(%)
0.00 – 5.00	0	0	16	25.4	39	13.2	12	5.4	18	14.2
5.01 – 15.00	3	1.8	25	39.7	148	50.0	54	24.3	40	31.5
15.01 – 25.00	1	0.6	13	20.6	72	24.3	50	22.5	30	23.6
25.01 – 35.00	7	4.3	3	4.8	25	8.4	48	21.6	13	10.2
35.01 – 45.00	6	3.7	1	1.6	4	1.4	30	13.5	16	12.6
45.01 – 60.00	27	16.6	3	4.8	1	0.3	20	9.0	4	3.1
> 60.00	119	73.0	2	3.2	7	2.4	8	3.6	6	4.7
Total	163	100	63	100	296	100	222	100	127	100

Source: Based on HBC Farm Land Records

railways since grain had to be hauled to one of these points rather than to any location along a railway. Railway service centres were located approximately every 12 to 13 km along railways (Lewis 1981).

During the first period considered, 1909 to 1911, most of the land sold (71.1 percent) was distant from a railway (Table 1). The lack of railways in the study area best explains this. Also, while some purchasers of HBC land at this time were farmers, others were ranchers. Farmers needed railways nearby, but ranchers could trail livestock 100 miles or more to a railway service centre (Gauthier *et al*. 1993, 46). After 1912, land sales followed the anticipated pattern: land closer to railways was sold before land that was further from railways. Between 1912 and 1914, most of the land sold was within 25 km of a railway, with the largest amount being between 0 and 5 km from a railway. By 1915, land sales were most often for land between 5.01 and 15 km from a railway. In later years, land at further distances, though mostly no more than 35 km from a railway, increased as a portion of sales. Because railway service centres were located along railways, the statistics of year of sale and distance to a railway revealed a similar pattern (Table 2). Again, during the earliest years, most of the land sold was very distant from a railway service centre. After 1912, the majority of land sales were much closer to a railway service centre though the percent of land sold in the classes that were nearest to a railway service centre declined over time.

Still, the analysis of distance to railways and railway service centres did not account for several important factors that would have affected grain transportation. First, terrain characteristics were not considered. Second, the expansion of the elevator system was not incorporated into the analysis. Third, the importance of planned or anticipated, rather than actual, railways was not included. Terrain characteristics influenced the ease of hauling grain. The elevator system and the availability of railway service centres expanded substantially throughout the study period. Not infrequently, settlers chose homesteads in anticipation of railway construction, although plans for the location of rail routes in the study area developed and were modified as it was settled (Saskatchewan Department of Agriculture 1905–1931; McCormick 1980; Lewis 1981; Hamilton 2007, 117–119, 191–192).

Regression analysis on 868 quarters for which complete information was available calculated the relative importance of each factor in the timing of land sales. This showed, respectively, that distance to railways and distance to railway service centres explained 23 percent ($r^2 = 0.2306$) and 22 percent ($r^2=0.2222$) of the variation in the timing of land sales. Soil capability for agriculture and price appeared less important, accounting

for 15 percent (r^2 = 0.1509) and 3 percent (r^2 = 0.0307) respectively. Yet the collective association of all factors explained only 50 percent (R^2=0.4959) of the variation in timing of land sales. As Norton and Conkling (1974) found, in their study of southern Ontario, it is probable that human factors played a role in the timing of land sales. Very likely, HBC policies would have also explained some of the remaining 50 percent of the timing of land sales. Certainly, the effects of Lord Strathcona's policy, of selling only half a section and only part of the land in a township at a time (Galbraith 1951) are apparent in Figure 9. In many cases, several years

Table 3: *Land selling price and distance to a railway.*

Distance to a railway (km)	**Price per acre ($)**									
	0.00 – 9.99		10.00 – 14.99		15.00 – 19.99		20.00 – 24.99		25.00 – 34.00	
	no.	(%)	no.	(%)	no.	(%)	no.	(%)	no.	(%)
0.00 – 5.00	2	4.2	12	4.6	35	12.1	62	30.2	30	46.2
5.01 – 15.00	12	25.0	27	10.3	77	26.6	95	46.3	25	38.5
15.01 – 25.00	15	31.3	24	9.2	71	24.6	30	14.6	8	12.3
25.01 – 35.00	5	10.4	40	15.3	46	15.9	7	3.4	1	1.5
35.01 – 45.00	5	10.4	30	11.5	16	5.5	1	0.5	0	0
45.01 – 60.00	3	6.3	48	18.3	6	2.1	3	1.5	0	0
> 60.00	6	12.5	81	30.9	38	13.1	7	3.4	1	1.5
Total	48	100	262	100	289	100	205	100	65	100

Source: Based on HBC Farm Land Records

Table 4: *Land selling price and distance to a railway service centre.*

Distance to a railway service centre (km)	**Price per acre ($)**									
	0.00 – 9.99		10.00 – 14.99		15.00 – 19.99		20.00 – 24.99		25.00 – 34.00	
	no.	(%)	no.	(%)	no.	(%)	no.	(%)	no.	(%)
0.00 – 5.00	0	0	8	3.1	25	8.7	34	16.6	18	27.7
5.01 – 15.00	14	29.2	26	10.0	79	27.3	117	57.1	34	52.3
15.01 – 25.00	15	31.3	28	10.7	75	26.0	36	17.6	11	16.9
25.01 – 35.00	2	4.2	38	14.6	48	16.6	7	3.4	1	1.5
35.01 – 45.00	8	16.7	28	10.7	18	6.2	1	0.5	0	0
45.01 – 60.00	3	6.3	43	16.5	6	2.1	3	1.5	0	0
> 60.00	6	12.5	90	34.5	38	13.1	7	3.4	1	1.5
Total	48	100	261	100	289	100	205	100	65	100

Source: Based on HBC Farm Land Records

Table 5: *Land selling price and land capability for agriculture.*

Land capability for agriculture	Price per acre ($)									
	0.00 – 9.99		10.00 – 14.99		15.00 – 19.99		20.00 – 24.99		25.00 – 34.00	
	no.	(%)	no.	(%)	no.	(%)	no.	(%)	no.	(%)
Class 2 or 3	7	13.2	117	44.8	161	55.3	152	72.7	54	83.1
Class 4	26	49.1	106	40.6	119	40.9	50	23.9	11	16.9
Class 5 or 6	20	37.7	38	14.6	11	3.8	7	3.3	0	0
Total	53	100	261	100	291	100	209	100	65	100

Sources: Based on HBC Farm Land Records and CLI *Soil Capability for Agriculture* Maps 72 G, H, I and J

separated sales of quarters within townships and sales of quarters on the same section.

Selling prices:

Distance to railways and railway service centres, land quality and the timing of sales influenced the selling price for HBC land. First, in accordance with its policies, throughout the region the HBC charged more for land nearer railways and railway service centres than for land that was further from these facilities. Land capability for agriculture further influenced prices. Table 3 shows that land nearest to a railway predominated in the highest price categories. Land that was further from a railway was more common in lower priced categories. A similar relationship is demonstrated for selling price in relation to railway service centres (Table 4). Very little land in the highest price categories was beyond 25 km from a railway service centre. Most of the land that was distant from a railway service centre sold for $10 to $14.99 per acre. The lowest price category included land at variable distances to a railway service centre, except land that was less than 5 km from a railway service centre. The timing of land sales and land capability for agriculture were potentially also involved in this pattern. Tracts of relatively poor land were found near several railway service centres, including some of the main railway service centres such as Swift Current. According to Table 5, the best land, Class 2 or 3, usually sold for at least $20 per acre. No Class 5 or 6 land fetched more than $25 per acre and little Class 5 or 6 land sold for between $20 and $24.99 per acre. Most of the land that sold for less than $10 per acre was Class 4, 5 or 6.

Regression analysis showed that during the full study period distance to railway service centres explained 22 percent ($r^2 = 0.2224$) of the variation in the price of land. Distance to railways also explained 22 percent ($r^2 =$

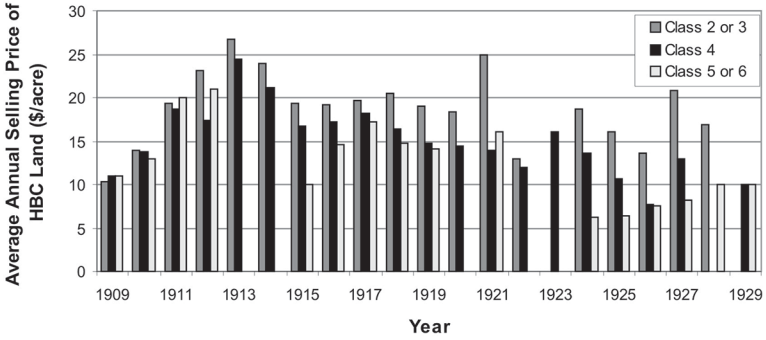


Figure 10: *Annual average selling price of Hudson's Bay Company lands and soil quality.*
Sources: HBC Farm Land Records and CLI Soil Capability for Agriculture Maps 72 G, H, I and J

0.2180), while soil capability for agriculture explained 11 percent (r^2= 0.1065), and year of sale just 3 percent (r^2= 0.0307). The limited importance of year of sale may seem surprising for two reasons. First, the prices charged for Company land peaked in 1913 and then declined as the Company sought to reduce its tax burden. Second, an increasing portion of the land sold in later years was of poorer quality. According to HBC policy, this land was to be sold for lower prices than better land (HBC *Hudson's Bay Company Proceedings* 1916, 1926; Galbraith 1951). Despite some declines in prices during poor years, the general trend of increasing prices for farm land appeared to offset HBC policies (Saskatchewan Department of Agriculture 1905–1931; Lindert 1988).

Figure 10 depicts another discrepancy in the overall pattern of better land selling for higher prices than poor land. During the earliest years of the study period, relatively good and poor land appeared to sell for nearly equal prices. As time moved on, differences developed and became pronounced. This discrepancy was investigated further. Other researchers' findings, namely, that human characteristics, including a lack of knowledge about an area, played a role in prices, directed this additional analysis (Norton and Conkling 1974). Indeed, evidence suggests that the agricultural capability of prairie land was ill known to those who first assessed it. Tyman (1975), for example, found that surveyors frequently made erroneous appraisals of farm land quality in western Canada. Early settlers in southwestern Saskatchewan, knowing little of the significant possibilities of drought, approached the area optimistically and settled in many areas that were later abandoned as ill suited to farming (Potyondi 1995).

Regression analysis showed that soil capability for agriculture played an increasing role in land prices as time moved on. Before 1918, soil capability for agriculture explained just 0.08 percent (r^2 = 0.0008) of the variation in land prices while distance to railways (r^2 = 0.3801) and to railway service centres (r^2 = 0.3789) each explained 38 percent of the variation in prices. Between 1918 and 1921, soil capability for agriculture explained 28 percent (r^2=0.2782) of the prices while distance to railways (r^2=0.3988) and to railway service centres (r^2 = 0.3829) explained 40 percent and 38 percent respectively. After 1922, soil capability for agriculture explained 32 percent (r^2 = 0.3151) of the variation in land prices while distance to railways (r^2=0.2294) and railway service centres (r^2=0.2342) each explained 23 percent. This suggests that the HBC, like settlers, may have optimistically and unknowingly appraised all land in the area before the drought. As the limits of the land became increasingly apparent, selling prices came to take greater account of land suitability for farming. In fact, during the post drought period, capability for agriculture provided the most significant explanation for differences in the pricing of land.

Table 6: *Results of regression of land capability, distance to a railway and distance to a railway service centre on land selling price.*

Year	R^2
1909	0.2116
1910	0.1350
1911	0.0635
1912	0.1405
1913	0.1267
1914	0.5325
1915	0.5318
1916	0.2412
1917	0.2448
1918	0.4877
1919	0.4682
1920	0.3813
1921 to 1923[2]	0.1459
1924	0.6692
1925	0.4953
1926	0.2290
1927	0.6420
1928 to 1929	0.7792

[1] Coefficients are for regression of land capability, distance to a railway and distance to a railway service centre on price of land per acre.

[2]Values for 1921 to 1923 and 1928 to 1929 were regressed together because of the limited number of farm land sales during these years.

Source: HBC Farm Land Records

Finally, while timing, soil capability for agriculture, and distance to railways and railway service centres were important in explaining variation in the price that the HBC charged for land, these factors clearly did not fully explain that variation. During the full study period, the collective effects of these factors explained 44 percent (R^2=0.4442) of the variation in the price. Soil capability for agriculture, distance to railways and distance

to railway service centres only explained 39 percent (R^2 = 0.3875) of the variation in price before 1918, 48 percent (R^2=0.4798) of the variation between 1918 and 1921, and 32 percent (R^2=0.3151) of the variation after 1922. Multiple regression coefficients for individual years are shown in Table 6. The explanatory value of soil capability for agriculture, distance to railways and distance to railway service centres reached 78% in 1928 to 1929, but in most years they did not explain 50% the variation in price and in several years, they explained less than 25%. From this, it is reasonable to conclude that other factors influenced HBC land prices.

Potential of speculation:

The initial analysis of purchasers' characteristics suggests a lack of entrepreneurs from outside the area who speculated for large tracts of land. First, 556 (79.5 percent) of the 699 identified purchasers of HBC land gave addresses in southwestern Saskatchewan when they entered into contract with the HBC. Only 12.4 percent of those who bought HBC land were from elsewhere in Saskatchewan. The remaining 8.1 percent of purchasers gave addresses from various locations: Ontario, Manitoba, Alberta, British Columbia, Nova Scotia, and the western, mid-western and eastern states of the United States. One purchaser gave an address in Washington while another gave an address in England. Second, the vast majority of people who purchased HBC land were farmers (74.9 percent). Again, a much smaller group had other occupations, the most common being unknown (9.0 percent) and wife (3.7 percent).

Purchase patterns also suggested that most HBC land was purchased by small local farmers attempting to expand their land holdings and choosing farm land that was for sale. Many purchasers bought one or two quarters sections in proximity to their farms (Figure 11). Nevertheless, this does not dismiss the possibility of small farmers buying for speculative intent and being ready to keep the land if it could not be sold profitably.

In contrast, purchasers who were not farmers frequently bought land near rail routes and often bought relatively good land (Figure 12). Although this does not tell whether non-farmers were speculators or people involved in other occupations who took up farming, land near rail lines was likely to increase in value. Unfortunately, as described earlier, there was no information available about whether or not these individuals improved their land (suggesting they intended to farm) or did not improve it (suggesting speculation).

Non-completion:

Voisey (1988, 44) concluded that approximately 40 percent of prairie homesteaders did not persist to gain title to their land. The lack of

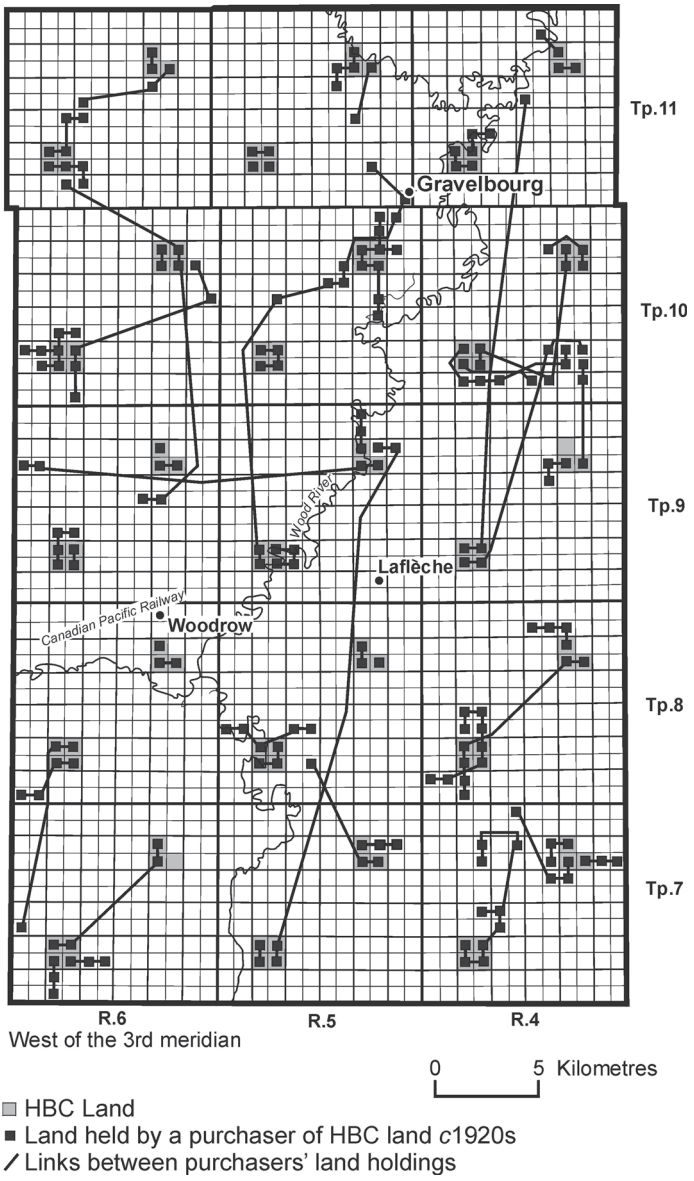


Figure 11: *Example of purchase patterns for HBC land.*
Source: Based on HBC Farm Lands Records

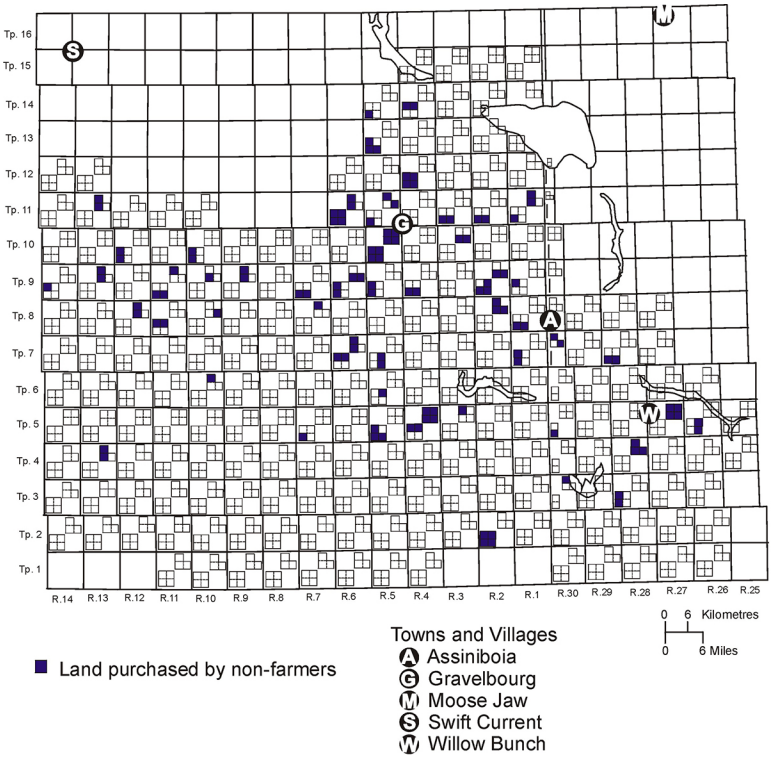


Figure 12: *Non-farmers' land purchases.*
Source: HBC Farm Land Records

Table 7: *Rate of non-completion and soil capability for agriculture.*

Land capability for agriculture	Total HBC purchases	Total transfers or cancellations	% of purchasers who transferred the land or cancelled
Class 2 or 3	295	646	45.7
Class 4	192	385	49.9
Class 5 or 6	35	79	44.3
Total	522	1,110	47.0

Sources: Based on HBC Farm Land Records and CLI *Soil Capability for Agriculture* Maps 72 G, H, I and J

Table 8: Rate of non-completion and distance to a railway.

Distance to a railway (km)	Total HBC purchases	Total transfers or cancellations	% of purchasers who transferred the land or cancelled
0.00 – 5.00	91	181	50.3
5.01 – 15.00	145	304	47.7
15.01 – 25.00	96	180	53.3
25.01 – 35.00	47	120	39.2
35.01 – 45.00	29	59	49.2
45.01 – 60.00	40	68	58.8
> 60.00	71	187	38.0
Total	519	1,099	47.2

Source: Based on HBC Farm Land Records

Table 9: *Rate of non-completion and distance to a railway service centre.*

Distance to a railway service centre (km)	Total HBC purchases	Total transfers or cancellations	% of purchasers who transferred the land or cancelled
0.00 – 5.00	62	111	55.9
5.01 – 15.00	166	348	47.7
15.01 – 25.00	103	203	50.7
25.01 – 35.00	47	116	40.5
35.01 – 45.00	28	61	45.9
45.01 – 60.00	40	67	59.7
> 60.00	73	193	37.8
Total	519	1,099	47.2

Source: Based on HBC Farm Land Records

persistence to title was equally important on HBC land. After deaths were accounted for, 46.3 percent of the remaining 689 purchasers did not persist. Tables 7 to 9 show the rate of non-completion by all purchasers on different classes of land and at different distances to railways and railway service centres. Very similar rates of non-completion were found on land of differing capability for agriculture. Rates of non-completion varied but, again, were often similar on land at different distances to railways. In fact,

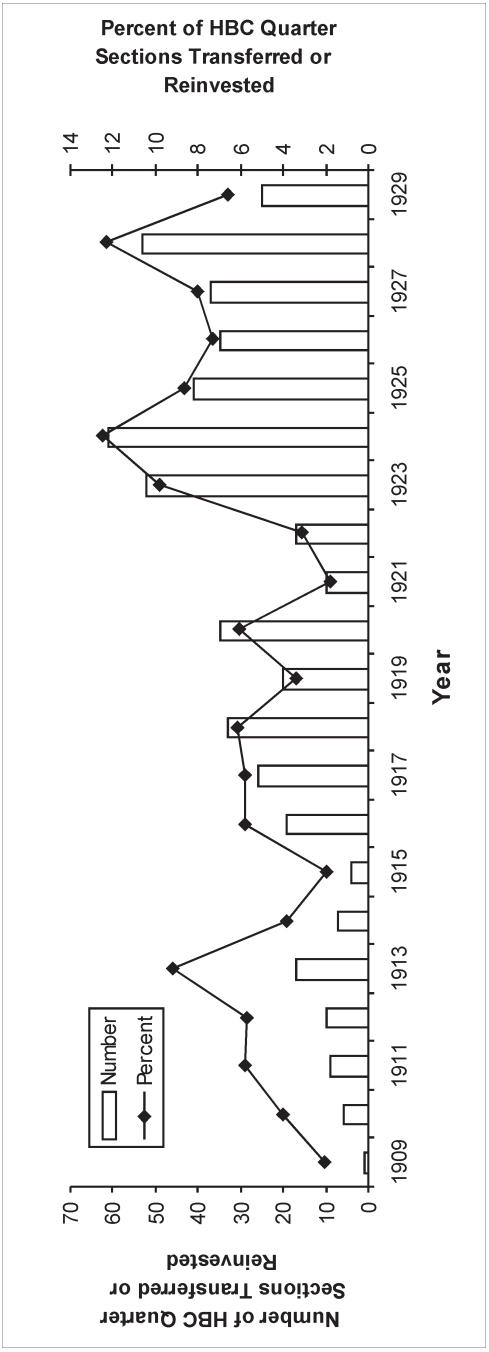


Figure 13: *Year of Transfer of Cancellation of HBC Contracts.*
Source: Based on HBC Farm Land Records

and perhaps somewhat surprisingly, the rate of departure was lowest on Class 5 or 6 land and on land that was furthest from both railways and railway service centres.

The year of transfer and cancellation of HBC contracts was also considered to determine if economic conditions and HBC policy played a role in reinvestment. As shown in Figure 13, both the number of reinvestments and the percent of HBC land that was reinvested were high during many poor years (HBC Farm Lands Registers; HBC *Hudson's Bay Company Proceedings* 1923–1924). Reinvestment continued even after the early 1920s, when the farm situation improved (HBC *Hudson's Bay Company Proceedings* 1925). The HBC policy of cancelling contracts where the land was not improved may have affected the later peaks in reinvestment. If the change in HBC policy at this time was the main reason behind cancellations and transfers, it would suggest that speculation may have been important in the study area, with many speculators loosing their land due to the change in HBC policy. Unfortunately, the lack of information on improvements to the land limits the conclusions that can be drawn about the intentions of purchasers who left the land at this time.

Table 10: *Period of sale of Hudson's Bay Company land.*

Period		Number of Quarter Sections Sold, Forfeited or Transferred
1916–1920		48
1921–1930		115
	1921–1925	32
	1926–1930	83
1931–1940		52
1941–1950		137
1951–1960		85
1961–1970		42
1971–1986		15

Source: Based on Saskatchewan Land Titles

At least some of those who left at this time were likely farmers who had planned to expand their holdings but were unable to retain HBC land if they had incurred debts during earlier, poor, years and later only harvested fair crops. Certainly, occupational patterns suggest that throughout the study period farmers reinvested land. Farmers made up only a slightly lower proportion of re-investors than of those who purchased land (72.7 percent of those who reinvested land were farmers while 74.0 percent of those who purchased land were farmers). On the contrary, reinvestment patterns suggest that some, with other occupations, may have purchased land with the intention of selling for a profit but, in the end, reinvested it. Notably, merchants and managers were not likely to persist. None of the three

managers who purchased land obtained title, and 10 of the 12 merchants who purchased land did not stay to earn titles.

Post-title period:

The temporal pattern of sales post title was mixed. Some purchasers sold their land quickly while others remained on it for years, often selling it or transmitting it to their offspring on retirement or death (Table 10)[5]. This pattern of land sales suggested the possibility that there were several types of purchasers of HBC land. First, speculators may have been among those who sold their land quickly. The increase in sales during relatively good periods, such as during the late 1920s, furthers the suggestion that speculators were among the buyers of HBC land. Second, others who left the land before the 1930s did so because of debt or death. Another group appeared to have purchased land for offspring or relatives, though, initially, they may have purchased the land for themselves but then determined to sell to offspring or other family members. The final group, who remained on the land for many years, was certainly made up in part by farmers who bought the land to expand their operations, though speculators who still had land and who had held onto it hoping for better times may have been included in this group.

Conclusions

As a result of the Deed of Surrender, the HBC gained title to one-twentieth of the farmland in western Canada. Recognizing that once the land was sold, it would no longer earn money, the Company sought to profitably dispose of its holdings. To this effect, it established policies of charging what the market would bear, including demanding higher prices for advantageously located land and limiting sales in the hope that land prices and profits would increase.

This study has provided an example of HBC policies. Land prices reflected distance to railways, distance to railway service centres, and land quality, though the effect of land quality was most apparent in later years of the study once the limits of the area were known. Nonetheless, despite their importance, these factors did not fully explain variation in the price charged for HBC land. This suggested that other things were involved in the Company's pricing of farm land.

Purchasers of HBC land behaved much as homesteaders, preferentially purchasing land that was well suited to farming in areas near to railways and railway service centres. Regression analysis showed that the factors studied (soil, distance to railways, distance to railway service centres and

prices) only explained about half of the temporal pattern of HBC land sales. Thus, it was suggested that other variables played an important role in the pattern of land sales. Human characteristics and HBC policies were suggested. At the same time, many purchasers of HBC land appeared to have elected to purchase land to expand their farming operations and likely knew of at least some limitations of the land, whether these limits were distance to railways and railway service centres or poor land quality.

An attempt was made to identify speculators, but there were important limitations to the analysis of speculation. Nevertheless, it appeared that speculators may have purchased some HBC land in the study area. Speculators may have been among those who acquired contracts but cancelled them, potentially as they, like *bona fide* farmers, became aware of the limits and the drought hazards of the area. Also, speculators may have been among those who completed HBC contracts and sold their land during better years. Unfortunately, due to data limitations, the importance of speculation remained unclear especially since farmers facing interest on debts incurred during poor years may have sold their land at times similar to speculators. To complicate matters still further, the Saskatchewan Department of Agriculture reported that speculation was limited in southwestern Saskatchewan (Saskatchewan Department of Agriculture 1916, 17). Thus, the final results of the analysis of speculation were incomplete: speculators were likely among the purchasers of HBC land, as shown in purchase and sale patterns, but they could not be adequately distinguished from other settlers. Consequently, the importance of their role as purchasers of HBC land is not clear.

Further Study

Given the significance of unexplained variations in the timing of sales and prices of land, further study of HBC farm lands is needed to determine the importance of other factors in land sales and pricing. Clarke and Brown (1987), for example, improved the results of their southern Ontario study by considering distances to roads and over-road distances to service centres of various sizes. Additional investigation along this line might involve another area with more variation in soil quality and other economic factors present in the land. But, even more so, future studies might adopt analysis that does not assume only logical behaviour. It is well known that economic decisions include a wide array of behavioural factors that are not based solely on normative behaviour (Fellman *et al.* 2007, 314). Thus, further

study that includes a detailed study of HBC pricing policies and land sales taking better account of human decision making and the underlying structures that affected the HBC governors' decisions, is desirable.

Epilogue

Although the HBC sold and surrendered part of its land in the southern part of the study area, in 1930 it still held many sections of land. Most of this land was in the Wood Mountain area. While this study of HBC land sales ends in 1929/1930, the HBC continued to sell its holdings and had sold most of its land by the 1950s. Sales declined thereafter such that by 1961 the significance of the HBC's land department was limited and it was brought under the Rupert's Land Trading Company, a wholly owned subsidiary of the HBC which had been established to hold title to the Company's real estate in Canada (Ross 1986). In 1984, the Company still owned 5,100 acres in Saskatchewan; it donated this land to the Saskatchewan Wildlife Association for use as habitat reserves (McKercher and Wolfe 1986, 11).

Notes

[1]Rice (1978) is among many authors who have conducted studies of the factors affecting land settlement patterns. Like many researchers, he found that land alienation policies, including homesteading policies, railway land grants, the granting of scrip and state grants affected settlement patterns.

[2]There are many examples including Boyd (1989), Lehr (1985), Lewry (1986) and Richtik (1985).

[3]'Railway service centre' refers to a centre along a rail line where farmers could ship grain.

[4]Park's (1984) work on the military tract in Illinois is an exception. Park also considered land purchase in an area where the tracts available were scattered.

[5]Several land titles could not be traced to the HBC land purchaser. Only the complete titles were included in this analysis.

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Interwar rail construction in Saskatchewan and Alberta: an evaluation

Charles W. Bohi, Independent Scholar, White River Junction, Vermont (*clbohi@sover.net*)
Leslie S. Kozma, Independent Scholar, Edmonton, Alberta (*Lkozma@telusplanet.net*)

Abstract: Between 1919 and 1935 over 4,600 miles (7,403 km) of new railway were built in the Prairie Provinces. More than 90 percent of these were low density branch lines built in Saskatchewan and Alberta. In 1932, the Royal Commission on Railways and Transportation, usually referred to as the Duff Commission after its Chairman, Chief Justice Lyman Duff, concluded that the construction of these branch lines was a 'disastrous' mistake. That became the prevailing view of historians and others who studied the Interwar period. In addition, many scholars blamed Canadian National and its President, Sir Henry Thornton, for causing this waste by invasions of Canadian Pacific territory. The purpose of this paper is to examine the pressures that caused so many new branch lines to be built, whether Canadian National was the aggressor, and, most importantly, whether the money spent on these lines was indeed wasted.

Key words: *railways, Saskatchewan, Alberta, Canadian National Railway, Canadian Pacific Railway*

Introduction

"Railways ... were as essential as rain and sun to progressive settlement on the Canadian prairie" (Mackintosh 1934, 46).

This outlook was the driving force behind the last great burst of rural branch-line construction in North America. Between the end of World War I in 1918 and 1935, the railways built some 4,600 miles (7,403 km) of new lines in the Prairie Provinces. Over 90 percent of these were in Saskatchewan

Table 1: *Miles (km) of track built during the Interwar period in Saskatchewan and Alberta.*

Province	CNR		CPR		NAR		Total	
	miles	km	miles	km	miles	km	miles	km
Saskatchewan	1,057	1,701	1,545	2,486			2,602	4,188
Alberta	506	814	752	1,210	425	684	1,683	2,709
Total	1,563	2,515	2,297	3,697	425	684	4,285	6,896

Sources: Based on CPR (1943); Hopper and Kearney (1962)

and Alberta. While the Canadian National Railway (CNR) and Canadian Pacific Railway (CPR) built most of these, the Northern Alberta Railway (NAR) also contributed (Table 1; Figures 1 and 2). When finished these new lines made up almost 30 percent of the rail network of the two provinces.

Surprisingly, the pace of railway construction in Saskatchewan and Alberta accelerated as the 1920s wore on. Over 40 percent of the 4,600 miles (7,403 km), including the Hudson Bay Railway and some NAR branches, were completed after 1928 (CPR 1943; Hopper and Kearney 1962). Spurred on by a very large wheat crop in that year, both CNR and CPR announced massive new branch-line construction programs that led to the construction of 731 miles (1,176 km) in 1929, the peak year. Despite the stock market crash in October, the railways continued to add lines at a brisk pace in 1930 and 1931 building a total of 969 miles (1,559 km). Even as late as 1932, they constructed 191 more miles (307 km).

With the onset of the Depression, Canadians turned Prime Minister William Lyon Mackenzie King and his Liberal Party out of office in 1930 and elected R.B. Bennett's Conservative Party to govern Canada. Trying to end the economic slump by cutting expenses, Bennett fixed on the increasing deficits of the CNR as an example of waste. Moreover, he thought the cause of this waste was the extravagant expenditures by both railways during the 1920s. To investigate further, in 1931 Bennett empanelled the Royal Commission on Railways and Transportation, usually referred to as the Duff Commission after its Chairman, Chief Justice Lyman Duff.

To make its case, the Duff Commission noted that the United States had 336 people for every route mile of railway while Canada had only 236 per mile. Saskatchewan, with over 55 percent of the new construction during the 1920s, had only 108 people per mile (Royal Commission 1932a, 39). Furthermore, all the Interwar branch lines comprised part of the 41 percent of prairie Canada's railways which carried only 4.3 percent of the traffic (Royal Commission 1932a, 37). From these data, the Duff Commission concluded that there was "no doubt as to the disastrous effects of this [branch line] competition" (Royal Commission 1932a, 21). One of the

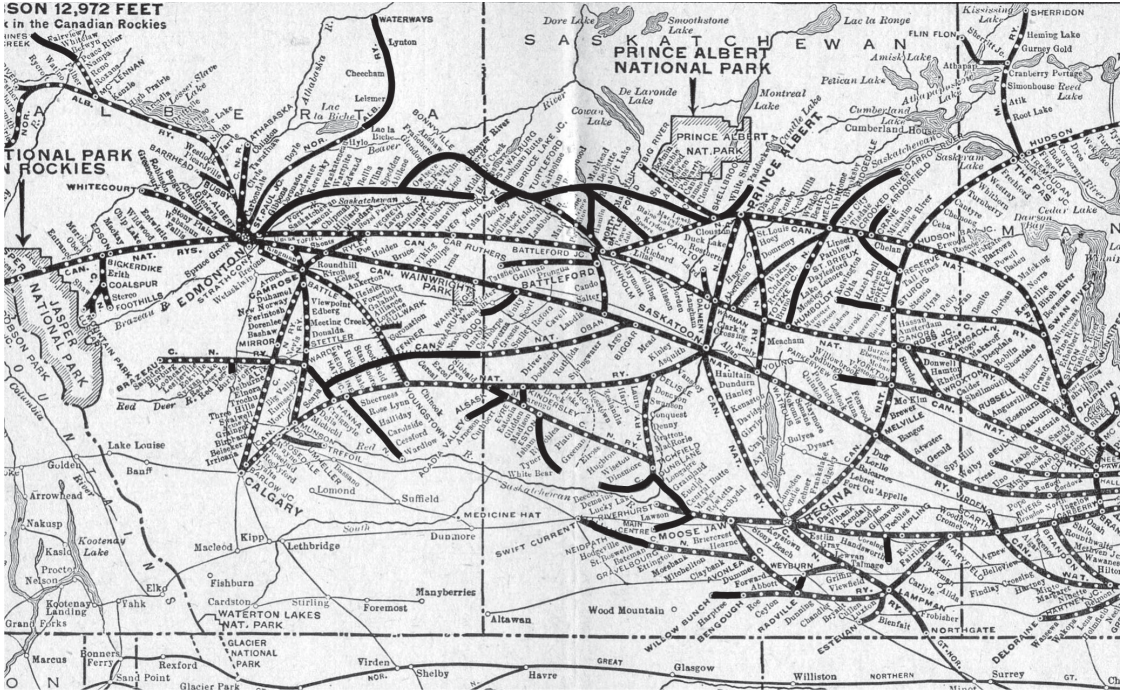


Figure 1: *Interwar CNR lines highlighted in black.*
Sources: Base map from CNR public timetable; Hopper and Kearney (1962).
East of Edmonton, the line from Beaver River, Alberta to St. Walburg, Saskatchewan was graded and may have had some track put down, but was never opened.

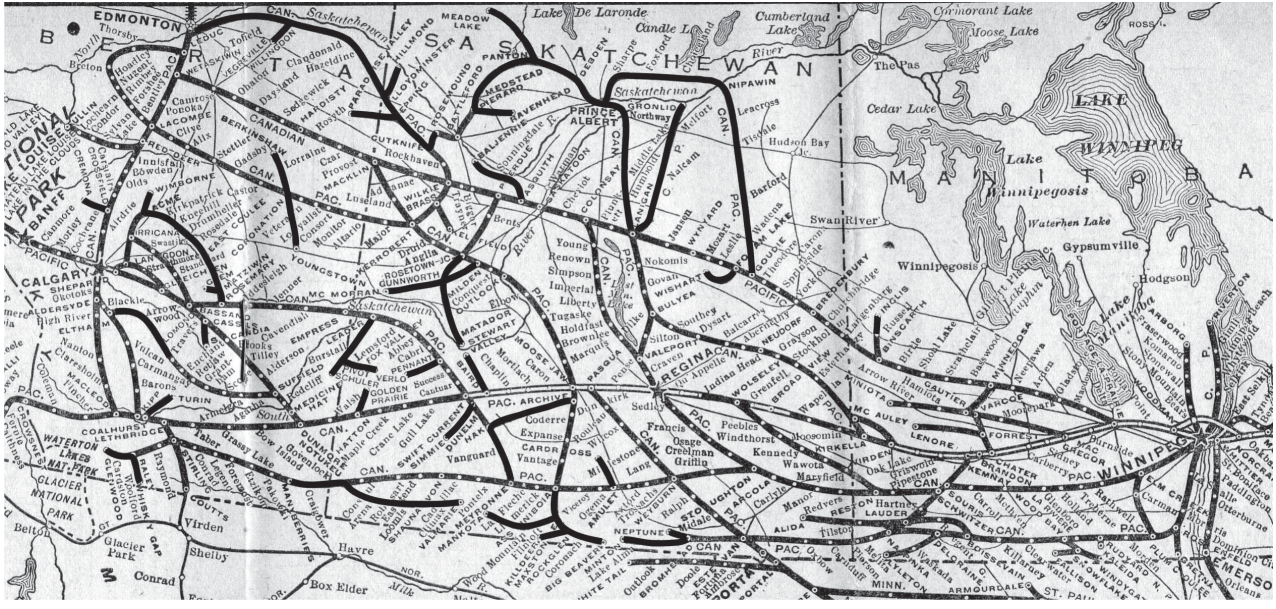


Figure 2: *Interwar CPR lines highlighted in black.*
Sources: Base map from CPR public timetable; CPR (1943)

working papers of the Commission went further saying that the "troubles of the [CNR and CPR] … constitute… perhaps the most pressing problem [facing Canada]" (Royal Commission 1932b, 7). Largely as a result of the Duff Commission study, rail construction in western Canada came to a virtual halt in 1932. The railways opened the last new grain gathering lines in 1935. Ever since this indictment by the Duff Commission the consensus among historians and other students of western Canada's railways has been that the construction of Interwar branch lines in Saskatchewan and Alberta was caused by the aggressive nature of the CNR and its President, Sir Henry Thornton and that construction was a catastrophic mistake.

To evaluate this consensus it is worthwhile to look at why these railways were built, examine whether the CNR was the aggressor during the Interwar period, and whether construction of these branch lines was a 'disastrous' blunder.

Why Were the Interwar Lines Built?

Political pressures:

Lacking a majority in the House of Commons, King was "sustained in power by a bloc of prairie members who called themselves the Progressive Party and who prosecuted to the utmost their sectional interests" (Stevens 1973, 330). "By 1920, prairie agriculture specialized in the production of wheat for export. By 1928, Canadian wheat sales constituted nearly half the world export market" (Friesen 1984, 301). In 1937, even with a very poor crop, wheat was Canada's second most important export (Britnell 1939, 50). Not surprisingly, many in prairie Canada argued that they were paying the costs of Canadian unity while other regions, especially Ontario and Quebec, reaped the benefits. After all, western wheat, sold in a highly competitive world market, generated a great deal of the money spent on manufactured goods from central Canadian industries protected by tariffs, thus financing much of the nation's industrial base (Waiser 2005, 132–133).

King, always an astute politician, knew that he could do little about tariffs without losing political support in central Canada and he was reluctant to restore the low grain rates pegged at 1897 levels – the so-called 'Crow Rate' – which had been suspended in 1918. However, the Progressives "rallied in support of the Crow … and King was cornered…" (Waiser 2005, 265). The rate was restored. As well, there were many questions about the practicality of the railway to Hudson Bay. The railway was ardently desired by western Canadians but King was reluctant to proceed. Having even less support after the 1926 election … "the

Progressive Party immediately put its pistol to [King's] head" and insisted on completion of the Hudson Bay Railway (Stevens 1973, 337).

Western desire for new branch lines was vividly shown by the reaction when Canada's Senate, controlled by the Conservative Party, blocked the CNR's branch-line construction programs of 1923 and 1924. Provoking traditional western anger about eastern elites allegedly growing fat from the sweat of western farmers, no doubt the *Eastend Enterprise* spoke for many when it called the Senate "the tool and mouthpiece of Eastern interests … sacrificing the interests of the Province of Saskatchewan" (*Eastend Enterprise* 1924, 1). Given such western vehemence, whatever King's personal views, he no doubt found it a political necessity to support new branch lines.

Economic concerns:

A severe economic recession gripped the world in 1921. The price of wheat had collapsed from $2.32 per bushel ($85.25 per tonne) in 1919 to 76 cents per bushel ($27.93 per tonne) in 1921 (Fairbairn 1984, 248). Before World War I, building the 'wheat economy' had created such a high rate of economic growth that historian Alan Artibise has argued that it was "sufficient to vitalize … the entire Canadian economy and to diffuse this economic vitality throughout the North Atlantic trading area" (Artibise 1981, 22). Given the stimulus that building the 'wheat economy' had provided in the past it is not surprising that King felt that renewing investment in transportation and grain handling infrastructure would revive Canada's economy. Not only would farmers benefit from shorter hauls to elevators, but renewed railway construction would also stimulate the steel and other industries in central Canada while building new elevators would help bring additional business to British Columbia's forest industry.

Urban rivalries:

With manufacturing largely concentrated in central Canada, in the West "[t]owns existed to serve the farmer …" (Friesen 1984, 324). The best chance for large and medium-sized towns to grow was to become distribution centres through which tires, hardware, farm machinery and other necessities of life could reach the villages, hamlets and those on the farms. To enlarge their hinterlands in the early years, communities eagerly sought railways because they were the only means to extend their urban hinterlands. Of course, the champion distribution centre in western Canada was Winnipeg. To giant freight stations in the city came all manner of merchandise from central Canada. "From there," wrote historian James H. Gray, "it moved out again into consumption in the wake of a small army of traveling salesmen who carried their order books as far afield as the Peace

River" (Gray 1966, 2–3). While the urban network was largely set by 1920, smaller centres like Camrose, Alberta, and North Battleford, Prince Albert, Estevan and Weyburn in Saskatchewan became enthusiastic supporters of new branch lines that they hoped would enlarge their role as wholesale distribution centres. Certainly the CPR felt it was "under heavy pressure from Northern distributing points such as Prince Albert and North Battleford to provide rail connection … so that these communities might share in the trade of new areas which might be opened up by its branch lines" (CPR 1932, L30). The CNR, as the following quotation from the *Camrose Canadian* (1922, 4) shows, was also under pressure from smaller centres for more railways.

> It will be a disappointment if The Alliance branch is not to be connected up with Coronation, a distance of only thirty miles. The wholesale businesses of Camrose have waited for years to have this additional territory ….

Swift Current vigorously promoted a railway bridge over the South Saskatchewan River to gain access for its wholesalers to rural communities to the north. Serving a hinterland of over 25,000 mi^2 (64,750 m^2) with 124,000 people, Swift Current was, its Board of Trade argued, the 'natural distribution centre of south-western Saskatchewan.' While it appreciated the new railway branch lines being built in its area, the lack of a bridge across the South Saskatchewan meant "*that farm producers and merchants located within 30 miles north of Swift Current [found] it practically impossible to communicate with the city*" (Emphasis in the original). Beyond that, the bridge would shorten the distance to the Hudson Bay Railway. If the new bridge were built, rates "would favor Swift as far west as Glidden, Kindersley and Alsask [on the CNR] and McMorran and Gunnworth [on the CPR] beat[ing] Saskatoon in much of the area North of the River" (Smith 1931).

Nevertheless, sometimes proposed new railways could exacerbate urban rivalries. Seeing itself as the "logical centre from which to distribute … products through the province and beyond," Estevan was ready to do battle to defend its hinterland (*Estevan Mercury* 1927a, 1, 3). When the CNR proposed to build a line from Weyburn to the former CNoR branch-line junction at Radville, the *Estevan Mercury* warned in a front page headline that "WEYBURN PLOTS RAID ON SOUTH COUNTRY TRADE." By creating a better link between Regina and the south country, Moose Jaw was also alarmed about the new railway. The story went on to describe how the "Moose Jaw and Estevan Boards of Trade would oppose the Branch Line Bill Authorizing Radville Branches." Most of the area was

already well served by railways and Weyburn was "asking the expenditure of public monies on an enterprise that will … do lasting injury to … Moose Jaw and Estevan…[and] in self preservation, it is the duty of Estevan to checkmate the daring raid of Weyburn on the national treasury" (*Estevan Mercury* 1927b, 1).

Naturally, Weyburn felt differently about the line to Radville. Not only did they hope it would be built, but they also agitated for further CNR construction in the border country of southern Saskatchewan. This would, Weyburn's leaders felt, "largely add to their distribution territory" (Dunning 1925).

Similarly, in northern Saskatchewan, the CNR mollified North Battleford's business community by delaying a connection to its Turtleford-Speers line to Prince Albert for a year, "in order that North Battleford might be given the opportunity to preserve what they consider as their territory north of their city against the inroads that might be made by the City of Prince Albert …" (Gzowski 1928). No doubt many other instances of urban rivalry took place during the 1920s railway construction boom.

Vast Areas Not Served

The Canadian Northern (CNoR), the CNR's largest predecessor in western Canada, had an extensive system in northern Saskatchewan and Alberta but there were very few branches north of its mainline west of North Battleford, Saskatchewan. This meant that grain growers north of the North Saskatchewan River had to overcome a difficult crossing of the river as well as haul their grain great distances to deliver to elevators on the CNoR mainline in western Saskatchewan and eastern Alberta (Figure 3).

Similarly, although the CPR had built an extensive system in Saskatchewan and Alberta by 1919, it had very little north of its line from Yorkton west through Saskatoon to Wetaskiwin, Alberta. Nor did it serve southwest Saskatchewan south of its line from Weyburn through Assiniboia (Figure 4). This left farmers in the border country with long hauls to grain delivery points.

Relying almost entirely on horse drawn wagons and sleds to haul their grain, getting harvests to elevators was difficult for farmers even if delivery points were nearby. After World War I, there were large areas that were far from railheads. Exacerbating problems caused by these long hauls was the state of the roads used by farmers wanting to deliver grain to elevators. The 1931 Canadian Census reported that over 97 percent of the

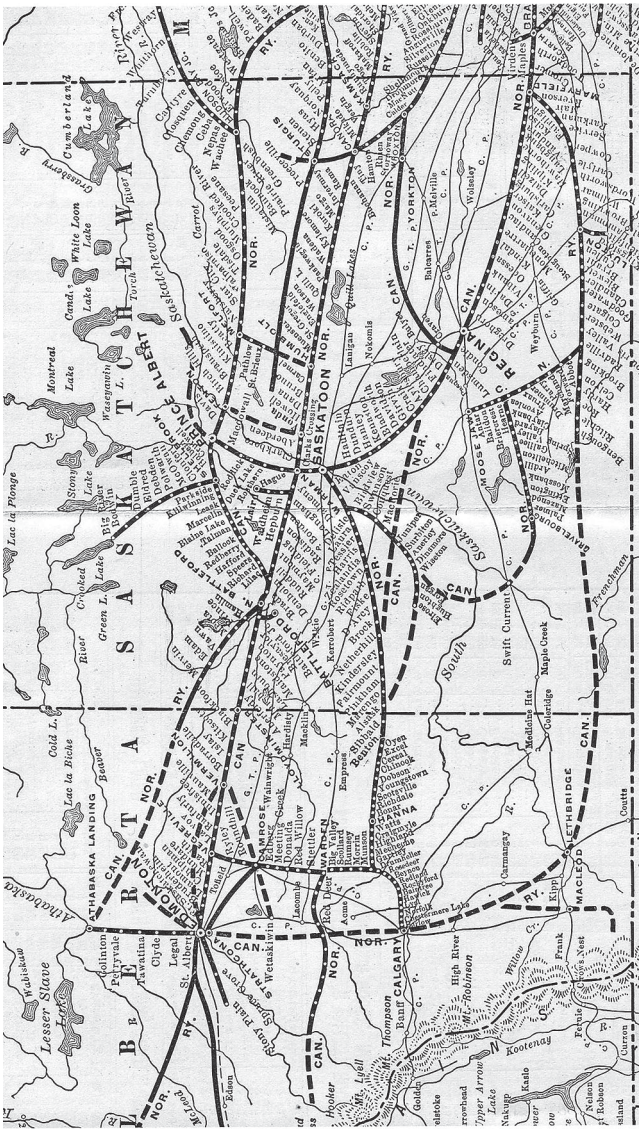


Figure 3: *CNoR in Saskatchewan and Alberta in 1917.*
Source: CNoR public timetable

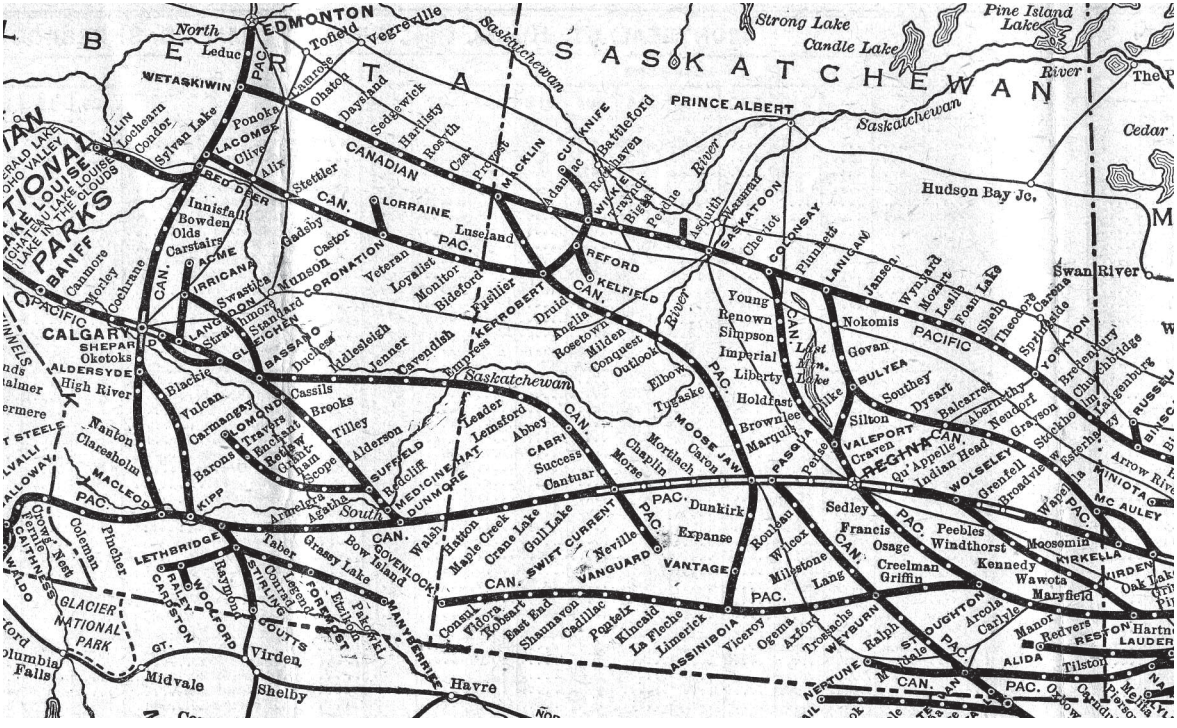


Figure 4: *CPR in Saskatchewan and Alberta in 1919.*
Source: CPR public timetable

farms were on either improved or unimproved dirt roads (DBS 1936, 628, 696). Making matters worse, in Saskatchewan the deficient road system actually deteriorated during the Depression and World War II (Robbins and Lamb 1970, 222). Nor did the Province maintain its rudimentary road system in the winter until the mid-1950s (Smith 1993, 23).

Besides the poor roads, significant geographical barriers hindered grain delivery. Large rivers, such as the North and South Saskatchewan, Battle and Red Deer, effectively cut off whole regions from railways. Even a relatively minor stream, such as the Frenchman River in southwest Saskatchewan, could present a serious obstacle to farmers trying to carry their grain to an elevator. In justifying the construction of three branch lines south of Assiniboia, for example, the CPR noted that settlers living in the border country faced an "uneconomical haul … involving … fording of rivers and ranges of hills" (CPR 1932, L30). Similarly, the branch from Rosetown to Perdue, Saskatchewan was built for farmers "shut off from existing lines by Valley of Kneehill Creek" (CPR 1932, L32).

The increasing use of automobiles and trucks did not stem the demand for new branch lines. During the 1920s, competition from motor vehicles undoubtedly undercut passenger revenues of all branch lines, including those built between the wars. Like most branch lines in Saskatchewan and Alberta, those built between 1919 and 1935 usually had only 'mixed trains' that handled both freight and passengers. Often operating on a less-than-daily basis, they did not provide convenient links for those wanting to travel any distance. No wonder residents of the two provinces had purchased 107,911 automobiles by 1931 (Britnell 1939, 41).

Freight, however, was another matter. With just 18,257 trucks in service by 1931, only a small fraction of the more than 225,000 farms in Saskatchewan and Alberta had them (Britnell 1939, 41). Furthermore, the low Statutory Grain Rates – the so-called 'Crow Rate' – based on 1897 tariffs, which even in the 1920s made shipping grain cheaper in western Canada than for comparable distances in the United States, gave farmers powerful incentives to want elevators as close as possible (Parker 1932, 183).

Given his need for western political support, the terrible economic recession he faced on coming to power in 1921, as well as the desires of urban and rural dwellers alike for new railways, it is not surprising that King was willing to support branch-line construction in Saskatchewan and Alberta in the Interwar period.

Was the CNR the Aggressor?

Examination of the railway map in Saskatchewan and Alberta after 1935 would raise serious questions about whether the CNR aggressively invaded CPR territory during the Interwar period. After all, the CPR still maintained a virtual monopoly on the vast region south of its mainline from Moose Jaw to the Rockies. In part, this was because CNR President Thornton was prepared to be reasonable. Before World War I, the CNoR had completed a line to Bengough, Saskatchewan that was projected to be built to the coalfields around Lethbridge. However, because of previous commitments to Willow Bunch, Thornton was prepared to stop construction after building a short 28-mile (45 km) link from Bengough to Willow Bunch as long as the CPR provided adequate rail facilities in southwestern Saskatchewan (Anon 1926). To keep its end of the bargain and to make certain that the CNR did not build beyond Willow Bunch, the CPR filled the border country with nearly 200 miles (320 km) of new railways between 1927 and 1929 (CPR 1943).

In an era when everything moved by rail, serving large trade centres was very profitable. After all, manufactured goods and Less than Carload Lot (LCL) merchandise moved at much higher rates than did grain. In 1936, for example, manufactured goods accounted for 20.2 percent of the CPR's tonnage but garnered 22.85 percent of its revenue. LCL was even more lucrative accounting for 2.84 percent of tons carried but 7.30 percent of revenue (CPR 1937, 47).

To expand its merchandise business the CNR did reach for three important trade centres monopolized by the CPR: Swift Current, Saskatchewan, and Red Deer and Medicine Hat, Alberta. Even in the Depression year of 1930 these three trade centres did more than $10,000,000 worth of business (DBS 1934, 790–791, 874–875). While reaching Red Deer involved only a short spur off its line to the Brazeau coal country, attaining Swift Current and Medicine Hat proved impossible in the face of spirited CPR counter construction.

The CNR ultimately approached Swift Current from two directions (*Swift Current Sun* 1929, 1). From the southeast it extended its line from Gravelbourg in 1922 and 1924. This line was built into the city and joint use of some CPR facilities was arranged. However, it was never operated regularly beyond Friend, about 15 miles (24 km) east of Swift Current. To protect its position in Swift Current the CPR built several lines that constricted the hinterland of the CNR's branch from Avonlea to Swift Current (CPR 1943; Hopper and Kearney 1962).

From the northeast the CNR built toward Swift Current from Mawer, on the former Grand Trunk Pacific (GTP) branch from Moose Jaw to

Riverhurst, in 1931. Not only would this tie Swift Current to Moose Jaw and Regina, but also with other new construction, it would create a through route to Saskatoon, a route the CPR could not match. Acting quickly, the CPR built a line to Stewart Valley, 20 miles (32 km) north of Swift Current that lay directly across the CNR's proposed extension (*Swift Current Sun* 1925, 1). From that line a bridge over the nearby South Saskatchewan River could be built to connect to existing CPR lines to create a through route to Saskatoon. Despite agitation from Swift Current the bridge was never built (CPR 1943; Hopper and Kearney 1962).

With over $4,000,000 of retail business in 1930, Medicine Hat, one of the major cities in western Canada, was an even more tempting target (DBS 1934, 874**)**. CNR's attempts to approach Medicine Hat from the north only got as far as the Red Deer River south of Wardlow in the face of CPR's unwillingness to grant trackage rights into the city. Moreover, even if the branches that the CPR built into the sand hills country between its mainline and the South Saskatchewan River were to serve farmers as the company alleged, they also had the effect of pre-empting any plans the CNR may have had about building west from Swift Current to Medicine Hat (Figure 5).

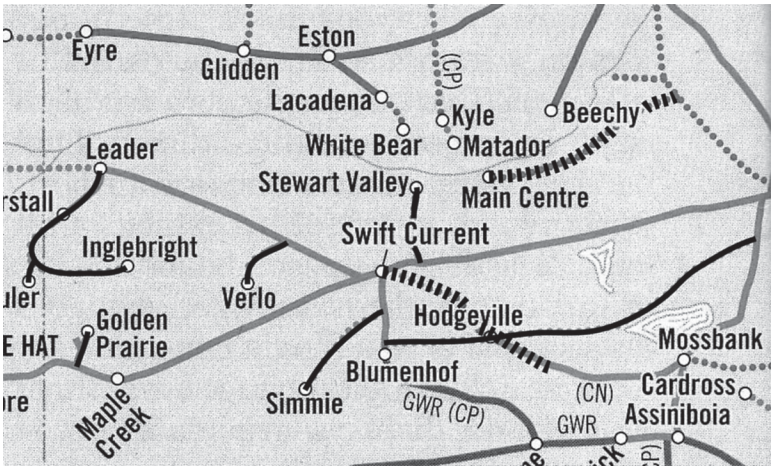


Figure 5: *CNR and CPR construction around Swift Current in the Interwar period.*
Sources: CPR (1943); Hopper and Kearney (1962)
The cross hatched lines were those built by the CNR to reach Swift Current. The lines in black were built by the CPR to protect its position in the city. The branches to Verlo, Ingebright, and Golden Prairie, Saskatchewan, had the effect of protecting Medicine Hat from CNR invasion.

The allegations notwithstanding about an aggressive CNR invading its rival's territory at every turn, the fact remains that the CPR succeeded in maintaining its monopoly in southwest Saskatchewan and southern Alberta. Moreover, this region included major trade centres such as Swift Current, Medicine Hat and Lethbridge, as well as the lucrative coal traffic from mines around the latter city that produced 600,000 tons of coal in 1926 (DBS 1926, 78).

However, the CPR aggressively invaded CNR territory in northern Saskatchewan by building more than 700 miles (1,127 km) of railway north of its Yorkton-Saskatoon-Wetaskiwin line. In addition to reaching fertile grain country, these new railways invaded six important trade centres along the former CNoR mainline. In 1930, these CNR towns had a combined population of 22,194 and retail trade worth nearly $26,000,000. While these communities represented only 2.4 percent of the province's population their retail trade represented almost 14 percent of the provincial total (DBS 1934, 790–791). The importance of the LCL freight to the CPR is illustrated by the fact that while they shared passenger facilities with the CNR in cities such as North Battleford, Humboldt and Prince Albert, they built their own impressive freight stations in these important trade centres. Ironically, though it was accused of aggressively invading its rival's territory, in fact, the CNR allowed the CPR to use its lines to reach both Prince Albert and North Battleford by granting it trackage rights into both cities (Figure 6; Table 2).

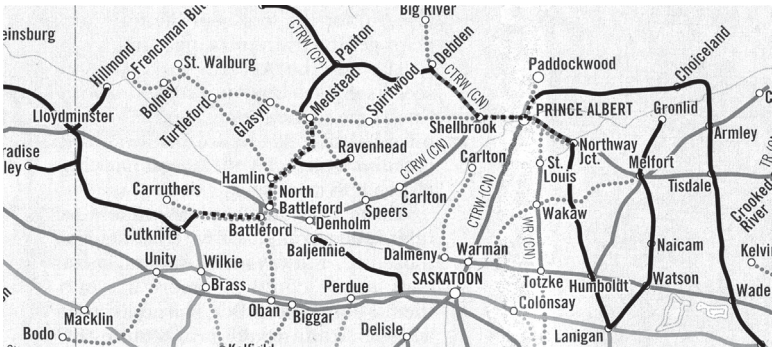


Figure 6: *CPR invasions of CNR territory in northern Saskatchewan.*
Source: Adapted from CPR (1943)
Lines built by CPR after 1919 that invaded CNR territory in northern Saskatchewan are shown as bold black lines. Trackage rights granted by CNR to CPR are shown as dashed black lines.

Table 2: *Seven CNR trade centres invaded by the CPR after WWI.*

Trade Centre	Population 1931	Percent of Population	Retail Trade 1931 ($)	Percent of retail Trade	Year CPR Arrived
Saskatchewan	921,785	100.00	189,181,100	100.00	
Humboldt	1,899	0.21	1,295,700	0.68	1930
Lloydminster	1,516	0.16	3,997,600	2.11	1926
Melfort, SK	1,809	0.20	6,287,000	3.32	1924
North Battleford	5,986	0.65	7,495,700	3.96	1930
Prince Albert	9,905	1.07	5,165,200	2.73	1930
Tisdale	1,069	0.12	1,649,500	0.87	1924
Total of six trade centres	22,184	2.41	25,890,700	13.69	
Alberta	731,605	100.00	176,537,100	100.00	
Vegreville	1,659	0.23	1,012,800	0.57	1930
Total of seven trade centres	23,843		26,903,500		

Source: Based on DBS 1934, 790–791, 875

In 1929, the CPR completed the Willingdon line between Lloydminster and Edmonton. Running through the North Saskatchewan River country, it was a clear invasion of territory that was served by the former CNoR mainline (Figure 7). In a further invasion of CNR territory, the CPR built a short branch south from Willingdon to Vegreville, on the former CNoR mainline 60 miles (97 km) east of Edmonton. A significant trade centre of 1,659 people that conducted over $1,000,000 in retail trade in 1930, the CPR thought this community had enough potential to build **both** an impressive passenger station and freight depot (DBS 1934, 875; Bohi and Kozma 1993). Probably in response, the CNR built a striking new depot in Vegreville in 1930 (Bohi and Kozma 2002). No wonder that S.J. Hungerford, CNR Vice President, in a memo to President Thornton bitterly observed: "[The Willingdon Line] is another case like that of the Tisdale branch in which, by the refusal of Parliament to allow us to carry out our plans in full, the Canadian Pacific have been afforded an opportunity to appropriate to themselves valuable territory within our sphere of influence, largely populated by our efforts. Of course, nothing can be done about it, but the result is exasperating to say the least" (Hungerford 1924).

The most serious CPR incursion into CNR territory in Alberta, however, was at Drumheller in the heart of the Red Deer Valley coalfields. One of the coal railways that were considered "the most successful of all Canadian Northern ventures" (Stevens 1962, 68), the Drumheller coalfields generated so much traffic that the CNR had double track from Munson, 11 miles (18 km) north of Drumheller, to Wayne, nine (14 km) miles to the southeast as late as 1939 (CNR 1939).

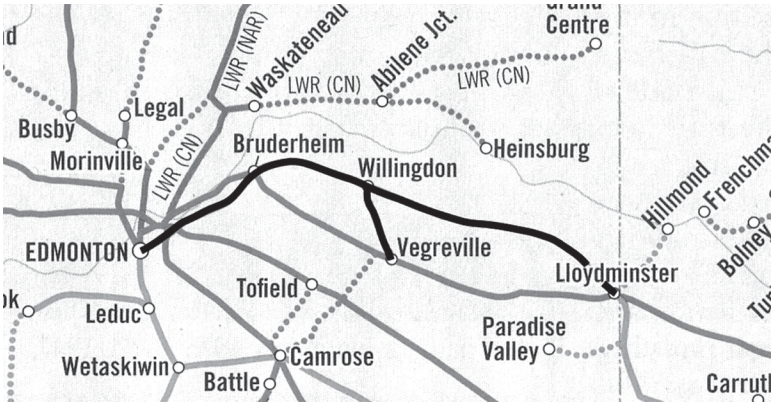


Figure 7: *CPR's invasion of the North Saskatchewan River country in Alberta.*
Source: CPR (1943)
Lines built by the CPR after 1919 to invade North Saskatchewan River Country in Alberta are shown in black.

Wasting no time trying to get a share of the Drumheller business, in 1919 the CPR succeeded in obtaining permission from the Board of Railway Commissioners to build into the Drumheller coalfields. Ultimately, the CNR granted them trackage rights through the city to Rosedale and built a joint line south of that point through East Coulee.

Given that in 1926 the Drumheller District was producing over 1,300,000 tons of coal that was distributed throughout the prairie west, it is not surprising the CPR built several branches to move Drumheller coal (DBS 1926, 78). These lines, that later appeared superfluous, included a branch from Perdue, Saskatchewan south through Rosetown to Gunnworth where it met a line from Milden to McMorran. The McMorran line was projected to Empress, Alberta, 13 miles (21 km) west of Leader, Saskatchewan, where it would join with other branches to Drumheller to create a less circuitous route from there to Saskatoon, a major coal distributing point (Figure 8).

At the time, in his testimony before the Duff Commission, Starr Fairweather of the CNR's Bureau of Economics, estimated that, while the CNR had invaded 3,570 mi^2 (9,246 km^2) of CPR territory, the CPR had encroached on 10,375 mi^2 (26,871 km^2) of CNR area. Of the undeveloped area earmarked for the CPR, the CNR built into 100 mi^2 (259 km^2). Conversely, the CPR built into 4,500 mi^2 (11,655 m^2) of undeveloped territory earmarked for the CNR (Fairweather 1931, 47–48). Moreover, as historian W. Kaye Lamb noted, [CPR President Edward] "Beatty was not averse to invading territory that the Canadian National regarded as exclusively its own" (Lamb 1977, 312).

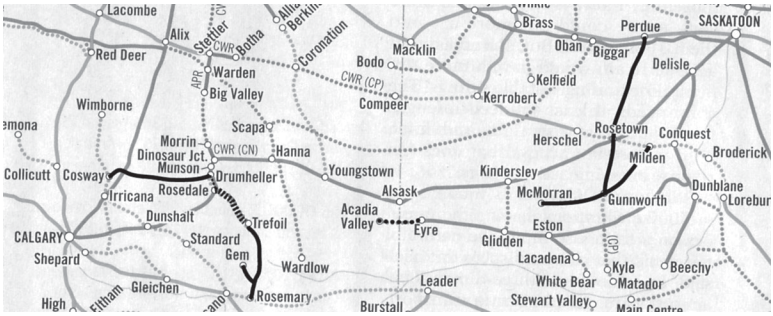


Figure 8: *CPR lines built to invade and serve Drumheller coalfields after WWI.*
Sources: CPR (1943); Hopper and Kearney (1962)
CPR lines built to invade the Drumheller area are shown in black. The CPR had trackage rights on dashed line from Drumheller to Rosedale. The cross hatched line between Rosedale and Trefoil was a joint line. The CPR built the branches in Saskatchewan, highlighted in black, to create a shorter route from Drumheller to Saskatoon. The CNR branch from Eyre, Saskatchewan to Acadia Valley, Alberta, highlighted by black dots, was projected to the Red Deer Valley at Trefoil.

Given the CPR's aggressiveness and the CNR's willingness to co-operate with it by granting trackage rights into major trade centres, the charge that the CNR was the aggressor in the interwar construction of branch lines is not supported by the evidence.

Was Building These Lines a 'Disastrous' Mistake?

Virtually all the Interwar branch lines in Saskatchewan and Alberta were built to serve grain growers. To evaluate whether the nearly $100,000,000 spent on these lines was, as the Duff Commission and later observers said, a 'disastrous' mistake, it is necessary to look at how well these railways served farmers and others (Royal Commission 1932a, 21).

Some of the Interwar lines were about moving coal, not grain. One of these was the 38-mile (61 km) line between Altawan, Saskatchewan, on the Alberta border west of Consul, and Manyberries, Alberta. Previously, coal headed from Lethbridge for towns like Shaunavon in southwest Saskatchewan had to move by a circuitous route of up to 679 miles (1,093 km) through Moose Jaw and Weyburn. Though a new line from Moose Jaw to Assiniboia cut the route to 542 miles (872 km) in 1917, when these 38 miles (61 km) were opened in 1922, it meant that coal for Shaunavon had to go only 224 miles (360 km), saving residents in the area significant amounts of money (*The Morning Leader* 1919, 9, 11).

Another role played by the new lines was to provide service centres where farmers could obtain supplies such as oil, coal and other necessities of life. A total of 605 'stations,' locations where railways built sidings and other facilities, were sited along the Interwar railways. By 1936, 57 (9.4%) locations had the 50 residents needed to be incorporated as a 'village,' and three communities had the 500 people needed to incorporate as a 'town' (Mackintosh 1935, 96; DBS 1938). Equally important, 143 (23.6%) had enough business to warrant the construction of permanent depots, the structures that served as the railway's local office at a station. These replaced the simple portable buildings that most had initially (Bohi and Kozma 1993; 2002). The fact that nearly a quarter of the new stations had enough traffic to justify the erection of such buildings is a good indication of a high level of commercial activity at these locations (Table 3).

But these raw numbers do not convey the importance of the communities that grew up along the Interwar branch lines. The CPR 79-mile (127 km) Fife Lake Subdivision between Assiniboia and Big Beaver in southern Saskatchewan offers a good example of the role these communities played in the lives of rural areas years after they were founded. Of the 14 stations along the line, 10 were part of a detailed examination published as the *The Weyburn Region* (Channon *et al*. 1971, 5).

These communities provided business services to their inhabitants and surrounding farmers. Even in 1960, eight had coal dealers that distributed 68 cars of this crucial fuel. In 1969, all 10 still had post offices, six had general stores and a seventh, the largest incorporated village on

Table 3: *Community development along Interwar branch lines.*

	Saskatchewan		Alberta		Total	
	No.	Percent	No.	Percent	No.	Percent
CNR Stations	155		74		229	
Villages	19	12.3	6	8.1	25	10.9
Towns	1	0.6	1	1.4	2	0.9
Permanent depots	45	29.0	27	36.5	72	31.4
CPR Stations	237		139		376	
Villages	21	8.9	11	7.9	32	8.5
Towns	1	0.4			1	0.3
Permanent depots	49	20.7	22	15.8	71	18.9
Total Stations	392		213		605	
Villages	40	10.2	17	8.0	57	9.4
Towns	2	0.5	1	0.5	3	0.5
Permanent depots	94	24.0	49	23.0	143	23.6

Sources: Based on DBS (1938, 367–379, 837–847); Bohi and Kozma (1993, 2002)



Figure 9: *CPR locomotives at Flintoft, Saskatchewan.*
Photograph: C. Bohi, 10 July 1984
Though their role in prairie life was much reduced by the 1980s, even then, railways and trains formed a part of the lives of many rural residents. The locomotives are switching to the elevator track at Flintoft, a hamlet located southwest of Assiniboia. Opened in 1928, the branch line to Mankota is now abandoned.

the line, Rockglen, had a grocery store. Seven also had gas stations. Farmers could obtain bulk oil deliveries from dealers in seven of the 10 stations. Lumber yards at Rockglen and Coronach provided access to that important product. No wonder three of these stations grew large enough to have permanent depots, though Fife Lake did not obtain its building until 1944 when a depot from elsewhere was moved in (Bohi and Kozma 1993).

However, these communities were more than just places where farmers bought what they needed. They were also social centres that gave residents of the area opportunities to break the isolation of sparsely populated rural Saskatchewan (Figure 9). Schools were important to the unity of communities. Of the 10 stations, six had an elementary school and two, Rockglen and Coronach, had a high school. Five had a total of eight ice rinks, an important part of rural community life, and five also had churches (Channon *et al*. 1971).

If the station was no longer the centre of rural life in 1970, local histories recalled a time when the coming and going of the trains did much to regulate the rhythms of a community.

> 'In 1928, the train came to Big Beaver three nights each week – Monday, Wednesday, and Friday. The mail came in on the train …
>
> 'On train nights, the stores were open until 11 p.m. – other days they closed at 6 p.m. By the time the girls who worked in the store got the sweeping and cleaning done, it was generally 12 p.m. or later. Then if company came, it was still later …
>
> 'Sometimes, if there was a dance in Big Beaver on a train night, people would come from Buffalo Gap [six miles (10 km) to the west] to the dance and return on the train the next morning.
>
> 'A good time was had by all on train nights in Big Beaver' (BBHS 1983, 51–53).

While country schools and churches provided opportunities for social interaction, it was the railways that created communities and gave access to needed supplies as well as social events. With most branch lines complete, in 1931 nearly two-thirds of the 233,880 farms in Saskatchewan and Alberta were within 10 miles of a 'market town' while only three percent were more than 25 miles (40 km) away (DBS 1936, 630, 698).

It was, however, the access to market offered by the Interwar branch lines that determined whether their construction was a waste. Clearly, Canada faced some tough choices after World War I. It could forgo the wheat grown in areas far from the railways that existed at that time, or make a large investment in transportation infrastructure. Construction and maintenance of all-weather roads could have created financial burdens on federal and provincial governments that equalled or exceeded the nearly $100,000,000 spent building the Interwar branch lines. Moreover, given the drastic drop in wheat prices after World War I, it is not likely that many farmers had the capital to invest in the trucks to use such roads even if trucking technology had been equal to the task (Royal Commission 1932a, 21).

In the 1920s, it was estimated that it cost three-quarters of a cent to move a bushel of grain one mile (1.6 km) from the farm to an elevator (Debates 1924, 274–285, 319). At that rate, it cost about eight cents to move a bushel 10 miles (16 km), 15 cents for 20 miles (32 km) and about 23 cents to haul it 30 miles (48 km). As prices dropped after World War I nearby elevators became even more crucial. For example, while a 10-mile haul represented 3.8 percent of the $2.32 paid for a bushel of wheat in 1919, in 1923 it represented 11.5 percent of the 65 cents a bushel brought in 1923.

Given these conditions, building the Interwar branch lines was essential if farmers in vast areas were going to be able to profitably grow grain (CPR 1932, L28–29).

Data presented during the Senate debate about 11 grain gathering CNR branch lines in 1924 offer a good indication of the choices facing Canada in the early 1920s. The estimated cost of these 397 miles (639 km) of railway was $9,500,000. It was believed that they would handle more than 10 million bushels of grain as well as 2,755 cars of other freight. Importantly, at three-quarters of a cent per bushel mile, these new branch lines would save the farmers they served over $1.3 million dollars a year, a return on investment of more than 13 percent (Debates 1924, 274–285, 319). As part of its submission to the Duff Commission, the CNR detailed 1929 operating cost data on its branch lines built between 1923 and 1930. Among these were 10 branch lines debated in 1924. These lines had gross revenues of $210,000 and expenses of $508,000 for a net branch-line loss of $298,000, a seemingly damning number. However, because cars handled on these lines almost always traveled on other parts of the CNR – grain went to the Lakehead or industrial goods had a long haul from central Canada, for example – they contributed over $937,000 to the revenues of the rest of the CNR while adding expenses of only $722,000. In short, they contributed over $215,000 to the company's net. However, this was not sufficient to overcome the direct losses of the branch lines so the total system net loss from operation was almost $85,000. After adding interest costs of five percent on the capital invested the 10 branch lines lost $428,000 (CNR 1932). All of this would seem to confirm that these branch lines were a financial disaster. However, using the data about farm savings from 1924, the 10 railways saved farmers almost $1,292,000. Subtracting the total loss, including interest, from these savings leaves a net profit of $864,000 (Debates 1924, 274–285, 319). When the net profit from these farm savings is included, there is a return of over 12 percent on the $6,895,000 invested. Had these branch lines not been built, the farmers would have incurred much higher costs or not been able to continue growing grain at all.

Beyond that, few areas in the industrialized world were hit as hard by depression and drought during the 1930s as "Saskatchewan where, by the end of the terrible crop failure of 1937, it was estimated that two in three members of the farm population were destitute" (Friesen 1984, 388). Without the Interwar branch lines, getting supplies to the stricken areas would have been even more difficult. Some of these railways were in southwestern Saskatchewan, "[where residents were] trying to endure ecological problems of Biblical proportion" (Waiser 2005, 294).

Ultimately, the Interwar branches provided thousands of grain growers with contact with their markets. When Interwar railway construction ended

in 1935 these branch lines represented about 30 percent of the rail network in Saskatchewan and Alberta. In that year, too, the grain elevator system was at or near its peak. Of that system, almost 25 percent of the elevators in the two provinces were located on the Interwar lines. More importantly, almost 29 percent of the total grain delivery points were along these railways. Somewhat surprisingly, perhaps, 27 percent of all the competitive points – those served by more than one elevator company – in Saskatchewan and Alberta were located on the Interwar lines (BGC 1936). The 1931 census reported that of the 233,880 farms in Saskatchewan and Alberta, more than 73 percent were within 10 miles (16 km) of a railway station and almost certainly a grain delivery point. Only two percent were more than 25 miles (40 km) away (DBS 1936, 630, 698). No doubt the 271 miles (436 km) of railway opened after 1931 improved these numbers still more (Figure 10).

Even in the mid-1960s, the Interwar lines were still moving a significant share of the grain crop. Of the over 646,000,000 bushels shipped in 1963, a very good year, 24 percent moved over the Interwar lines. Of the 10-year average of 465,000,000 bushels, the lines built between the wars moved 25 percent (BGC 1963). It is hard to view construction of lines that essentially provided a proportionate share of the grain delivery points in Saskatchewan and Alberta in 1935, and hauled a nearly proportionate share of the grain moved in the late 1950s and 1960s as 'disastrous.'

Perhaps the best evidence that these lines were needed is that none of the Duff Commission's recommendations called for significant abandonment of branch lines in western Canada. If building the Interwar branch lines was truly one of the nation's most 'pressing problems,' it is hard to understand why the Commission was willing to throw good money after bad by allowing the railways to continue to operate these lines. To say that abandonment was minimal after Duff would be a major understatement. During the 1950s, 115 miles (185 km) came up. Another 370 miles (595 km) were removed between 1960 and 1963 (Canada 1977, 31). By 1975, an additional 525 miles (845 km) were not in use and were abandoned (Canada 1977, 60). In short, in the more than 40 years between the Duff Commission and the Grain Handling and Transportation Commission (Canada 1977) that studied branch-line abandonment in western Canada in the 1970s, the railways were allowed to take up only slightly over 1,000 miles (1,609 km) of branch line. Because some of these branch lines were operated infrequently, it is surprising that it took so long.

Given the evidence it is hard to escape the conclusion that much of the criticism of the Interwar railway construction reflected the political struggles between the Conservative and Liberal parties. Mackenzie King



Figure 10: *Train picking up grain at Coronach, Saskatchewan.*
Photograph: C. Bohi, 26 September 2007
On a former CPR branch built in 1928, Coronach, Saskatchewan is one of nearly 500 delivery points, almost 29% of the total, located along the Interwar branch lines in Saskatchewan and Alberta in 1935. Though now served by the Great Western Railway, nearly 80 years after it was opened, Coronach, Saskatchewan still serves area farmers as a grain delivery point.

had driven the Conservatives to distraction with his electoral tactics during the 1920s and created animosities that sharpened the conflict between the two parties.

Despite the harsh rhetoric, the fact remains that, having scored their political points and driven Thornton from the CNR's presidency, Bennett and the Conservatives were willing to leave the grain gathering system in western Canada intact. And so it stayed for the next four decades. Speaking of western railways generally, perhaps historian and geographer W.A. Mackintosh offered the best evaluation of the Interwar branches when he wrote that

> [t]he inhabitant of the Prairie Provinces, … is peculiarly dependent on railways. His agricultural system depends on railway communication. … [t]he towns and villages are mere points on railways. … The railway with its unfailing accompaniments, the loading platform, the two to five grain elevators, the post-office, general store, machinery shed, and branch bank, closes the circuit through which the power of the

> world's economic organization flows into the pioneer community. … Beyond the end of steel there is only such settlement as waits month by month or year by year for the coming of the railway (Mackintosh 1934, 57).

Far from being a 'disastrous' mistake, the Interwar branch lines in Saskatchewan and Alberta brought large areas into the world economy, benefiting not only grain growers in the two provinces, but Canada as well.

Acknowledgements

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The Dakota railroad blues

Alec H. Paul, University of Regina (*paulal@uregina.ca*)

Abstract: This paper highlights the present-day grain/rail landscape or 'grailscape' of the North Dakota wheat belt's railroad branch lines. Its focus is the Northern Plains Railroad's line from Thief River Falls, Minnesota to Kenmare, North Dakota, referred to here as the 'invasion' line. Canadian Pacific Railway's Soo Line originally built it to invade the territory of the Great Northern Railway's grain branches between the main line and the Canadian border. The basic purpose today is the same as a hundred years ago but the *modus operandi* is very different. NPR has an air of 'patch up and mend where you can and retreat where you can't.' Its equipment and that of the grain elevators along the line is a patchwork of the antiquated, the middle-aged and the new. NPR is striving to survive in an era when moving grain to distant markets involves deregulated railways and a complex mix of other institutional, socio-economic and political arrangements. Yet despite the appearance of barely controlled chaos, the current situation in some ways represents progress. Local farmers are no longer so beholden to an alien railroad or grain-company administration in some distant metropolis. This part of North Dakota, at least, is moving forward even though it is still plagued by a modern version of those old railroad blues.

Key words: *railroads, shortlines, grain transportation, elevators, landscapes, North Dakota*

Introduction

The purpose of this paper is to illustrate the grailscape of the North Dakota wheat belt's railroad branch lines. The word 'grailscape' simply connotes the landscape of the grain-handling and rail-transport facilities along these branches. In June 2006, I experienced one of these grailscapes as I followed the Northern Plains Railroad (NPR) line all the way from Thief River Falls in Minnesota to Kenmare in western North Dakota. This route had been the Soo Line's 'invasion' line of the early 1900s to grab traffic from Jim Hill's grain branches heading northwest from his Great Northern (GN) main line up to the Canadian border (Figure 1). The Soo Line at that time was controlled by Canadian Pacific, which eventually gained full ownership of the company and folded it into the CP rail system.

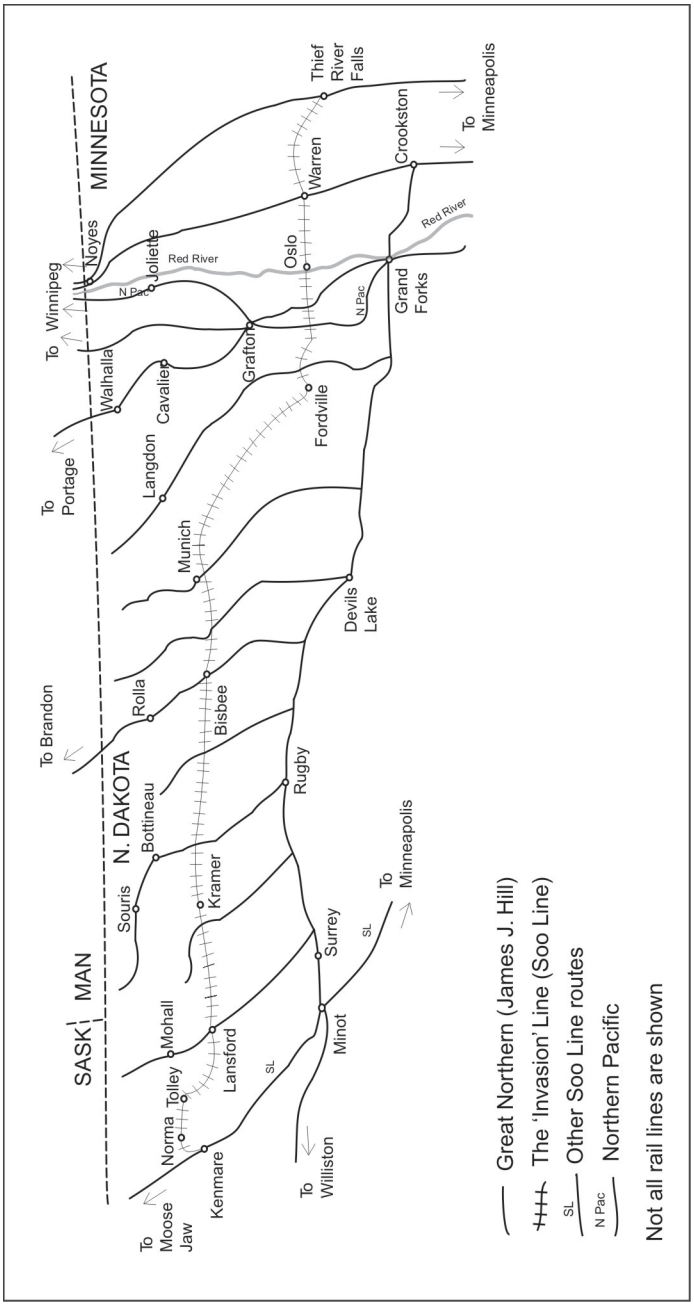


Figure 1: *Soo Line and Great Northern rail lines in the early twentieth century.*

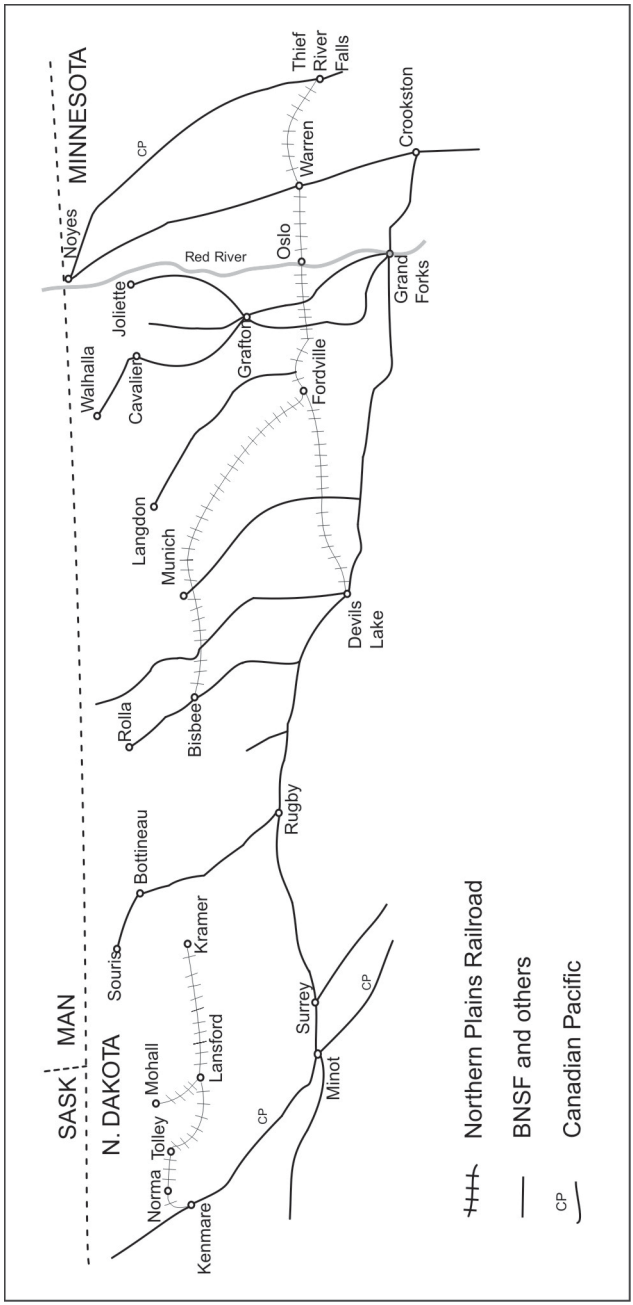


Figure 2: *The region's railroad map in 2006.*

En route I also saw some branch lines now operated by Minnesota Northern, Dakota Northern, Dakota Missouri Valley and Western (DMV&W) and even the Burlington Northern Santa Fe (BNSF), one of the U.S. mega railroads. My intention was simply to look at their grailscapes but as I mused about them I began to see them also as symptoms of the railroad problem in North America. Hence the title of this paper.

The NPR is the paper's main focus. Its invasion line is a holdover from the industrial era when trains dominated land transportation and the major railroads operated branch-line networks along with their main lines. In the 1960s and 1970s, many U.S. railroads went bankrupt. The industry went through a series of upheavals and mergers such that by 1996 only five major 'Class 1' railroads survived. They were no longer able to operate low-volume branch lines profitably, so these were either abandoned or transferred to short-line companies to operate (Paul 2000). NPR is one such short-line railroad. Another is the DMV&W which runs the other remaining former Soo Line grain branches in North Dakota. These two companies operate the 'wheat lines' in the state that currently connect with the Canadian Pacific (ex-Soo Line) main line.

Thief River Falls, Minnesota is the NPR's junction with CP's Winnipeg-Minneapolis secondary main line. From here west to Fordville, North Dakota the NPR invasion line traverses the fertile lands of the Red River Valley. This is a highly productive agricultural region where shortlines can be successful. West of Fordville the potato farming fades out quickly and the line reaches the true wheat belt. Trains go as far west as Bisbee (Figure 2), currently the western terminus of this branch of the NPR. The railroad has recently filed to abandon the 105 km (65 miles) of track from Bisbee west to Kramer – the gap in the invasion line – which are technically 'not in use', that is, they are closed although the rails are still there. The stretch at the west end from Kramer to Kenmare, where the NPR connects with the CP main line between Portal and Minot, serves several very large modern elevator complexes and continues to be active.

The Minnesota End

On Saturday 3 June 2006, the tracks to the old Soo Line roundhouse at Thief River Falls held an amazing array of NPR and CPR/Soo locomotives (Figure 3). Some were reasonably recent with brand new paint jobs, others were typical short-line hand-me-downs and there was even an antiquated former Milwaukee Road switcher with 1950s lettering. (Soo Line took over what was left of the moribund Chicago Milwaukee St. Paul and Pacific in 1986). West of Warren a dozen or more workers manipulated thoroughly

modern track machines. Short-line employees take on a whole range of railroad tasks. At Oslo, a kilometre east of the Red River of the North, an ancient NPR diesel locomotive and a string of hopper cars silently occupied the elevator track (Figure 4) while perspiring farmers used augers to load producer cars on the opposite side of the complex.

Eastern North Dakota

Fifty kilometres or so west of the Red River the NPR bifurcates, the southern fork heading for Devils Lake and the longer western fork for Bisbee (Figure 2). This second line crosses an active BNSF branch near Munich, the abandoned GN line from Devils Lake to Hansboro at Egeland, and at Bisbee the Church's Ferry-Rolla line which once extended to



Figure 3: *Thief River Falls, Minnesota.*
Photograph: A. Paul, 2006



Figure 4: *Oslo, Minnesota.*
Photograph: A. Paul, 2006

Brandon, Manitoba (Everitt *et al*. 1989). In geographical terms the most interesting adjustments to modern-day conditions are at Egeland and Bisbee.

Egeland once was the southeastern end of a rail corridor 40 km long served by grain branches of two different railroad companies only 1 to 5 km apart. The Soo Line had a wye junction connecting its Armourdale branch to the invasion line which itself was crossed by the GN Hansboro branch 2 km east of the wye. Neither of these branches survives today. This corridor exemplified the wasteful competition often characteristic of the days of rapid railroad expansion. In the long grass and weeds in June 2006, though, the wye and 500 metres of Soo Line branch track, officially known as Barks Spur (Walker 2005), still existed as access for tank cars to a fertilizer storage depot and – potentially at least – for grain hoppers to a small former commercial elevator now owned by the local farmer.

Bisbee, a few kilometres further west and the end of active track on this piece of the NPR invasion line, is a complete contrast with the atmosphere of slow decline pervading Egeland. A vast new North Central Grain Cooperative terminal accessible to both the NPR and BNSF lines and with a brand new circular loop track to permit continuous loading of unit trains coming off the NPR exemplifies today's technology applied to grain handling and transportation. On Sunday 4 June 2006, the Bisbee NCGC switcher locomotive (Figure 5) parked by the diamond crossing of the two rail lines sported a new paint job. But its mere presence indicated that unit grain trains like those operated on BNSF's ex-GN 'high line' across northern Montana are not yet a significant feature at Bisbee.



Figure 5: *Bisbee, North Dakota.*
Photograph: A. Paul, 2006



Figure 6: *Bottineau, North Dakota.*
Photograph: A. Paul, 2006

The Gap in the Invasion Line

Grailscapes of abandonment are widespread on the plains and the stretch of the NPR from Bisbee west to Kramer is very typical in some ways. The track and a few old-style elevators are still in place, although the possibility of a resumption of rail service is nil, with this gap in the line almost certain to see early abandonment. At Agate, two wooden elevators form part of a farm-service business which is entirely dependent on truck transport. Rolette is a larger town completely without rail service but the NPR right-of-way has not been taken over by other land uses. At Omemee, now a ghost town, the BNSF branch from Rugby to Bottineau and Souris crosses the NPR track on the level and the diamond crossing is controlled by a simple stop sign on the BNSF branch. Bottineau is an important rail point with large volumes of grain moving through the Farmers Elevator complex in the town (Figure 6). BNSF is hanging on to this branch, at least for the moment.

Kramer to Kenmare

This piece of the NPR line (Figure 2) is interesting because it reflects the rationalization of branch-line operations in a very straightforward way. The branch extends about 110 km (70 miles) from the interchange with the CP main at Kenmare east to Kramer where a simple derail and two red flags

on 4 June 2006 blocked any movements further east. The nerve centre is at Lansford, almost exactly halfway, where a connection to the former BNSF branch from Granville on the main line northwest to Sherwood has been made. This allowed the closure of all BNSF branches except the 15 km (9 miles) section from Lansford to Mohall, the Mohall-Sherwood section having been shut down many years ago. Mohall has a large Farmers Elevator terminal with its own ancient diesel switcher.

Lansford has a new engine house and track arrangement and uses the former BNSF branch to the southeast as an extended railcar storage siding. The population of the town has dropped drastically in recent years but it is still the largest of the towns and villages along this western section of the NPR invasion line. Kramer and Russell had 50 or more hopper cars each on 4 June 2006, most lettered for CP or Soo Line. Large concrete terminal elevators of Souris River Grain Cooperative are located at both places, neither of which has many residents. Tolley and Norma (Figures 7 and 8), the final two elevator points before Kenmare, are also very small places but handle significant tonnages of grain. The NPR track is not in the best of shape along this stretch. The overall impression is one of deferred maintenance and struggling to make the existing facilities do the required job.

Changes in the Local Railroad Map

Fifty years ago the invasion line crossed 10 south-to-north GN branches and one of the Northern Pacific between Kenmare and Thief River Falls, without making an actual connection with any of them. This was symptomatic of the era of competition and the industrial economy. Today the pendulum has swung the other way. The railroad map has been rationalized, overall track mileage has decreased and the number of elevator points also. Trucks play a larger part in the overall movement even though rail transport is still the most economical and environmentally the most suitable mode for large volumes of grain. Indeed the current high prices for diesel are likely to reduce the participation of truckers rather than increase it.

In this postmodern era, the NPR connects with four of those ‘cross branches’ and some of the others have been abandoned. Today’s railroad map (Figure 2) is one that has some logic to it, given the history of earlier rail construction, but it is clearly not the most efficient layout possible for handling the grain that must be moved. The current state of the NPR line shows aspects of antiquity, modernity and postmodernity as it adjusts to today’s economic realities governing grain transportation.



Figure 7: *Tolley, North Dakota.*
Photograph: A. Paul, 2006



Figure 8: *Norma, North Dakota.*
Photograph: A. Paul, 2006

Conclusion

The grailscape along the NPR invasion line has been adapted somewhat to current conditions but leaves the observer wondering whether there can be any long-term plans or overall solutions to overcome an increasingly fragmented approach to the movement of grain from the region to the markets. North Dakota's branches are trying hard but have not managed to shake the postmodern malaise of North America's minor-league railroads. In the words of common folklore, the area has the railroad blues:

> Our rail line here, they're liftin' the tracks.
> And some o' them truckers are gittin' the axe.
> Can't make a go of it, diesel's too high.
> Our Dakota grain should be put on the train
> But the big guys want out, and we got no clout.
> Short line can't go it alone, we're all gonna lose,
> In Dakota we're feeling those old railroad blues.

Acknowledgements

Professor Douglas Munski of the University of North Dakota, Grand Forks provided a major stimulus for this study in his field trip of urban Devils Lake at the fall 2000 meeting of the Prairie Division of the Canadian Association of Geographers. A block away from Lakes Region Grain Cooperative's massive concrete elevator and rail sidings was the old Soo Line depot ("classic Canadian Pacific", said Doug), reincarnated as an office for Northern Plains Railroad. I vowed to learn more about the NPR. Rae Ann Brenner and Rob Knox made my maps presentable, and I am grateful to them. The photographs are mine, as is the responsibility for any remaining errors.

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Aging-in-place in small town North Dakota: a case study of Larimore

Tina Billups, Independent Scholar, Acampo, California
Devon Hansen, University of North Dakota, Grand Forks
Douglas C. Munski, University of North Dakota, Grand Forks
(*douglas_munski@und.nodak.edu*)

Abstract: An important attribute of the increase in elderly population in the United States, particularly the Great Plains states, is aging-in-place, that is, the residential stability of growing old in a familiar location. Larimore, a rural-oriented North Dakota community with a substantial elderly population, serves as the focus of this case study. Data were gathered using the snowball sampling method. Data collection was designed to determine Larimore's specific elderly demographics, identify reasons for ongoing local residence, indicate if Larimore can be characterized as an aging-in-place location, and identify possible implications for the community. Preliminary results indicate that Larimore is aging-in-place with senior citizens having a range of reasons for remaining in the town including physical nearness to family and friends, owning property, place loyalty and economics. This initial study contributes uniquely to the literature on North Dakota's elderly population. It is anticipated that it will be a useful starting point for medical and social service providers, economic developers, and government leaders in Larimore and elsewhere because of the increasing significance of aging-in-place to quality of life.

Key words: *aging-in-place, small town, North Dakota, elderly, population*

Introduction

Aging-in-place is a term heard frequently in conversations regarding the elderly, including when dealing with reverse mortgages (NRMLA 2003). Graff and Wiseman (1978, 382) give a concise definition: "Aging-in-place denotes the process of cohort transition to increasing age and residential inertia." The definition of elderly includes those aged 65 years and older (He and Schachter 2003). Within the elderly, further specifications can be

made regarding age groups. According to Conway and Houtenville (2003), three age groups comprising persons of 65 to 74 years, 75 to 84 years, and 85 years and over can be used. Those aged 65 to 74 years often are referred to as the 'young old' or 'young elderly.' Individuals aged 85 years and over are known as 'oldest old' or 'older elderly.'

Aging-in-place studies are important for planning in a variety of regional economic sectors. Medical service providers, local governments and businesses will be impacted greatly by a large elderly population and will need information to make the best decisions possible about a wide range of issues for the future regarding these senior citizens. One recurring theme suggests that places with a growing elderly population, due to aging-in-place, will experience a decreasing tax base and an older population more dependent on medical services (Rogers and Woodward 1988; Lawler 2001). Litwak and Longino (1987) examined three potential moves in the aging process, the second of which involves moving closer to family for informal care and nurturing. When elderly persons reside already in their retirement location and also near to their families, this removes the need for changes in residence, thus another indication of aging-in-place.

There are many American studies focusing on the elderly population at the national and regional level (*e.g.*, Graff and Wiseman 1978, 1990; Longino 1990; Plane 1992; Lawler 2001; Prince Market Research 2007). However, there is a lack of research focusing solely on North Dakota, and specifically rural North Dakota. Consequently, the community of Larimore (Figure 1) was selected as a case study to create a baseline from which to determine the extent to which it is aging-in-place and to establish how that process might be affecting the general quality-of-life in a particular rural part of the state according to these four research questions:

Question 1: *What are the social and demographic characteristics of the elderly population of Larimore?*

Question 2: *Why do the elderly residents of Larimore choose to reside there? Does it have anything to do with attachment-to-place, homeownership, and/or close proximity to family members?*

Question 3: *Is Larimore aging-in-place? If yes, why?*

Question 4: *What are the implications for Larimore due to aging-in-place?*

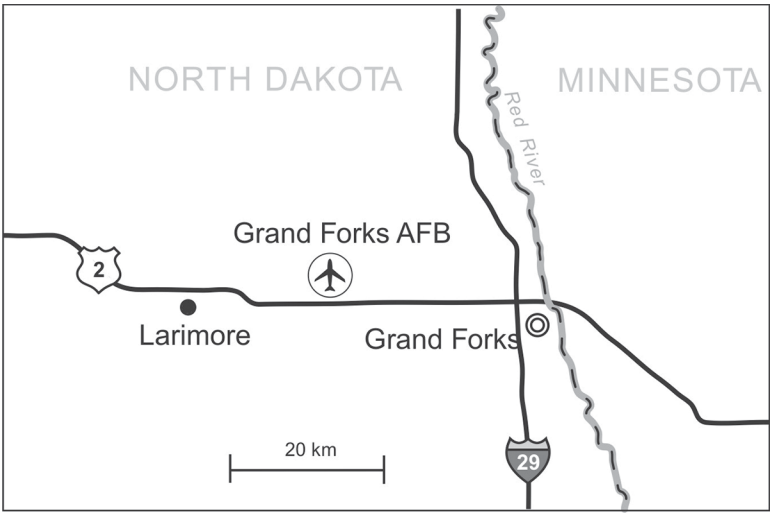


Figure1: *Location of Larimore, North Dakota.*

Background to the Community of Larimore

Larimore is an agricultural community located in west-central Grand Forks County, North Dakota. It was founded in the summer of 1881 near the site of the Elk Valley Farm. Larimore's namesake, Newel G. Larimore, was a grain commissioner and one of four men involved in the organization of the Elk Valley Farm (Larimore Centennial Committee 1981).

Since its beginning, Larimore has had its share of ups and downs in terms of population. Figure 2 shows change in the size of Larimore's population from 1920 to 2000. Similar to other Midwestern towns, Larimore endured its most significant drop in population during the Great Depression of the 1930s. During the 1940s to the 1960s, the community experienced noticeable growth, adding approximately 800 people. This coincided with the construction of the Grand Forks Air Force Base in the 1950s (Grand Forks Air Force Base 2003).

According to the 2000 United States census, the population of Larimore is 1,433. Of this total, 289 (20%) are aged 65 and over, 748 (52%) are aged 18 to 64 years, and 396 (28%) are under 18 years. Figure 3 shows the population in five-year age groups; the elderly population forms a substantial portion of this population pyramid. A 'bulge' in the pyramid

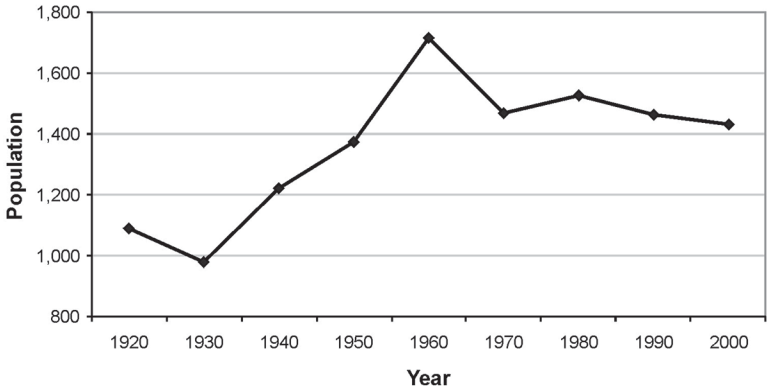


Figure 2: *Change in Larimore's population, 1920 to 2000.*

from 30 to 44 years reflects persons who live in Larimore and commute to Grand Forks Air Force Base. Conversely, there is a noticeable 'gap' in those aged 20 to 29 years. Presumably, these individuals have left in pursuit of college or employment opportunities elsewhere.

Currently, Larimore has several facilities intended to benefit senior citizens. The Good Samaritan Center is a nursing home associated with the Evangelical Lutheran Good Samaritan Society. This is a national organization that operates numerous nursing homes throughout the United States. There is also the Larimore Senior Center, a quasi-governmental agency which is located in the town's central business district. It serves as a gathering place for the elderly for subsidized meals, card games and other activities.

Methods

Data for the study were gathered through archival research, questionnaires and personal interviews. Archival data provided basic descriptive demographic characteristics of the community's aging population. Questionnaires and interviews were given and conducted that specifically focused on the issues of Larimore. Contacts were made through members of the Larimore Community Action Club and the Larimore Senior Center. This multi-methodology of statistical data, surveys and interviews generated several dimensions from which to analyze aging-in-place. More credibility is given to studies in which multiple methods arrive at similar conclusions (Hays 2004; Schutz *et al*. 2004).

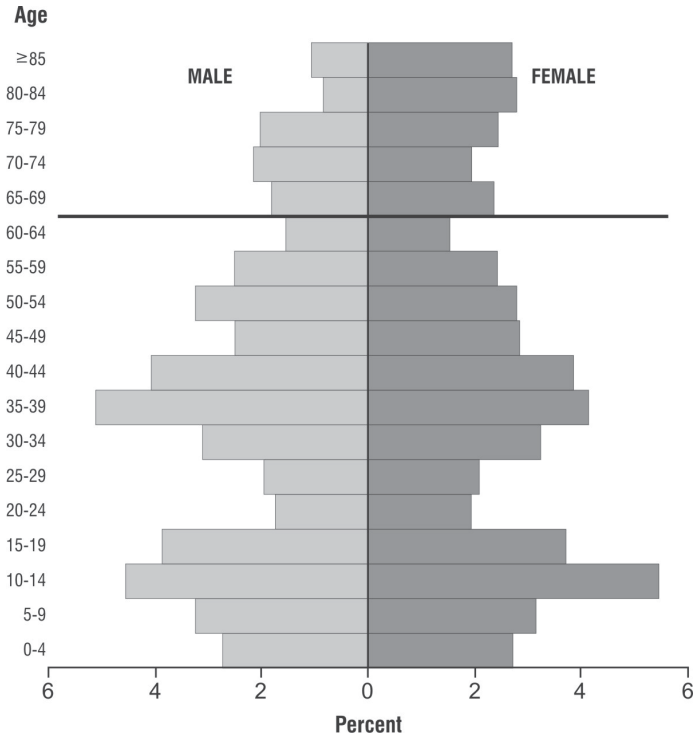


Figure 3: *Population pyramid of Larimore, North Dakota.*

Participants were selected based on the criteria of being over the age of 65 and residents of the Larimore community and were identified using the snowball method. "Snowball sampling, also referred to as network selection, involves, use of referral, 'word of mouth,' and other methods of identifying potential survey respondents through previously identified participants" (Hutchinson 2004, 292). Residents of nursing facilities were not surveyed or interviewed because their residence is generally not due to choice but that of physical limitation. Thus no responses for nursing home and assisted living facilities are presented in the data.

The Survey:

The survey questionnaire was designed with the target population in mind. Length, format and content frequently influence responses (Hutchinson 2004). Because the survey was intended for elderly persons, the length was kept short and the font was selected for readability. The survey consisted of 11 questions. Nine questions were structured with

specific answer choices while two were designed for more open-ended responses. Three questions enquired about demographic information (age, gender and marital status). Seven questions addressed aging-in-place and related issues such as homeownership, birth location, length of residence in Larimore, sense of community and proximity to family members. One question asked participants for comments on how Larimore could better serve its senior citizens.

The surveys were distributed on two separate occasions at the Larimore Senior Center in October 2006. Working with the Larimore Community Action Club, questionnaires were prepared for 40 citizens, the sample size deemed appropriate in this form of qualitative research. Twenty-two surveys were completed and returned, resulting in a 55 percent response rate.

The Interviews:

Interviews were conducted to supplement the questionnaires. Interviewing a limited number of individuals as a qualitative research methodology is considered an effective study tool in that it allows the researcher to amplify the themes discovered in the research. In this study, six elderly residents of Larimore were interviewed. Because this qualitative study focuses on Larimore, a small community, only a half-dozen residents aged 65 years and over were deemed necessary on the acceptable premise that a saturation point would have been reached starting with a seventh interviewee. Five of the six interviews took place in Larimore and, for the convenience of the interviewee, one was conducted in Grand Forks. Interviews gave participants the opportunity to give more detailed explanation as to why they chose to reside in Larimore.

The interview questions and length of interview were constructed in consideration of the target population. With a substantial range in age there was a need to accommodate those less physically able, as well as those without physical limitations. The 15-question interview was kept relatively brief with 11 questions being straightforward and four questions being open-ended. Interviews were conducted between November 2006 and January 2007 in Larimore and Grand Forks. Each interview took between 15 and 45 minutes to administer. Participants were contacted and signed informed consent forms. The interviews were recorded and transcribed from the audiotapes to allow more detailed investigation of the key themes that emerged during each of these visits.

Contact with Community Leaders:

To add an extra level of understanding to the implications of aging-in-place, two community leaders were contacted by e-mail correspondence.

These individuals were contacted because they are in a direct position to change and improve the quality of life for Larimore's elderly citizens. Similarly, no fewer than two and no more than three such representatives were required for this research before pertinent answers would become repetitive and redundant. The questions addressed to community leaders were intended to ascertain two things: first, what initiatives were planned to continue to meet the needs of senior citizens; and second, to determine whether the responses of community leaders matched with seniors' expectations of what they would like to see in Larimore. The responses given by community leaders are presented under research Question 4 as they contribute to determining the implications of aging-in-place.

Discussion

The findings from the surveys and interviews are presented according to the four key research questions that were addressed as per the protocols of this type of human geography qualitative research.

Question 1: What are the social and demographic characteristics of the elderly population of Larimore?

Table 1 presents the social and demographic characteristics of the survey group. Eleven (50%) respondents were aged 65 to 84 years, and eight (36%) were aged 85 years or over. Three (14%) respondents identified their age as under 65 years. Seventeen (77%) respondents were female, four (18%) were male, and one (5%) did not indicate gender. Respondents were overwhelmingly either married (41%) or widowed (41%).

Nineteen (86%) respondents had lived in Larimore for more than 20 years. Of these, six had lived in Larimore for over 50 years, thereby reflecting length of residency as an aging-in-place measure. Seventeen (77%) respondents were homeowners whilst four (18%) were renters. No one identified a nursing home or assisted living facility as their living situation.

All interview participants were married and all indicated that they owned their home. Four interviewees were born outside of North Dakota, while two were born within North Dakota. All had moved several times in their lifetimes, with four relocations being the minimum and 11 being the maximum number of migrations. All interviewees had lived in Larimore for a substantial amount of time, with the range being from 18 to 40 years.

Table 1: *Demographic survey results.*

	Responses (n = 22)	Percent of Responses*
Gender		
Male	4	18
Female	17	77
Not indicated	1	5
Age		
Under 65	3	14
65-74	5	23
75-84	6	27
≥ 85	8	36
Living Situation		
Homeowner	17	77
Renter	4	18
Nursing Home Facility	0	0
Assisted Living Facility	0	0
Other	1	5
Marital Status		
Married	9	41
Widowed	9	41
Divorced/Separated	2	9
Single	1	5
Widowed and Divorced/Separated	1	5
Born in Larimore		
Yes	3	14
No	19	86
In North Dakota	9	41
Out of North Dakota	9	41
Not Indicated	1	5
Years Lived in Larimore		
0- 5	1	5
6-10	1	5
11-20	1	5
21-30	8	36
31-40	3	14
41-50	2	9
> 50	6	27

*Percentages have been rounded and may not sum to 100%

Question 2: Why do the elderly residents of Larimore choose to reside there? Does it have anything to do with attachment-to-place, homeownership, and/or close proximity to family members?

Reasons for residing in Larimore included attachment-to-place, homeownership, and proximity to family (Table 2). When asked if they felt Larimore was their home, twelve (55%) respondents strongly agreed and six (27%) agreed. Only one (5%) respondent disagreed. Nineteen (86%) agreed or strongly agreed when asked if they felt part of the community. Again, only one (5%) person disagreed. Twenty (91%) respondents said "yes" when asked if they identified with the lifestyles and values of the people who live in Larimore. Only one (5%) disagreed. One individual selected "yes" and "no", commenting, "Yes, because people care for and help one another. No, none with similar religious beliefs."

Table 2: *Aging-in-place general survey results.*

	Responses (n = 22)	Percent of Responses*
Do you feel Larimore is your home?		
Strongly Agree	12	55
Agree	6	27
Neutral	3	14
Disagree	1	5
Strongly Disagree	0	0
Do you feel that you are part of the community?		
Strongly Agree	8	36
Agree	11	50
Neutral	2	9
Disagree	1	5
Strongly Disagree	0	0
Do you identify with the lifestyles and values of the people who live in Larimore?		
Yes	20	90
No	1	5
Yes and No	1	5

*Percentages have been rounded and may not sum to 100%

Survey respondents selected a variety of reasons for staying in Larimore (Table 3). The common themes that emerged were centred on both familiar surrounding/sense of belonging and owning their home. Over half of the respondents checked friends, family members living nearby, community, and medical and social services as reasons for staying in Larimore. Other factors cited included the cost of living outside of Larimore being too expensive, enjoyment of recreation activities, relocating would be too costly, and the weather/climate. Employment and involvement with agriculture were among the least selected reasons for living in Larimore, reflecting local conditions. Just one person noted that the Larimore real estate market was not favourable for selling their home. All respondents had family nearby and all replied that family members, mainly children and grandchildren, were a big part of why they elected to remain in Larimore.

Not surprisingly, attachment-to-place, homeownership and close proximity to family and friends quickly emerged as predominant themes. Questions 7 to 9 of the survey were asked to determine if respondents felt an attachment-to-place. The vast majority of respondents replied that they agreed or strongly agreed to these questions, indicating a strong sense of place attachment. Only one respondent did not feel a part of the community. This respondent had the shortest time of residence in Larimore of all survey respondents. By comparing this individual with those who have lived in Larimore for a substantial length of time, it suggests that

Table 3: *Ranking of reasons for aging-in-place.*

	Responses (n = 119)	Ranking	Percent of Responses
You stay in Larimore because…			
(Check all that apply)			
Familiar surroundings, sense of belonging	17	1	14
You own your own home	17	1	14
Friends	14	3	12
Family members live nearby	12	4	10
The community	11	5	9
Medical and social services	11	5	9
The cost of living is more expensive outside Larimore	10	7	8
Enjoy recreational activities	9	8	8
Relocation would be too expensive/costly	6	9	5
Weather/climate	4	10	3
Employment	3	11	3
Born and/or raised here	2	12	2
Involved with agriculture	2	12	2
The Larimore real estate market is not favourable for selling your home	1	14	1

there is a time component to attachment-to-place. The longer a person lives in a location, the greater the place attachment; the less time a person has lived in a location, the less attachment-to-place.

As mentioned above, homeownership, also an aspect of place attachment, was a dominant theme. In Question 11 of the survey, 17 (77%) respondents indicated that owning their home was a part of why they chose to remain in Larimore. This finding is similar to other reported research (Rowles 1993; Lawler 2001).

Another significant reason for staying in Larimore was that of the close proximity to family and friends, also a facet of attachment-to-place. Survey and interview respondents alike answered that a major part of why they chose to reside in Larimore was because their friends and family were close by. Other researchers also have found that family and history create strong ties to a location (Rowles 1993; McHugh and Mings 1996).

In addition to the time and place components associated with aging-in-place, economic factors appeared to be important in deciding to remain in Larimore. Ten (45%) of the 22 survey respondents felt that the cost of living outside of Larimore was too costly. Similarly, six (27%) respondents felt that relocating would be too costly. While these responses were not expressed as strongly as those related to family and friends or attachment-to-place, they do suggest that financial conditions definitely influence retirement choices.

Question 3: Is Larimore aging-in-place? If yes, why?

Larimore can be considered aging-in-place based on the length of residency. As mentioned previously under Question 1, the majority of questionnaire respondents had resided in Larimore for 20 years or more. From these, six (27%) had lived in Larimore for more than 50 years. This is a substantial indication that Larimore's senior citizens are choosing to remain through their older years, thus aging-in-place. Combining age ranges with length of residence (Figure 4) shows that there is a good chance that the older a person is, the longer they have lived in Larimore. Such descriptive demographics indicate a trend of aging-in-place.

When asked if they would choose to retire in Larimore, all respondents stated that they currently were retired or probably would retire in Larimore. One respondent indicated that Larimore would likely be "the hub" for family and family gatherings. All interviewees replied that they were not planning to move in the near future. Another respondent, looking to future stages of life said, "Physically, when we can't live in this house anymore, then I would assume we're going to move somewhere in Larimore that we can afford."



Figure 4: *Years lived in Larimore classified by age of survey respondents.*

Homeownership was a predominant trend. Seventeen (77%) survey respondents owned their homes, while all interviewees were homeowners. This finding is similar to other research (Rowles 1984) which indicates that the majority of elderly own their homes. Long-term homeownership reflects a stationary living situation. For the future, when older persons change their living situation due to the physical limitations of aging, there will be more available housing stock locally. Homes could become residences for younger elderly persons, or for non-elderly in-migrants who could be employed in services supporting the elderly. It also means that there will be a need for more care facilities in the near future and the employees to staff these facilities. Consequently, the aforementioned housing stock could house those staffing facilities such as the Good Samaritan care facility.

Question 4: What are the implications for Larimore due to aging-in-place?

Interviewees were asked what they would like to see in Larimore for the elderly that the community currently does not have. Better access to transportation arose as a common theme. Three interviewees mentioned that an affordable taxi service was needed, even just within Larimore to provide transportation to the Senior Center. In a related response, two interviewees expressed the desire for home delivery of the mail.

Another common thread was encouraging more community involvement. One interviewee wanted seniors to be more active within the community, while another saw a need for more involvement at the Senior Center. One interviewee wished that there were more cultural events for the overall community.

A ready response from one interviewee was the need for a learning centre where seniors could exercise or take classes. The same person saw a need for a location where seniors, or anyone without a computer, could access the internet. The library was suggested as a good location. This interviewee also felt that there was a lack of affordable housing for seniors.

In a similar question, senior citizens were asked to identify the advantages and disadvantages of their current location. A common positive response among interviewees was that Larimore was a small community in which everyone knew each other and that residents were caring and would assist each other. Another frequent favourable response noted, that as a more secluded location compared to Grand Forks, Larimore was low in crime and residents presently do not worry about break-ins like they might in Grand Forks.

Interviewees appreciated the fact that they could live in a small community with its own amenities, including a general practice physician, and still be close to a major population centre to take advantage of the amenities it offered such as major medical facilities and entertainment opportunities.

In addition to the advantages, interviewees also mentioned a few disadvantages about Larimore. One interviewee missed the shops and restaurants that have closed down. Closely related to this, another individual mentioned that it was a disadvantage in having to travel farther to buy things and that the price of gas made it even more inhibiting. This made it difficult for seniors who had little or no transportation. Another comment noted there was only one grocery store in town and because of this there was no competition in pricing.

Interviewees also were asked if they identified with the lifestyles and values of the people who lived in Larimore. For the most part, all but one interviewee agreed in response to the question. One person reflected overall sentiments by noting that lifestyles in Larimore were centred around the churches and with high school and grade school sporting events.

The final interview question asked interviewees if they would be willing to invest more time or effort to make Larimore an even better place. One hundred percent of those interviewed agreed that they would be willing to help improve and make Larimore a better place to live. One said it best, "Sure, why not? Nothing's going to get done if no one's going to step out and do it…." This was echoed in terms of deeds as one interviewee

and a second interviewee's spouse were involved with beautification of various locations around Larimore, including one of the cemeteries, the local museum's grounds, and a playground.

As a follow-up to the above interviews, each community leader was asked several questions including *What do you have planned for the elderly of Larimore?* One of the two respondents wrote that currently "the City is not working on any projects directly." However, this individual did highlight the senior centre and its social opportunities. Also mentioned was the Good Samaritan Center and the fact that it is in the process of constructing independent living apartments for seniors hoping to downsize their living situations. The second community leader responding to this question was more closely affiliated with the Good Samaritan Center and, therefore, provided greater detail as to what the agency is planning for senior citizens.

The second question involved asking the community leaders if the elderly were actively involved in planning and decision-making processes. One respondent said "no" regarding general city business, but that they would be at the senior centre if they were members. The second respondent also mentioned the senior centre and that it has a functioning executive board. For the Good Samaritan Center there is a resident council that is asked for input and there is an advisory board which consists of community members, most of whom are senior citizens.

Community leaders were queried as to whether there are plans to attract younger persons. As noted by one respondent, "It is always on the minds of the City and businesses." The community wants to draw in more families, as the schools and churches need new people to continue to exist. The second respondent personally felt that the community did not keep its young people and hoped this could be reversed with more professional jobs. In relation to the Good Samaritan Center, there were no plans to attract younger cohorts. This respondent said that the average age of Good Samaritan residents was over 80 years.

Community leaders also were asked if they identified with the lifestyles and values of the people who lived in Larimore. Both respondents gave positive answers. One stated "Most definitely," and, that while it is a rural area, it is a diverse population and that neighbours look out for each other and help one another. The other respondent answered in terms of the Good Samaritan Center whose employees and administration strove to provide services and surroundings that would make the residents feel comfortable and at home.

The final question posed to community leaders asked if they would be willing to invest more time or effort to make Larimore an even better place. Again, both respondents replied positively, that they wanted to

improve Larimore. In the words of one, "We need to determine priorities, and get started!"

Responses and comments from senior citizens and community leaders clearly demonstrated the care they have for their community. All stated they were willing to contribute to Larimore and make it a better place. The various groups of the community, including the Larimore Senior Center and the Larimore Community Action Club, were active in working to improve the quality of life for its residents.

Conclusion

Larimore certainly would be considered aging-in-place based on the responses from the surveys and interviews. One significant indicator was that all interviewees stated that Larimore is to be their retirement location. Even those still working foresaw remaining in Larimore for their retirement. Many survey respondents were well into their retirement years and had already lived in Larimore for a substantial amount of time, thus a strong indication that Larimore is aging-in-place. The findings show that there is a good amount of longevity among the elderly population of Larimore. Also, the baby-boomer generation is represented here and that means there will be a substantial elderly population for years to come. This same population will impact the local economy in a positive way because they will continue to need goods and services. Further evidence of aging-in-place includes the majority of responses that convey attachment-to-place, including close proximity to family and friends, strong ties to the community and homeownership.

The phenomenon of aging-in-place will certainly have an impact on the community of Larimore. The nursing and medical facilities must continue to expand and meet the needs of the senior citizen population. One survey respondent commented that there was a need for more smaller-sized, more manageable apartments. Responses from community leaders indicated that this was in the process of taking place. In addition, these facilities will continue to employ the needed staff, thus resulting in jobs for the community.

While the community is meeting the needs of the elderly in this sector, there is still a need for a ride or taxi service within Larimore and to Grand Forks. This is an important concern that needs to be addressed in a future study because those in their younger retirement years will continue to age and need such service. Another implication seen in the data is toward the elderly social scene itself. Numerous comments were received expressing the desire for more involvement at the Senior Center from fellow senior

citizens. Other sentiments expressed a desire for cultural events and a learning facility where seniors could go for classes, crafts and internet access.

There is and will be a significant elderly population in Larimore for years to come. Services for this population, such as medical and social, should be a priority of community leaders. Medical facilities must be maintained and grow to provide care and services at the level needed. To this point, community leaders indicate that the local nursing facility is accomplishing this task.

This study can be an effective pattern for future work to gain consequential results. Any part of this study, including research questions, methods, surveys and interview questions, could be adapted to meet the needs of a future study. Such work could include looking at other rural North Dakota communities. If one wished to look further into Larimore, the town's proximity to the Grand Forks Air Base could be a component of the research. Perhaps Larimore is unique due to proximity to a military base, as compared to other rural communities.

The findings of this research may be of use to community leaders or government agencies as they continue to work to provide services to the elderly population. By knowing if a community is considered aging-in-place, community leaders can better plan for the future. Also, by knowing the concerns and suggestions of elderly residents, leaders can make plans tailored to a specific community or region.

Aging populations will continue to be a significant part of North Dakota's population. Given North Dakota's population shift towards an aging population, this will continue to be a concern for local and state leaders. While it may be seen as a tremendously difficult challenge to serve the aging-in-place population of the state, there is room for optimism. Local community leaders and community groups will continue to strive to provide services and care for their senior citizen residents. The senior citizens themselves will continue to provide friendship and support to each other in their communities. These seniors have lived and thrived in the less than hospitable environment of North Dakota. The younger residents of North Dakota should consider it a privilege to assist and improve the quality of life of these senior citizens.

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Knowledge of the environmental risk and communication gaps between experts and the public: the case of climate change-induced heat waves in Winnipeg

Parnali D. Chowdhury, University of Manitoba (*parnali@hotmail.com*)
C. Emdad Haque, University of Manitoba (*haquece@ms.umanitoba.ca*)

Abstract: The 2006 North American heat wave caused the death of at least 225 people. Many scholars concede that recent heat waves are correlated with global warming of the atmosphere. Concerns about heat wave vulnerability have been accentuated by the current 'greying' trend and by the marginalization of some socio-economic groups since reaching them through conventional means of communication has been quite difficult.

Research reported here investigates options for improving risk communication on climate change-induced environmental hazards in urban Manitoba, Canada. Emphasis is placed on heat waves and examines the preparedness of individuals and local communities in Winnipeg (Manitoba) to deal with climate change-induced heat wave hazards. The literature suggests that recipients of risk-communication messages understand and interpret them differently than intended by their senders. Communication gaps are thus established. Minimization of these gaps is sought through creation of user-friendly messages and two-way communication routes between responsible authorities and community residents.

A 'Knowledge Model' is developed to identify the degree of stress associated with extreme heat wave events and to determine how local-level community capacity and the preparedness of individuals can be enhanced. Interviews and a questionnaire survey report on individual characteristics, coping and adapting processes, levels of awareness, and belief and knowledge concerning heat waves. Findings reveal that improved risk communication could change the risk perceptions of individuals and influence initiatives to change their behaviour.

Key words: *climate change, heat wave, elderly, health, knowledge model, communication gaps, risk perception, Prairies*

Introduction

The specific effects of global climate change are complex and wide ranging. While a consistent trend of warming of the global atmosphere has been recorded in recent years, its effects are not easily detectable. However, a positive correlation between global warming and severe weather events has been postulated by many researchers (IPCC 2001, 2007; Lemmen and Warren 2004; Van Aalst 2006), and consequently, it has been predicted that occurrences of heat waves and other weather-related calamities will become more common than in the past. In this respect, the effects of extreme temperatures on human physiology and consequential mortality have received attention from numerous contemporary studies. It is worth noting here some extreme heat waves that have been seen as correlated with recent global warming. A record heat wave that scorched Europe in August 2003 claimed an estimated 35,000 lives. In the same year, heat-related fatalities across the United Kingdom reached 2,045. A heat wave in India in June 1998 was estimated to have caused 2,600 deaths over 10 weeks of high temperatures. During a record-setting heat wave in Chicago, USA, in July 1995, there were at least 514 heat-related deaths and in excess of 3,300 emergency admissions.

Heat waves carry a significant amount of risk through posing both the threat of heat-related illnesses and the aggravation of pre-existing conditions. Most heat-related illnesses are in essence consequences of varying severity of failure in the thermoregulatory system. Heat waves have been implicated in the aggravation of existing conditions such as heart disease, high blood pressure, kidney failure and psychiatric disorder. Recent studies indicate that mortality due to heat waves is preventable through effective preparedness, prevention and mitigation strategies, but these demand effective risk communication as a prerequisite. It is generally contended that by increasing citizen participation in mitigation and response strategies, emergency managers can build an informed constituency for mitigation, preparedness and response, as well as earn a real commitment from established institutions for undertaking appropriate actions.

It is also known that significant knowledge gaps remain between the general public's perception of risk and the risks as identified by the expert-group community. Risks as seen by the latter are usually expressed in terms of mathematical probabilities and confidence intervals, and identified by causal links between dependent and explanatory variables (Okrent and Pidgeon 1998; Slovic 2000). A large body of research shows that members of the public (particularly when asked about risks outside their area of expertise) apply a complex understanding of risk when making personal

judgments about risks and threats, and their acceptability. Slovic *et al*. (1974, 1979) and Slovic (2000) have continually argued that the gap between the 'expert' and the 'public' must be eliminated in order for the public to trust the judgments made by informed (*i.e*., expert) individuals.

Research now supports that risk communication strategies must take societal concerns and values into account in order to improve the desired outcome of the process (Okrent and Pidgeon 1998). It is contended that, in order to communicate with the public, factors outside of expert estimates need to be considered. Therefore, there is an apparent need to investigate dynamic changes in both the extent and nature of public perceptions of risk to hazards in order to better understand the concerns and levels of awareness among the public. The successful communication of health risks related to heat waves requires a more innovative approach than current practice. This can be achieved through developing a two-way communication system wherein the state of local knowledge and resources is emphasized to inform the decision makers so that their knowledge base embodies local concerns and priorities. Any communication problems or concerns should be addressed through programs during non-emergency time and be given the due attention that would not be possible during the constrained time lines of an emergency. In turn, communication efforts by the decision makers to inform community residents should be characterized by a dialogue and negotiation between specialists and residents. In this way, misconceptions that may exist among experts as well as community residents could be addressed.

Conceptual Consideration

Among climate change communicators, advocates and scientists there is a growing frustration that politicians and the public do not pay due attention to the issue that global climate is changing at a pace surpassing natural projections, and that the incremental change reflects the effects of anthropogenic release and accumulation of greenhouse gas emissions in Earth's atmosphere (IPCC 2001; Van Alast 2006). It has been alleged that recent communications regarding climate change, particularly in the media, may have emphasized 'fear appeals', essentially attempting to scare the public into action. Moser (2007) argues that this approach has ultimately divided public opinion regarding climate change, thereby making communication ineffective. This further suggests that a more positive communication strategy is needed. Overall, very few attempts have been made to examine how to communicate more effectively the risks of climate change to the public.

It is asserted that once members of the public are aware of the risks, they will take more effective means to address the problem, including demanding policy change (Moser 2007). For some time now, discrepancies between expert assessments and public or first responder perceptions of risk, sometimes called the 'objective perceived risk dichotomy,' have concerned risk managers and theorists (Slovic *et al.* 1990). Pidgeon defines risk perceptions as "people's beliefs, attitudes, judgments and feelings, as well as the wider social or cultural values and dispositions that people adopt, towards hazards and their benefits" (Pidgeon *et al.* 1992, 89). By this definition, risk perceptions appear to be multidimensional and much more context-sensitive than formal measures of risk which focus on single dimensions (*e.g*., expected loss). Risk communication can be implemented effectively only by identifying the extent and nature of the public's risk perceptions concerning the nature of the hazard (Morgan *et al.* 2002).

In the Canadian prairies, where it is predicted that extreme environmental events will increase in terms of frequency and intensity (Haque and Burton 2005), there is an utmost need to communicate effectively the risk posed by climate change-induced extreme environmental events so that pre-disaster efforts can be made to enhance the coping capacity of communities. At the community level, public capacity to cope with risk and disasters can be optimized through effective preparedness, prevention and mitigation strategies. These strategies may be inhibited by the level of risk perception among community members. Improvement in the knowledge and perception of environmental risk through effective risk communication is therefore imperative.

To send effective and efficient advice to the public and thereby achieve effective risk communication, experts need to adapt their explanations to the knowledge level of the public (Nückles *et al*. 2003). From both educational (*e.g*., Renkl 2002) and psychological perspectives (*e.g*., Clark 1992, 1996), adaptation to the background knowledge of communication partners is regarded as fundamental for achieving comprehension and learning. Despite this, experts often fail to take into account the knowledge domain of public (lay) audiences. Their highly interconnected, extensive domain of specific knowledge (Chi *et al*. 1988; Schmidt and Boshuizen 1992) makes it difficult for specialists to anticipate the wholly different perspective of members of the public (Hinds 1999; Nathan and Koedinger 2000). One way in which differences between expert and public opinions is explained is in terms of the 'rival rationalities' of the two groups, suggesting that the public views risk more widely than the expert, whose expertise is narrow and therefore likely to 'miss something' of importance to the broader community (Morgan *et al*. 2002). The general inclination of experts is to neglect the gap between their own knowledge and that of the public (Hinds

1999; Nathan and Koedinger 2000), and their methods follow a one-way communication path, which is also known as the *factual information model* or *empty bucket model*. In contrast, the notion of two-way risk communication has led to information dissemination processes characterized by mutual understanding and equal and fair participation rather than the exertion of power.

In order to improve current practice in risk communication, the Mental Model has been used as a tool, particularly to address knowledge gaps between concerned groups. The term 'Mental Model' was introduced first by Kenneth Craik and was pursued further from a psychometric perspective by Morgan *et al*. (2002) as they were interested primarily in the cognitive mechanisms of the learning processes in a system. Thus, the focus of the goal was upon human cognition and its elements. However, as the model has evolved over time, the goal of this framework has widened and incorporated many other dimensions. In the context of present-day environmental issues, the appropriate term for this framework is 'Knowledge Model' as it refers to a concept applied to explain the cognitive processes for representing and making inferences about a system or problem, the state of knowledge, and the learning mechanisms that influence both perception and behaviour (Borgman 1984). In reflecting this broader context and perspective, the term Knowledge Model is used throughout the present study as it basically defines expert and stakeholder perception, conception and knowledge of the phenomenon under concern.

The Knowledge Model approach here is an option to minimize knowledge gaps regarding climate change-induced extreme events, and it poses fairly high demands on the experts compared to any other approaches such as the Delphi method or the stratified socio-economic survey method. The Knowledge Model approach focuses on communicating issues that people do not yet know but need to know (Morgan *et al.* 2002). Unlike the Delphi method where reliable judgment or forecast results are made by experts through allowing the sharing of information and reasoning among participants, the Knowledge Model focuses on understanding people's mental models (*e.g*., knowledge, beliefs and perception) in order to craft effective risk communication messages that can help them understand complex or unfamiliar phenomena. In comparison with stratified socio-economic survey methods (where participants are targeted for structured interviews rather than obtaining open-ended ideas from each participant), in the Knowledge Model approach evidence regarding individual differences in both attitudes and knowledge about risks suggests that each message is tailored to the knowledge set of the targeted audience. Bier (2001) further suggests that risk communication messages using the Knowledge Model are more

effective at conveying both general knowledge and information about risk reduction strategies.

Risk communication in heat wave hazards refers to the verbal or other links intended to supply the public with the information they need to make informed, independent judgments about risks to health during a heat wave (Fischhoff 1989). The Knowledge Model approach in this regard assists the procurement of information on the extent and nature of public perception of heat wave hazards and their associated risks, and it addresses the existing problems in risk communication as well as public mitigation and response behaviour.

A conceptual framework is introduced in this regard (Figure 1). The distinction between expert and public risk assessment and understanding is made by asserting two separate triangles. Expert risk assessment is characterized primarily by a scientifically-based objective analysis of data (real-time based or simulated) whereas public understanding of risk is characterized by subjective processing and interpretation of experiential data or observation. The types of risk communication and their related approaches profoundly influence the effectiveness of risk communication. Four primary types of communication means are cited in the literature. Specifically, these are one-way communication (*e.g*., brochures and leaflets), two-way, interactive communication (*e.g*., public meetings and talk shows), stakeholder communication (*e.g*., Delphi exercises and round tables) and the media (newspapers, radio and TV).

As can be seen in the risk assessment subsets or triangles for experts and the public, under the one-way communication approach, very little overlap is exhibited between them. In contrast, a two-way based Knowledge Model application allows the knowledge gap to narrow down and be minimized (see 'D' in Figure 1). In a nutshell, this conceptual framework captures the notion that the types and effectiveness of risk communication profoundly affect the outcomes among experts, policy makers and the public. Under the Knowledge Model approach, experts and the public can adopt each other's explanations more effectively since the percentage of shared risk perception, information and knowledge is higher. Also, the process might enable both groups to calibrate each other's mental model more quickly and accurately than by other means.

Objectives and Study Area

The objectives of this research are threefold. First, the study intends to determine the 'knowledge gaps' that may exist between experts and the public regarding the health risks related to climate change-induced heat

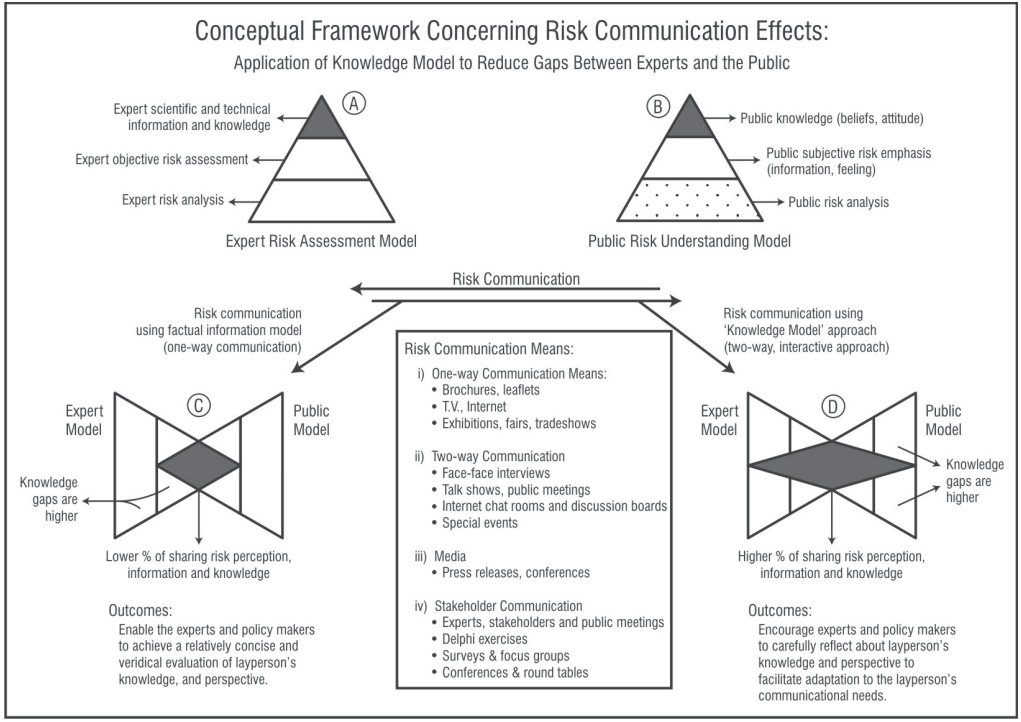


Figure 1: *Conceptual framework concerning risk communication effects: application of Knowledge Model to reduce gaps between experts and the public.*

waves. Second, the research aims to examine the extent and nature of public perceptions of climate change-induced heat wave events in light of scientists' perceptions of these phenomena. Third, it attempts to identify the gaps and overlaps in understanding and knowledge between experts and community residents concerning the best possible practices in risk communication; public views are incorporated in an attempt to decrease mortality rates during heat waves.

Study Area and Methodology

Winnipeg is a typical large urban centre in the Canadian prairies and is subject to extreme heat waves during summer months. The city is inhabited by about 700,000 people and has residential areas spatially divided according to the socio-economic conditions of its inhabitants. North Kildonan ward is located in north-east Winnipeg (Figure 2). It possesses mixed neighbourhoods representing prairie urban communities with vulnerable populations such as elderly, low-income and single-parent households. This study uses the case of North Kildonan to test its assertions and to make inferences.

The first step in application of the Knowledge Model involves construction of an 'expert knowledge model' by creating an influence diagram that captures the pooled beliefs of technical specialists about heat wave phenomena. The model is created through the use of a focus group of experts from various, yet related, disciplines. In this research, a team of experts representing 12 different stakeholders provided their input into framing an influence diagram on the risks of heat waves related to climate change. In the second step, 25 respondents ($N_1 = 25$) from North Kildonan were interviewed using 'open-ended' instruments. The survey instrument was kept open so that respondents' personal views could be captured rather than ones prompted by the researchers' biases or needs. Special emphasis was placed upon the targeted community members' beliefs about heat waves. As indicated in the existing literature, elderly and low-income groups are particularly vulnerable in a heat wave period. Consequently, the sampling plan required a stratified sampling. Among the 25 direct interviewees, 10 were chosen from the elderly population (age $\geq$65 years) and five were from financially challenged groups (annual income < $35,000). The remaining 10 were selected from members of the general public within the community. Telephone directories were used to obtain the names and addresses of potential respondents in the general public category. To conduct interviews with the elderly and low-income groups, a 'snow-ball' contact procedure was followed. To fulfill the third

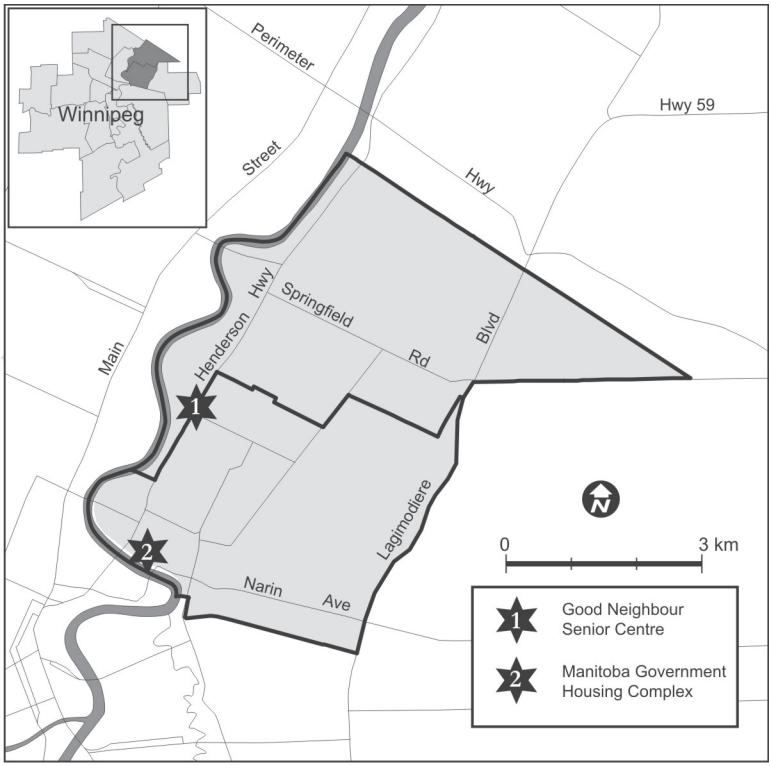


Figure 2: *Location of the study area, North Kildonan, Winnipeg.*

step of the Knowledge Model process, a quantitative confirmatory questionnaire was created and distributed among a large sample of the overall community of North Kildonan (N_2 = 300). The purpose of this questionnaire was to estimate the prevalence of beliefs about heat waves in the wider population and to substantiate the initial findings of the interview process. The response rate was 38 percent (N_3 = 114). Finally, the results, both qualitative and quantitative, were analyzed to determine which distorted beliefs, if any, need intervention for improvement and which knowledge gaps require attention for convergence.

Results and Analysis

Expert knowledge of a subject such as climate change-induced heat waves involves complex variables, with factors influencing each other in

direct and indirect ways, and they are expressed in the form of an Influence Diagram. It is possible to identify certain factors and relationships that exist between these variables and to determine the areas that require lucid communication. From the initial model, some primary relationships have been identified which warrant thorough consideration. The formulated Influence Diagram, as elicited in Figure 3, depicts the Knowledge Model developed by the participant experts, along with their influence indicators. The Knowledge Model developed under the present study indicates that the three most important factors contributing to the physical risk of extreme heat are: 1) a rise in mean temperature; 2) changes in atmospheric moisture; and 3) changes to surface moisture. In the physical presence of a heat wave, risk exists only if individuals are exposed to sunlight for a long time, have a lack of access to water and/or are exposed to inadequate ventilation in housing/building structures. If adverse conditions continue for too long, the advanced effects of a heat wave detrimentally affect infrastructure, the environment and human health. Many physiological and psychological conditions may be aggravated by these effects.

In this study, knowledge gaps were examined in three key areas. These were: 1) predictions regarding the causes of heat waves; 2) predictions regarding whether heat waves cause significant health risks including high mortality rates; and 3) predictions regarding whether the heat exposure risk could be minimized by taking precautionary measures. A five-point Likert-type instrument was used to generate quantifiable information that could reveal the extent of agreement or disagreement.

In calculating the knowledge gaps between experts and members of the public with respect to the cause of heat waves, experts assert the hypothesis that a rise in mean temperature is correlated with an increase in atmospheric greenhouse gas concentration (GHG). In terms of the stated hypothesis, all low-income and elderly respondents believed (*i.e.*, they agreed or strongly agreed) that increased GHG concentration indirectly influences the occurrence of heat waves, particularly by causing a rise in Earth's mean temperature. Among all community respondents, only 50 percent recognized such a pattern and correlation. The cross-sectional survey results revealed that 87.7 percent of respondents ($N_3 = 114$) either agreed or strongly agreed with the assertion that GHGs cause Earth's mean temperature to rise and thereby indirectly help heat waves to occur (Table 1). The data were further analyzed to gain insight on the remaining 12.3 percent of respondents. It was revealed that most respondents who were unable to consider such a correlation were from younger age groups (25–45 years) and none of the respondents was from the low-income category.

Figure 3: *Simplified expert knowledge model of heat waves.*

Table 1: *Distribution of responses to the concerned statements(N = 114).*

Statement	True	Maybe True	Don't Know	Maybe False	False
"Heat waves are occurring due to increased greenhouse gas concentration in the atmosphere."	16.6	71.1	12.3	0	0
"High mortality rates are associated with an extreme heat wave condition."	52.6	37.7	8.8	0.9	0
"High mortality rates due to heat waves are largely preventable by taking precautionary measures."	2.6	16.7	23.7	20.2	36.8
"Heat exposure risk could be minimised by improving building codes (*e.g* ., design, materials, air conditioning)."	2.6	7.0	28.9	17.5	43.9
"Heat exposure risk could be minimised by paying adequate media attantion."	0	9.6	13.2	31.6	45.6

When respondents were asked to state their feelings on whether they conceded that heat waves caused a significant health risk including high mortality rates, almost the same pattern of answers appeared. In this regard, all low-income and elderly respondents agreed or strongly agreed that climate change-induced heat waves constituted a significant health risk including high mortality. But at the broader community level, less than one-fifth of respondents (N = 114) either did not know or were not aware of such relationships (Table 1).

Mixed results appeared with regard to the notion of whether heat exposure risk could be minimized by taking appropriate precautionary measures. Notably, 60 percent of elderly respondents did not recognize that heat wave-related disasters could be avoided by proactive measures, whereas about 20 percent of the low-income group and larger community members fell into this category. Thus, a large variation existed among elderly and low-income respondents. This may be indicative of a low level of interest among the elderly population and their heavy reliance on external supports such as institutional assistance. In part, the reluctance of the elderly population can be attributed to their limited physical capability to undertake proactive measures to reduce risk. The cross-sectional survey (N = 114) data revealed a contrary perspective from the face-to-face interview (N = 25) data with regard to the possibility of reducing the impact of heat waves through interventions. In the face-to-face survey, 50 percent of respondents believed that human interventions could minimize the heat wave hazard impact, whereas only 20 percent of the cross-sectional survey sample agreed or strongly agreed with the same notion (Table 1). Also, 23 percent of the cross-sectional survey sample reported that they did not have enough information to comment on this subject.

Additional investigation was pursued with regard to effective measures for prevention, mitigation and preparation to deal with the risk of heat wave hazards. A total of 61.4 percent of cross-sectional survey respondents did not believe that by improving building codes (*e.g.*, design, materials and air conditioners) heat exposure risks could be minimized. Only 9.6 percent thought that such institutional measures could reduce heat exposure risks. Furthermore, the data of the confirmatory questionnaire survey reveal that community respondents did not recognize a vital role of the media in increasing awareness and in providing suggestions for actions and thereby minimizing the heat exposure risk. A total of 77.2 percent of respondents thought that heat exposure risk could not be minimized by paying adequate attention to media coverage of the concerned issue.

It is apparent that the majority of respondents did not believe that precautionary measures can be effective in reducing heat wave-related mortality. Also, about one-quarter of respondents were totally unaware of such precautionary measures. Overall, the data revealed that community members either lack knowledge of such vital issues relating to heat wave hazards or do not have the confidence that individual responsibility or collective responsibility could save a considerable number of lives. In this context, the findings of a study in the USA conducted by Bord *et al.* (1998) are worth citing. They concluded that the low salience of global warming and the persistent misunderstanding of the problem were likely to create hindrances against behaviour change towards mitigation measures.

The above responses illustrate a common misconception and misunderstanding about the role of precautionary measures prior to and during a heat wave period (Table 1). In order to obtain further insights, an analysis of some selected explanatory variables was attempted. These included age and income. Table 2 shows the response pattern of different age groups concerning whether a high mortality rates due to heat waves

Table 2: *Relationships between responses to the statement that "high mortality rates due to heat waves are largely preventable by taking precautionary measures" (Hypothesis 3) and age of the respondents (N_3 = 114).*

	Response (%)				
Age (years)	**Strongly Disagree**	**Disagree**	**Don't Know**	**Agree**	**Strongly Agree**
25 to 45	20	12	34	28	6
46 to 65	28	33	21	16	2
66 to 85	86	0	14	0	0
Total	37	20	23	17	3

Table 3: *Relationship between responses to the statement that "high mortality rates due to heat waves are largely preventable by taking precautionary measures" (Hypothesis 3) and income of the respondents (N_3 = 114).*

	Response (%)				
Yearly Income	**Strongly Disagree**	**Disagree**	**Don't Know**	**Agree**	**Strongly Agree**
$10,000-$34,999	55	8	18	19	0
$35,000-$64,999	36	19	31	14	0
≥$65,000	23	33	21	15	8
Total	38	20	23	16	3

are largely preventable by taking precautionary measures (Hypothesis 3). The data reveal that most of the elderly population (86%) strongly disagreed with the notion that precautionary measures were effective in reducing risk and impact. This reflected their lack of interest in undertaking proactive measures. A cross-tabulation between respondents and income groups is indicative of the fact that the low-income groups were passive in taking risk-reduction measures (Table 3).

Discussion

The main purpose of the research, as stated above, is to identify different knowledge gaps that lie between experts and the public by means of the Knowledge Model assessment tool. The present research successfully identified wide knowledge gaps both in the prediction of psychological stress associated with heat wave health hazards and in terms of the question of whether heat wave health risk could be minimized by taking precautionary measures during a heat wave period. Public understanding of the cause and extent of the health risk related to heat waves overlapped significantly with the understanding expressed through expert theoretical explanations. A key question arises here concerning whether the Knowledge Model method increased the effectiveness and efficiency of identifying knowledge gaps since an expert model existed prior to the interview phase (*i.e.*, the main means of analyzing the public's knowledge level). Given that not all people share common interests and

values, did the displayed knowledge gaps truly support the same knowledge level in the broader public sample? The results of the present research provide some answers to these questions about the level of public response to the targeted inquiries, as well as about the outcomes of the communication process.

With regard to the effectiveness and efficiency of the identified knowledge gaps, the results of this study show clearly that members of the public were quite knowledgeable and did not inquire much when questions were asked about the cause and risk associated with heat waves even though they were based on the expert heat wave model. Here, it is critical to assess the role of experiential learning about heat waves in the past by members of the public in Winnipeg. The results of a recent study have demonstrated that heat stress events have affected most areas of Canada, including Winnipeg, to varying degrees (Bellisario *et al*. 2001; Sauchyn and Kulshreshtha 2007). Using the absolute approach to identify the frequency of heat waves for the same cities lasting from two to five days or even longer, it is evident that the Prairies (Sauchyn and Kulshreshtha 2007), Southern Ontario and the St. Lawrence River Valley region of Quebec experience the highest incidence of heat waves. With a record averaging four episodes per year over the 62-year period, Toronto shows the highest count of extreme heat events in Canada. An analysis of mean temperature values as percentiles reveals that the Prairies experience the highest maximum temperature range in Canada. Similar to the absolute approach, the relative approach indicates that even the 99th percentile of summer temperatures in the Pacific Coast, the North and the Maritimes is below 30°C. Notably, Winnipeg and Saskatoon recorded the highest maximum temperatures of the cities analyzed, even though they experience temperatures of 30°C or higher less frequently and for shorter duration compared to Toronto and Ottawa. From this, it is apparent that communities in Winnipeg are familiar with exceptionally high temperatures. However, this does not imply that such temperatures transform into heat waves because humidity also plays a key role in causing heat wave stress among humans. Generally, communities in the Prairies are well adapted to high temperatures and are knowledgeable about heat wave effects (Sauchyn and Kulshreshtha 2007).

At the same time, questions related to net knowledge of the psychological effect and heat wave risk minimization seemed to deal with issues that were unfamiliar to members of the public. As they were less knowledgeable in these areas, they asked more questions. These results indicate that the Knowledge Model process did not create any underlying bias in identifying the gaps between the knowledge and ideas of the

public on the one hand and the assessed objective knowledge of experts on the other.

A relevant question is whether the displayed knowledge gaps truly support the same knowledge level in the broader public sample. Since the study sample was not representative of the population, and it was not the intention of the study to generalize from the sample, the findings need to be considered from a case study perspective. The displayed information about public knowledge obviously could help experts and policy makers in constructing accurate and adequately informed risk communication messages. However, there is no indication that the new knowledge created by this study regarding risk communication would be effectively implemented. The present research has successfully created a scope for adopting the Knowledge Model approach to assist policy and decision makers to address the gap between their own specialist knowledge and the knowledge and understanding of the public.

Conclusions

This study intended to determine the knowledge gaps that may exist between experts and the public regarding climate change-induced heat wave health risks. Second, the study examined the extent and nature of public perceptions of climate change-induced heat wave events in light of scientists' perceptions of these phenomena. Third, an attempt was made to identify the gaps and overlaps in understanding and knowledge between experts and the public concerning the hazard of carrying out the best possible practices in risk communication by incorporating public views in an attempt to decrease mortality rates during heat waves.

Findings of the study reveal that public knowledge and perception of climate change and its associated hazards are similar to expert understanding of the phenomenon. However, significant variation exists between the so-called 'scientific' Influence Diagram and first responder knowledge of heat-wave mitigation options and coping measures. Ironically, the most knowledgeable socio-demographic groups, namely the elderly, were found to be the least interested group in undertaking heat wave risk and impact mitigation measures. Low-income respondents also expressed a general reluctance to take precautionary or corrective measures to reduce the heat wave disaster impact.

It is clear that climate change and heat wave risk communications have been least effective among the vulnerable groups. This finding needs special policy attention. Risk communication strategies need to take prevailing social, economic, demographic, ethno-cultural and other human

dimensions into account. Canadian public health and emergency preparedness policies have already emphasized the need to move away from conventional one-way risk communication strategies towards more participatory, interactive, two-way communication strategies. However, an effective implementation of the newer, interactive communication approaches has yet to be carried out, especially in ways reflecting the perspectives of local community members. Local community perspectives appear to be more important than previously thought. This is partly because of the high degree of uncertainty that exists with regard to climate change and its effects on community health and other resources. Valuing and strengthening community resilience would help to build local capacity further and would facilitate the functioning of interactive, two-way communication channels that reflect minimized gaps between expert and community-based first responder knowledge of risk and mitigation measures concerning climate change impact and adaptation.

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Applicability of Land Surface Temperature (LST) estimates from AVHRR satellite image composites in northern Canada

Zhaoqin Li, University of Saskatchewan (*zhl237@mail.usask.ca*)
Xulin Guo, University of Saskatchewan (*xulin.guo@usask.ca*)
Paul Dixon, Western Canada Service Centre, Parks Canada, Winnipeg (*Paul.Dixon@pc.gc.ca*)
Yuhong He, University of Saskatchewan (*yuh783@mail.usask.ca*)

Abstract: Canada's northern ecosystems are vulnerable to climate change. Reliable temperature data are indispensable for assessing the region's response to global warming. Unfortunately, air temperature data for northern areas are lacking or of poor quality due to the small number of weather stations. Land surface temperature (LST) derived from satellite images may complement or substitute for air temperature data. To verify the suitability of LST derived from 10-day AVHRR composites, the relationship between LST and air temperature at weather stations was investigated for 2004 to 2006 using an error analysis conducted by computing average relative error (ARE) and root mean-squared error (RMSE). Since the difference between LST and air temperatures was relatively large, a linear adjusted model was developed to correct LST. Finally, the capability of the adjusted model was tested using reserved data. The results show that, despite high correlations, LST cannot be used as a direct substitute for air temperature at weather stations due to the large differences in their absolute values. The adjusted model, however, can decrease the difference between LST and estimated air temperatures to an acceptable level.

Key words: *land surface temperature (LST), thermal remote sensing, AVHRR, correlation analysis, error analysis, northern Canada*

Introduction

Northern ecosystems are very sensitive to global warming. Temperature therefore plays an important role in northern ecosystem

studies. Weather stations, however, are sparse in northern areas so it is difficult to acquire good quality air temperature data. Land surface temperature (LST) derived from satellite images has the potential to complement or substitute for air temperature. In addition, LST is an important input to climate and hydrology models (Dash *et al*. 2003; Pinheiro *et al*. 2006). It is therefore essential to study the use of LST in northern areas. Attempts have been made to use LST in many fields including geology (Bonneville *et al*. 1985, 1987), evapotranspiration (Kerr *et al*. 1989; Seguin *et al*. 1989), sensible heat fluxes (Seguin *et al*. 1994; Chehbouni *et al*. 1997), spring frosts (Kerdiles *et al*. 1996; Francois *et al*.1999), fire monitoring, regional hydrology, as well as drought indices (Kerr and Ostrovsky 2003). However, the usability of the absolute value of LST is still a challenge.

Advanced very high resolution radiometer (AVHRR) data have great potential for LST retrieval and application to climate change studies due to the long (24 years) historic data record and specific design purpose for determining surface temperature. AVHRR was carried on the polar-orbiting NOAA (National Oceanic and Atmospheric Administration) series of meteorological satellites. So far, the instrument has been improved twice. The outcome of the first update was AVHRR/2 which was carried on NOAA-7, 9, 11 and 14 and has three thermal bands (band 3B, band 4 and band 5) (WDC 2007). The second update was successful with the advent of AVHRR/3 in 1998 which also has three thermal bands (band 3B, band 4 and band 5) (WDC 2007). Of the latter, bands 4 and 5 are commonly used to retrieve LST.

Many researchers are dedicated to enhancing the accuracy of LST absolute values derived from AVHRR data. Improved LST retrieval methods and adjusted models of derived LST are the two primary methods used to improve the accuracy of LST. Adjusted LST derived using a generalized single-channel algorithm was shown to be lower than 2°C for AVHRR channel 4 (Jiménez-Muñoz and Sobrino 2003). The accuracy of LST retrieved from AVHRR compared to the ground reference data is 0.24°C or 1.75°C with or without correction using precise *in situ* atmospheric water vapour contents, respectively (Qin *et al*. 2001). Multiple regression relationships between LST from AVHRR and areal averages of air temperature for several surface types were conducted with extremely good correlations and root-mean-square differences of about +/–1.5°C (Prata 1994). These studies to some extent show the feasibility of using LST data. It should be noted, however, that the analyses were based on LST derived from daily images. Few studies have focused on assessing the accuracy of LST derived from satellite image composites, although LST from image composites have the potential to supplement or substitute for mean air temperature in some programs such as the northern Canada

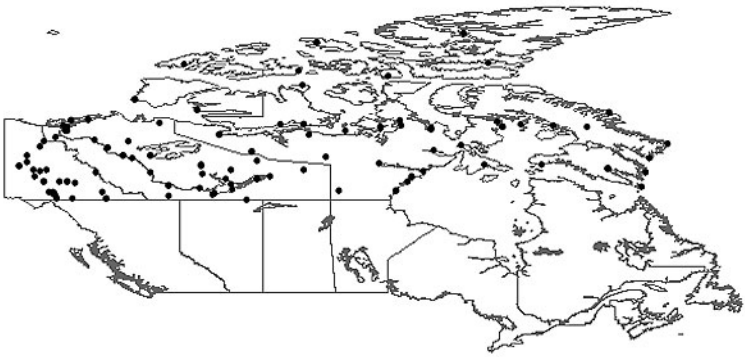


Figure 1: *Study area showing location of weather stations.*

ecosystem monitoring program initiated by Parks Canada (Parks Canada 2007). The present study therefore has the objectives of adjusting LST derived from 10-day AVHRR composites by a linear regression model, and testing the suitability of LST for northern Canada ecosystem studies.

Data and Methods

Study Area:

The study area shown in Figure 1 was selected to overlap with the northern ecosystem monitoring project of Parks Canada, which guarantees that the results in this study are suitable for application in northern ecosystem research in the future. The area roughly extends from 60° to 83°N and from 62° to 141°W and includes the 116 weather stations used in this study.

Data:

Two datasets are used in this study. The first is a LST dataset extracted from the 10-day NOAA/AVHRR composites from 2004 through 2006. The composites cover the April to October time period for each year. AVHRR has a temporal resolution of one day and a spatial resolution of 1.1 km for Local Cover Area (LAC) data and 4.0 km for Global Cover Area (GAC) data (Cracknell 1997). 10-day AVHRR LST composites were produced using the 10-day composite of maximum brightness temperature method (MaxT) (Holben 1986). The MaxT method retains pixels within 10 days and selects

the pixels with the highest brightness temperature to reduce the effect of clouds and shadows (Yang and Yang 2006). In the case of clouds covering a pixel for all of the 10 days, the data for this pixel are considered to be missing.

The second dataset is comprised of the air temperatures obtained from Environment Canada together with the location information for the weather stations. The air temperature dataset was acquired for the same days as the LST dataset.

Methods:

To investigate the suitability of LST over the 10-day composites, the correlation between LST and air temperature was computed (Equation 1) and differences were quantified by average relative error (ARE) and root mean-squared error (RMSE) (Equations 2 and 3). Because the differences between LST and air temperature are quite large, an adjusted linear model was developed to relate LST to air temperature. The capability of the model was verified by calculating ARE and RMSE between LST and air temperature and between adjusted LST and air temperature. The mean air temperature and the mean of LST were computed by averaging the values from April through October of each year. The spatial distributions of the means were mapped using Kriging interpolation to investigate their spatial variation.

Relationship. Correlation between LST and air temperature was studied by computing Pearson's product moment correlation coefficient, *r*:

$$r = \frac{\sum_{i=1}^{n}(t_i - \bar{t})(t_{li} - \bar{t}_l)}{\sqrt{\sum_{i=1}^{n}(t_i - \bar{t})^2 \sum (t_{li} - \bar{t}_l)^2}} \qquad \text{(Equation 1)}$$

where *r* is the correlation coefficient, t_i and $\bar{t}$ are the air temperature and its average value, and t_{li} and $\bar{t}_l$ are the mean LST and its average value.

Error analysis. Average relative error (ARE) and root mean-squared error (RMSE) were used to evaluate differences between LST and air temperature, and were computed as follows:

$$r_e = \frac{1}{n}\sum_{i=1}^{n}\frac{|t_{li} - t_i|}{t_i} \times 100 \qquad \text{(Equation 2)}$$

$$S = \sqrt{\frac{(t_1 - t_{l1})^2 + (t_2 - t_{l2})^2 + ... + (t_n - t_{\ln})^2}{n}} \qquad \text{(Equation 3)}$$

in which r_e and S stand for ARE and RMSE respectively, t_i is air temperature and t_{li} is LST. n is the number of test samples and equals the number of weather stations (116) times the number of 10-day periods within one year (21) times 3 years, with both missing air temperatures and missing LST data excluded.

Correction and adjustment. Approximately 5 perecent of the pairs (~ 40) of LST and air temperature data were randomly selected and reserved for testing the capability of the model (Equation 4). The remaining 95 percent of the pairs were used to develop a linear regression model to correct the LST value:

$$T_l' = \alpha T_l + b \qquad \text{(Equation 4)}$$

where T_l' is the adjusted LST, T_l is the original LST, α is the regression coefficient, and b is the intercept.

Results and Discussion

Relationship and error analysis:

Figure 2 indicates the spatial variation of the two measurements. Generally the greatest differences between the two variables are found in areas of low average temperature while in the areas of high average temperature the differences tend to be smaller. Figure 2 also shows that the mean temperature over the summer period in half of the study area is less than zero, which indicates that the difference between the air temperature and LST is quite large. The difference is very obvious in the

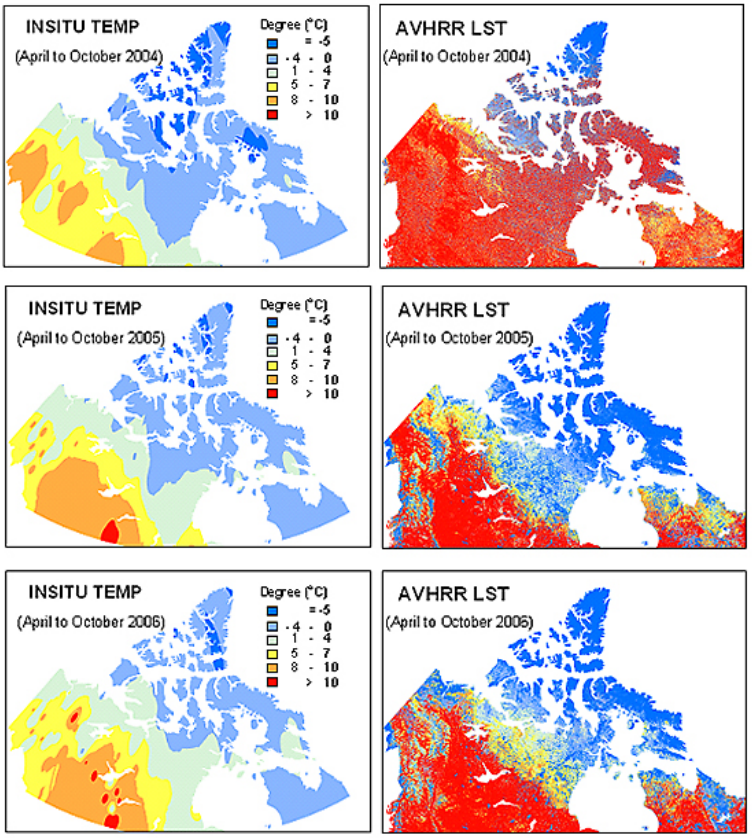


Figure 2: *Spatial relationship of in situ temperature and LST from 10-day AVHRR composites, 2004–2006.*

2004 map in which LST in a large area is much higher than the air temperature. The spatial patterns of the difference between the air temperature and LST in 2005 and 2006 are similar to each other but different from 2004.

Relationships between air temperature and LST over 10-day periods from 2004 to 2006 were calculated using approximately 1,720 data points (Figure 3). In general, the higher the temperature, the more closely clustered are the data along the trend line. The spread of the data is greater when temperatures are below zero, which probably can be accounted for by the low quality of the imagery. Compared to the 1:1 line, most LST values are less than the air temperature values when temperatures are below zero. When the temperature is above zero, however, the majority of LST values are higher than the air temperature values. Pearson's *r* shows moderately

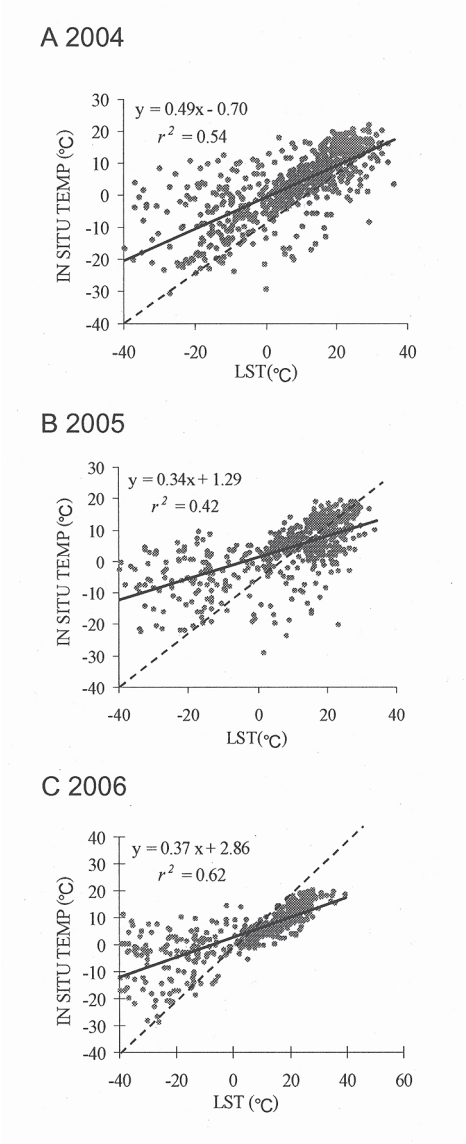


Figure 3: *Relationship of in situ temperature and LST from 10-day AVHRR composites 2004–2006 (solid line is a trend line; dashed line is 1:1 line).*

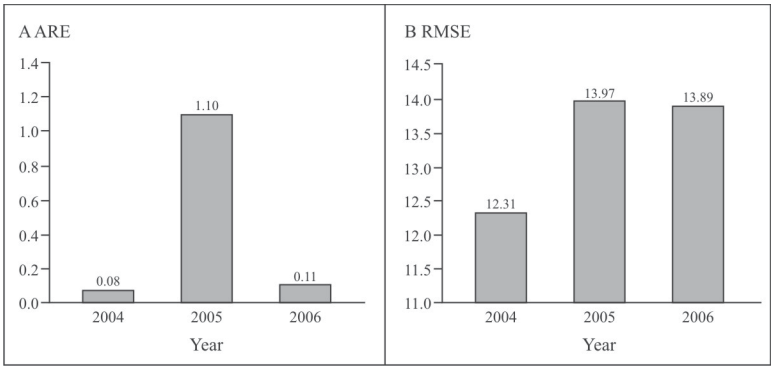


Figure 4: *ARE and RSME of in situ temperature and LST from 10-day AVHRR composites, 2004–2006.*

high associations between LST and air temperature with values of 0.73, 0.65 and 0.79 in 2004, 2005 and 2006, respectively (Figure 3). Although there are differences between LST and air temperature, a moderate to high percentage of the air temperature can be estimated from the LST as indicated by coefficients of determination (r^2) of 0.54, 0.42 and 0.62 for the three years.

ARE and RMSE of air temperature and LST were calculated for 2004 to 2006 (Figure 4). The results show that the ARE is quite large in 2005 with a value of 1.10, although relatively low values are observed in 2004 (0.08) and 2006 (0.11). The RMSE values are relatively high in all three years, and greatest in 2005 when a RMSE of 13.97 is observed.

Adjustment:

The large differences between LST and air temperature indicate that LST cannot be used directly to estimate air temperature, in spite of their moderate to high correlation. After reserving 5 percent of the data points, a linear adjusted model (Equation 5) was developed using LST as the independent variable and adjusted LST as the dependent variable for all data points from 2004 through 2006:

$$y = 0.39x + 1.29 \ (r^2 = 0.50, n = 1{,}681) \qquad \text{(Equation 5)}$$

where y is adjusted LST, x is LST derived from the 10-day AVHRR composites, n is the number of data points (one weather station for one year amounts to 21 data points if there are no missing data), and r^2 is the strength of the regression model. In this model, r^2 is 0.50, which means 50

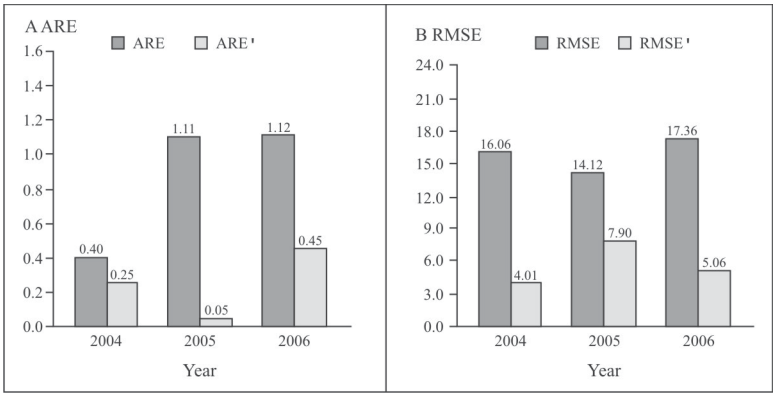


Figure 5: *ARE, ARE′, RMSE and RMSE′ of in situ temperature and LST for the reserved 5% data, 2004–2006 (ARE′ and RMSE′ indicate ARE and RMSE values after adjustment).*

percent of the variation of *in situ* temperature can be explained by the LST data.

ARE and RMSE between air temperature and adjusted LST were calculated based on the reserved 5 percent data over the three years. A comparison with and without adjustment was used to evaluate the functionality of the adjusted model (Figure 5).

Figure 5 shows that both the ARE and the RMSE decreased after the adjustment in all three years. Without adjustment, the ARE values are 0.40, 1.11 and 1.12 in 2004, 2005 and 2006 respectively. With adjustment, they are reduced to 0.25, 0.05 and 0.45. Similarly, before adjustment the RMSE values are 16.06, 14.12 and 17.36 in 2004, 2005 and 2006 respectively. After adjustment, RMSE values decrease dramatically to 4.01, 7.90 and 5.06. Overall, the decreases in both ARE and RMSE values after adjustment increase the confidence of using LST over 10 days.

Conclusions

An investigation of the relationship between LST and air temperature demonstrates that differences are relatively small in areas of high temperature but are larger in low temperature areas. This conclusion is confirmed by an analysis of the relationship between air temperature data and LST for each year, which indicates that LST and air temperature are more divergent when the average temperature is below zero in the seven months of April through October. In general, moderate to high correlations of 0.73, 0.65 and 0.79 were observed between air temperature and LST. On

this basis, 54, 42 and 62 percent of variation in air temperature was explained by LST in 2004, 2005 and 2006 respectively.

Despite moderate to high correlations, LST cannot be directly used as a substitute for air temperature due to large differences between the absolute values. A linear regression model therefore was developed to adjust LST data. The model indicated that 50 percent of variation in air temperature could be explained by LST in the all three years, and it was demonstrated to be capable of largely reducing the difference between adjusted LST and air temperature. Based on the reserved 5 percent data, RMSE dramatically decreased by 12.05, 6.22 and 12.30, and ARE was reduced by 0.15, 1.06, and 0.67 after the model adjustment in 2004, 2005 and 2006 respectively.

Overall, this study shows a moderate to high correlation between air temperature and LST in both space and time. Although large differences between the two constrain the application of the LST, a linear model can generally be developed to effectively enhance the accuracy of the LST. The success of the model makes it appropriate to use LST as a substitute for air temperature in the Canadian north.

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Limnological and macronutrient regimes in potential sport fishery 'pothole lakes' of southwestern Manitoba

Andrew W. Burton, Brandon University **(***aburt_2000@hotmail.com*)
Roderick A. McGinn, Brandon University **(***mcginn@brandonu.ca*)

Abstract: A history of prevalent summer-kill and annual winter-kill in trout stocked pothole lakes indicates that sophisticated management practices are required to foster a successful and sustainable sport fishery in the Prairie Pothole Lake Region (PPLR) of southwestern Manitoba. Electro-mechanical-pneumatic aeration during the ice-cover season is required and periodic summer aeration/agitation can offset summer nutrient loading and temperature induced stress by breaking up anaerobic strata.

This study examines the limnological and nutrient regimes of four potential sport fishery pothole lakes in the PPLR. Four pothole lakes (Rose, Sand, Leda and KT) and a control lake (Grayling) on the Riding Mountain Uplands were sampled throughout the open-water season in 2006. On-site instruments recorded seasonal trends in temperature, pH, dissolved oxygen and total dissolved solids. Epilimnion samples were collected for laboratory analysis. Five macronutrient parameters were analyzed in the laboratory – total ammonia, nitrate, orthophosphate, total phosphorus and total Kjeldahl nitrogen. Un-ionized ammonia concentration was calculated from the total ammonia-temperature-pH equilibrium. Seasonal observations in the five lakes suggest that an accumulation of nutrients and organic biomass accompanied by increased levels of productivity occurs in the wetlands and shallow kettle-hole depressions south of Riding Mountain National Park.

Water quality and trout habitat conditions in Rose Lake were statistically similar to those of the control lake and meet the recommendations for stocking of rainbow and tiger trout. In Sand, Leda and KT lakes, however, high concentrations of soluble reactive phosphorus and total phosphorus could result in the growth of toxic algal blooms during heat spells. Cyclic summer aeration is required to alleviate adverse water conditions and prevent the growth of toxic algal blooms. Sand Lake has periodic sub-lethal spikes in pH and concentrations of un-ionized ammonia during the summer. Consequently, Sand Lake may support summer stocking of rainbow trout for autumn harvest, but is not suitable for a trout sport fishery. Leda Lake is hypereutrophic and has periodic sub-lethal spikes in pH, concentrations

of un-ionized ammonia and lethal dissolved oxygen concentrations during the summer. Leda Lake is not suitable for trout stocking.
Water temperatures, total dissolved solids and dissolved oxygen concentrations favour trout stocking in KT Lake. However, a relatively high pH and periodic spikes in alkalinity and sub-lethal concentrations of un-ionized ammonia during the summer are detrimental to fish stocking. Consequently, KT Lake while marginally suitable for fish stocking cannot be recommended as a sport fishery lake.

Key words: *aquaculture, macronutrients, nitrogen, phosphorus, pothole lake*

Introduction

In 1968, the Fisheries and Oceans Canada Freshwater Institute in Winnipeg Manitoba began experimental summer stocking of rainbow trout (*Salmo gairdneri*) in the Prairie Pothole Lake Region (PPLR) south of Riding Mountain National Park. These small but permanent pothole lakes typically are void of native fishes due to the high incidence of winter-kill associated with biological depletion of dissolved oxygen (DO) under an ice cover. Consequently, stocked fish must be harvested in the fall before freeze-up. The 1968 trials were encouraging and by 1970 a summer commercial trout farming industry had been established (Lawler *et al*. 1974). Despite initial success, inconsistent harvests associated with unexplained summer-kill, cormorant predation, inefficient harvesting techniques and poor quality control (frequently a 'muddy' flavour) doomed the industry.

During the severe winters of 1988, 1989 and 1990, widespread winter-kill expunged the local fish populations in many of the larger and deeper pothole lakes in the region. In the early 1990s, locals undertook small scale restocking in these larger lakes (less subject to winter-kill) with rainbow and tiger trout (*Salmo trutta x salvelinus fontinalis*), a brown-brook hybrid, for the purposes of sport fishing. In the next four years stocked rainbow and tiger trout exhibited astonishing growth rates and trophy size fish were common. Unfortunately, the 1998 El Niño resulted in significant summer-kill in these recently stocked and highly productive lakes, probably due to low DO concentrations following the collapse of algal blooms (*e.g*., Barica 1975; Ayles and Lark 1976). A history of prevalent summer-kill and annual winter-kill in trout stocked pothole lakes indicates that sophisticated management practices are required to foster a successful and sustainable sport fishery in the PPLR.

In 2000, a non-political volunteer organization, Fish Lake Improvement Program for the Parkland Region (FLIPPR) was created. The purpose of

this organization is to enhance regional water quality and angling possibilities for the entire Parkland Region (Prairie Pothole Lake Region) and surrounding areas (FLIPPR 2008). As such FLIPPR's objectives are to act as a supportive extension of Manitoba Water Stewardship and to assist in identifying potential 'trout lakes' so as to broaden the sport fishing resource and gain economic benefits in the Parkland Region.

FLIPPR's primary form of management is to construct aeration facilities on small permanent pothole lakes. Electro-mechanical-pneumatic aeration during the ice-cover season eliminates winter-kill and cyclic summer aeration/agitation can offset summer nutrient loading and temperature induced stress on fish populations by breaking up anaerobic strata.

FLIPPR acknowledges the need for clean, clear water and that it is unfortunate that many pothole lakes in the region are affected by phosphorus and nitrogen loading to a point where they are susceptible to algae blooms and summer-kill. As a consequence, FLIPPR recommends that studies be initiated to examine phosphorus and nitrogen loading in these lakes.

The Prairie Pothole Lake Region in Southwestern Manitoba

This study examines the limnological and nutrient regimes of four potential sport fishery pothole lakes in the PPLR. The PPLR is a broad zone of stagnant ice moraine (kame kettle topography) generally bounded by Provincial Highway 16 on the south and by the southern boundary of Riding Mountain National Park to the north (Figure 1a). The region extends from the town of Russell in the west to Neepawa (Figure 1a). Fedoruk (1971) estimates that there are between 5,000 and 6,000 lakes larger than 1 ha in the region. Of these, 97 percent are smaller than 8 ha and 65 percent smaller than 2 ha.

Operational definition of a pothole lake:

A pothole lake is a shallow, small volume body of water and associated wetland, generally oval in shape. Groundwater springs and/or shallow concentrated overland flow runoff derived from rainfall events or snowmelt, supply inflow to the pothole lake. A few intermittent first or second order inlet channels may be functional during times of high surface runoff. Generally, there is no annual outlet. Periodically however, an outlet may be established during extremely high water levels. Primary water losses are attributed to evapotranspiration and/or groundwater seepage.

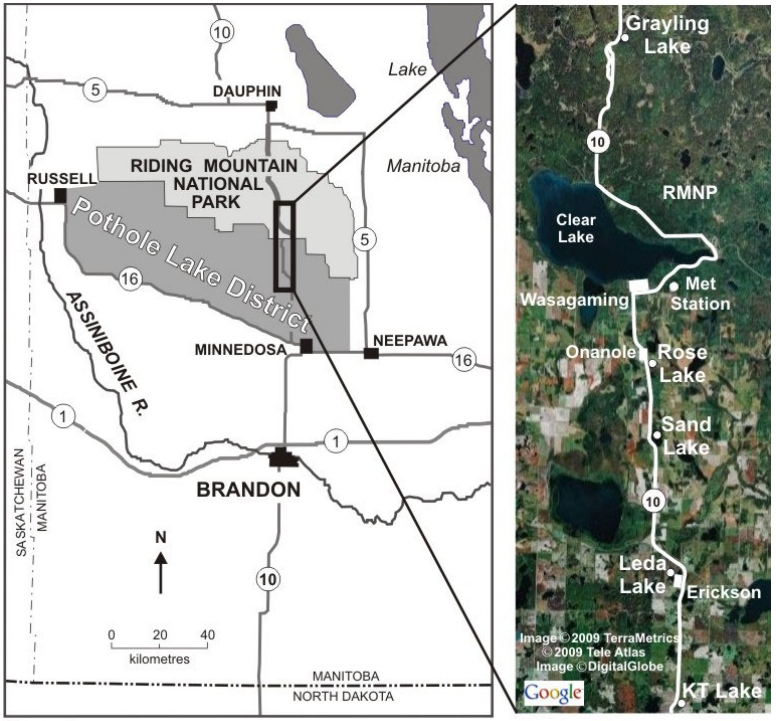


Figure 1a Figure 1b

Figure 1: *Sample sites in the permanent pothole lake study area.*

Thermal and nutrient regimes in prairie pothole lakes:

Generally pothole lakes are classified as polymictic; well mixed and too shallow for thermal stratification (Sunde and Barica 1975). Consequently, the thermal regime of a typical pothole lake is dependent on the diurnal radiation exchange and thereby directly related to ambient air temperature.

From 1971 to 1974, 51 summer stocked pothole lakes in the Erickson-Elphinstone district of the PPLR (Figure 1a) were analyzed for geochemistry (ion composition), and nitrogen and phosphorus nutrient regimes (Barica 1975). Unlike ion composition, nutrient concentrations in the Erickson-Elphinstone pothole lakes varied considerably through the year, specifically, the concentration range and extreme values (Barica 1975). Consequently, Barica concludes that mean nitrogen and phosphorus concentrations are of little comparative use and that the sampled lakes while similar are unique.

Suitable habitat and water quality for rainbow and hybrid trout:

Rainbow and hybrid trout species such as tiger trout are acknowledged to be tolerant of warmer water temperatures and higher pH than other salmonids (Ayers *et al*. 1976; Minnesota Department of Natural Resources 1982). Because of this, they have become the preferred species for stocking small shallow eutrophic lakes subject to winter-kill and periodic summer-kill (Ayers *et al.* 1976; Deyne 1990).

Kerr and Lasenby (2000) summarize information pertaining to the current state of knowledge regarding rainbow trout stocking of inland waters. They recognize five environmental factors influencing stocking success, namely: habitat and water quality; predation; inter/intra specific competition; prey availability and disease/parasites. Recommended habitat and water quality parameters are summarized in Table 1.

Ayers *et al*. (1976) recommend that trout ponds should be at least 10,000 m^2 (1 ha) in surface area, have a mean depth of 2 to 3 m and maintain stable water levels. Several researchers have established 15°C to 20°C as an ideal temperature range for trout rearing and Soldwedel (1967) determined 29°C as a lethal maximum temperature for two-year old trout. Marshall and Johnson (1971) recommend that water pH range from 6.2 to 9.6 whilst Murray and Ziebel (1984) have established a pH of 9.8 as a lethal maximum.

Dissolved oxygen (DO) concentration is a measure of gaseous oxygen found dissolved in water and is inversely proportional to the water temperature. DO levels below 5.0 mg L^{-1} have sub-lethal or lethal effects on aquatic organisms (Davis 1975; CCME 1999).

Gipson and Hubert (1991) demonstrate a positive correlation between total dissolved solids concentration (TDS) and biological productivity in stocked trout lakes. Wiley (2006) recommends TDS as an index of trout stocking productivity. Values exceeding 200 mg L^{-1} are considered excellent, 100 mg L^{-1} to 199 mg L^{-1}good, and less than 100 mg L^{-1} fair. Barica (1975) however, found a propensity for summer-kill when electrical conductivity values ranged from 800 μScm^{-1} to 2,000 μScm^{-1}, that is, TDS concentrations greater than 512 mg L^{-1} to 1,280 mg L^{-1}.

Nitrogen concentrations, specifically free or un-ionized ammonia ion (NH_3-N), can be lethal to a variety of aquatic organisms. Un-ionized ammonia is considered acutely toxic to 19 of Manitoba's invertebrate species when concentrations exceed 0.5 mg L^{-1} and 29 species of fish are subject to chronic toxicity when free ammonia concentrations exceed 0.08 mg L^{-1} (Williamson 1998). Consequently, Manitoba Conservation (2002) has established a 0.02 mg L^{-1} concentration as the recommended guideline for un-ionized ammonia concentration in surface waters. Toxicity of total ammonia concentrations (NH_3-N + NH_4^+-N) is dependent on water temperature and pH. The US Environmental Protection Agency (EPA)

Table 1: *Habitat and water quality requirements for trout production.*

Parameter	Recommended Value	Reference
Size of the waterbody		
Minimum surface area	1,000 m^2 (1 ha)	Ayers *et al* . (1976)
Mean depth	2 to 3 m	Ayers *et al* . (1976)
Pools	4 m	Ayers *et al* . (1976)
Water levels	stable	Ayers *et al* . (1976)
Temperature		
Range	15°C to 20°C	Dickson and Kramer (1971)
Maximum	26°C	Bigood (1980)
Lethal maximum	29°C	Soldwedel (1967)
pH		
Range	6.5 to 8.0	Kerr and Lasenby (2000)
Minimum	6.2	Marshall and Johnson (1971)
Maximum	9.6	
Lethal maximum	9.8	Murray and Ziebel (1984)
Dissolved oxygen		
Range	7.0 to 9.4 mg l^{-1}	Groutage 1968
Minimum	5.0 mg L^{-1}	Davis (1975)
TDS (productivity)		
Excellent	> 200 mg L^{-1}	Wiley (2006)
Good	100 to 200 mg L^{-1}	Wiley (2006)
Fair	< 100 mg L^{-1}	Wiley (2006)
MEI		Ryder (1965)
TDS/Mean Depth	8 to 10	Kerr and Lasenby (2000)
Nitrogen		
Total ammonia	0.5 mg L^{-1}	US EPA (1999)
Free ammonia	0.02 mg L^{-1}	Manitoba Conservation (2002)
Nitrate	10.0 mg L^{-1}	Manitoba Conservation (2002)
Phosphorus		
Orthophosphate	0.025 mg L^{-1}	Manitoba Conservation (2002)
Total phosphorus	1.0 mg L^{-1}	Van der Leeden *et al.* (1990)

Source: After Kerr and Lasenby (2000)

(1999) has established 0.5 mg L^{-1} concentration of total ammonia nitrogen as a guideline for evaluating quality for aquatic life.

Nitrate (NO_3^-) is the final product of nitrification, which is the oxidation of ammonia to nitrite (NO_2^-) and then to nitrate (NO_3^-). Nitrate nitrogen (NO_3^--N) is the most highly oxidized form of nitrogen found in a wetland pond and is an essential nutrient for plant growth. Excess nitrate, however, produces increased algal and aquatic plant growth in surface waters, which ultimately can lead to eutrophication. Nitrate nitrogen concentrations in unpolluted waters rarely exceed 0.30 mg L^{-1} (Reid and Wood 1976). Manitoba

Conservation (2002) has established a maximum nitrate concentration of 10.0 mg L^{-1}.

Phosphorus is an essential nutrient required for plant and animal growth and is frequently the limiting factor for vegetative productivity. Orthophosphate or soluble reactive phosphorus concentrations ($PO_4^{—}$ - P) should not exceed 0.025 mg L^{-1} in lakes and reservoirs or in tributaries at points where they enter such bodies of water (Manitoba Conservation 2002).

Total phosphorus (TP) is the sum of the various forms of organic and inorganic phosphorus, including orthophosphate. Excessive phosphorus compounds can accelerate the eutrophication process and result in increased algal growth. The US EPA has established TP concentrations exceeding 1.0 mg L^{-1} in rivers, lakes and wetlands as a 'violation level' (Van der Leeden *et al*. 1990 Table 7.7).

Pothole lakes rarely contain native fishes (Sunde and Barica 1975). When this is the case, fish predation and inter-species competition is nil.

Prairie pothole lakes are rich in salmonid food source. High fertility, a mean alkalinity greater than 300 mg L^{-1} (pH greater than 8.0), and waters rich in calcium (Barica 1975) support large populations and growth of gammarus (Menon 1969; Pennak and Rosine 1976). *Gammarus spp*. is a preferred food for trout (Groutage 1968; Degani *et al*. 1987; Ade 1989; Newman 2008) and it is estimated that *Gammarus spp*. constitutes 30 to 42 percent of the salmonid food source in the PPLR.

The Study Area

The sample study area is approximately 35 km long, 6 km wide and parallels Provincial Highway 10 (Figures 1a and 1b). Five pothole lakes were selected based on physical parameters such as the Ducks Unlimited Shallow Pond-Wetland classification system (Stewart and Kantrud 1971), longevity, nominal size, evaporation potential (EPI), inflow streams Shreve Number (PSn), and road and hydro power accessibility (Table 2).

***Grayling Lake*.** Grayling Lake is a large permanent pothole lake (Stewart and Kantrud 1971) located in Riding Mountain National Park (Figure 1b). Scanned panchromatic aerial photographs (August 1994) in ArcGIS 9.1 were employed to estimate lake surface area, lake surface elevation and watershed relative relief. The surface area of Grayling Lake is 173,911 m^2, the estimated mean depth is 3.0 m and the calculated volume on July 1, 2006 exceeded 5,217 dam^3. Evaporation Potential Index (area/volume ratio) was calculated to be 333, low potential. August 1994 aerial photography

Table 2: *Pothole lake classifications (July 1, 2006).*

Lake ID	Trophic Index	Longevity	Inflow Shreve Number (PSn)	Surface Area (m^2)	Estimated Mean Depth (m)	Estimated Volume (dam^3)	EPI Index	MEI Index	Ducks Unlimited Shallow Pond Classification	Subjective Anthropogenic Influences
Grayling	eutrophic	permanent	3	173,911	3.0	5,217	333	21	permanent lake	natural/control
Rose	eutrophic	permanent	0	155,499	1.9*	2,954	530	31	permanent lake	recreation/golf course
Sand	eutrophic	permanent	2	541,521	1.7**	8,989	600	30	permanent lake	residential/livestock
Leda	eutrophic	permanent	4	618,983	3.0	18,569	333	57	permanent lake	urban/agriculture
KT	eutrophic	permanent	5	430,324	3.0	12,910	333	25	permanent lake	agriculture

* Barica (1975) ** McGinn (2000)

MEI, the Morpheodephic Index (TDS/mean depth), is a measure of fish productivity (Ryder 1965)

(2.0 m resolution) indicates one seasonal first order inlet channel and a single second order permanent inlet stream. As a result, the Pothole Lake Shreve Number (PSn) equals 3 (Table 2). The lake surface elevation is approximately 609 m and the watershed relative relief is estimated to be 3.0 m.

Grayling Lake receives surface runoff from the surrounding spruce forest zone and from a small picnic area with a self-contained washroom facility located 30 m from the west shoreline. Snowmelt, stormwater runoff and surface drainage enter the lake by way of overland flow and the second order stream. Since the lake has an annual outlet, it does not fit the operational definition of a pothole lake.

The mean riparian buffer width was calculated to be 30 m and consists of open stretches of grasses and aquatics. The length of the surrounding buffer is estimated to be 1,800 m. Mature spruce (*Picea spp.*) and aspen (*Populus tremuloides*) surround 90 percent of the riparian buffer length. Observed waterfowl include the occasional loon (*Gavia immer*) and two pair of nesting mallards (*Anas platyrhynchos*). Northern pike (*Esox lucius*) and white sucker (*Catostomus commersoni*), beaver (*Castor Canadensis*) and muskrat (*Ondatra zibethicus*) are present in the lake. Water quality sampling was collected off a floating dock on the west side of the lake (430207.57 E, 5626138.24 N). *Gammarus spp*. were observed during water sampling. Grayling Lake with its native fish population is the sample control.

Rose Lake (002). Rose Lake is a large permanent pothole lake (Stewart and Kantrud 1971) located southeast of the town of Onanole (Figure 1b). This lake is included in the Sunde and Barica (1975) aquaculture study area and identified as lake 002. However, the lake's geochemistry and nutrient regimes were not examined in Barica's 1975 study of 51 winter-kill pothole lakes in the Erickson-Elphinstone District. Lake surface area is calculated to be 155,499 m^2. The estimated mean depth is 1.9 m (Barica 1975) and the estimated July 1, 2006 volume is 2,954 dam^3 (Table 2). Rose Lake is characterized as a large surface area, shallow depth pothole lake. EPI was calculated to be 530, moderate potential. August 1994 aerial photographs indicate no discernable streams entering the lake. Surface elevation of Rose Lake is 615 m; the surrounding mean watershed divide elevation was determined to be 618 m with relative relief of 3.0 m.

The mean riparian buffer zone surrounding Rose Lake is approximately 45 m wide; riparian buffer length was calculated to be 1,970 m. Sedges (*Carex spp.)*, rushes (*Juncus spp., Scirpus spp*.) and reeds (*Typha spp.*) dominate the aquatics. A population of nesting Canada geese (*Branta canadensis*) frequents the lake throughout the summer. Measurements and samples were collected from the northwestern side of the lake. Spruce,

pine (*Pinus spp*.) and aspen are the dominant tree species, which surround 60 percent of the lake. Thirty-three percent of the riparian buffer length belongs to Lakewood Hills Golf Course. Beaver and muskrat have been observed in this lake. There are no sport or game fish in Rose Lake, although Sunde and Barica (1975) report the presence of fathead minnows (*Pimephales promelas*) and brook stickleback (*Culaea inconstans*). The sample location is found on the northwestern shore (431923.87 E, 5607646.24 N). Irrigated, nutrient rich runoff from the Lakewood Hills Golf Course may be contributing to the eutrophication of Rose Lake. No runoff from the town of Onanole enters the lake.

Sand Lake (011). Sand Lake is a large permanent pothole lake (Stewart and Kantrud 1971) located 100 m east of Provincial Highway 10, 5 km north of the town of Erickson (Figure 1b). This lake is included in the Sunde and Barica (1975) aquaculture study area and is identified as lake 011. However, the geochemistry and nutrient regimes of the lake were not examined in Barica's 1975 study. Surface area is calculated to be 541,521 m^2 with an estimated mean depth of 1.7 m and a volume of 8,989 dam^3 (McGinn 2000). The calculated EPI is 600, moderate potential. Aerial photographs (2.0 m resolution) and on site verification indicate an intermittent second order inlet stream (PSn = 2). Surface elevation of Sand Lake is calculated to be 611m with a maximum relative relief in the surrounding watershed of approximately 14 m on the 1,000 m long east side and 2.0 m for the remainder of the west buffer length.

Sand Lake receives surface runoff from the surrounding forest/ agricultural region. Six cottages/homes are located around the lake, four on the east side ridge. The mean riparian buffer zone surrounding the lake is estimated to be 55 m in width with a buffer length of 3,000 m. The buffer zone consists of stretches and clusters of shrubs, grasses and trees. Dominant trees include spruce, pine and aspen, which encompass 85 percent of the riparian buffer length. However, no large fish are present in the lake; two-year old rainbow trout have to be summer stocked. Unharvested fish die over the winter. Beaver and muskrat have been observed in the lake. A nesting pair of common loons feed upon the trout fingerlings. Samples were collected from a dock on the western side of Sand Lake, 432377.76 E, 5603203.03 N. *Gammarus spp*. were observed during sampling. Sand Lake serves as a water-ski recreational lake. Residential wastewater and nutrient rich runoff from a small livestock operation might be accelerating eutrophication processes in the lake.

Leda Lake (116). Leda Lake is a large permanent pothole lake (Stewart and Kantrud 1971) located west of the town of Erickson (Figure 1b). This

lake was included in the Sunde and Barica (1975) aquaculture study area and identified as lake 116. Its geochemistry and nutrient regimes were not examined in Barcia's 1975 study. Lake surface area is calculated at 618,983 m^2 and the mean depth is estimated to exceed 3.0 m. Consequently, the estimated volume is 18,569 dam^3 (Table 2). Large surface area and high volume indicates an EPI of 333. The 1994 aerial photographs and site verification indicate one seasonal first order inlet steam and three 'first order' stormwater runoff drains from the town of Erickson (PSn = 4)**.** Surface elevation of Leda Lake is 609 m with a surrounding watershed divide approximating 620 m.

Leda Lake receives surface runoff from the undulating agricultural fields towards the north, west and south. Along the eastern shore, stormwater runoff and surface drainage enter the lake directly from the town of Erickson by way of three stormwater drainage channels. In addition, the Erickson three-cell sewage lagoon system discharges a single event June flush via an outlet channel into a small pothole lake (103) south of Leda Lake and from there into Leda Lake. The mean riparian buffer width is approximately 30 m. The surrounding riparian buffer length is estimated to be 3,650 m and consists of stretches of immature aspen, willows (*Salix spp.*) and open areas of grasses and aquatics. Approximately 30 percent of the buffer zone can be classified as aquatics, sedges and reeds. Eighty percent of the buffer length consists of trees. Numerous species of waterfowl such as Canada geese, mallards, teal (*Anas spp.*) and coot (*Fulica americana*) have been observed on the lake and inhabiting the riparian buffer zone. There are no sport or game fish in Leda Lake. Water samples were obtained from the north side of Leda Lake, 434860.36 E, 5595193.17 N, 200 m northwest of Erickson's major stormwater outlet.

KT Lake (008). KT Lake is a large permanent pothole lake (Stewart and Kantrud 1971) found on the eastern side of Provincial Highway 10 approximately 5.5 km south of Erickson, Manitoba (Figure 1b). This lake is included in the Sunde and Barica (1975) aquaculture study area and identified as lake 008. Its geochemistry and nutrient regimes were not examined in Barica's 1975 study. Surface area is estimated to be 430,324 m^2 with a mean depth greater than 3.0 m (Table 2). KT Lake has a large surface area, is relatively deep and has a very large volume. The EPI is 333, low potential. Aerial photographs indicate two first order streams and a single second order intermittent stream entering the lake (PSn = 5). These observations could not be verified in the field. The surface elevation of the lake is 625 m with a watershed relative relief of 5.0 m.

KT Lake receives surface runoff from the surrounding agricultural region to the north and east, while Provincial Highway 10 bends around

the lake to the west. Field peas were grown along the east side of the lake and a farmyard is located directly to the south. In 2006, no livestock were held within the watershed. Surface drainage and stormwater runoff enter the lake by overland flow and by three first order stream channels and one second-order intermittent channel (PSn = 5). A 50 m wide riparian buffer of 4,300 m surrounds the lake. The shoreline is comprised of 70 percent poplar (*Populus tremuloides*) and willow trees. No observable bare ground was found within the buffer width. The dominant aquatic species include reeds and sedges. Numerous species of waterfowl have been observed on the lake and inhabiting the riparian buffer zone. A large flock of white pelicans (*Pelecanus erythrorhynchos*) frequents the lake in the summertime. There are no sport or game fish in KT Lake. Water quality measurements and samples were collected from the southwest side of the lake at 435575.89 E, 5588599 N. Minnows and gammarus scuds were observed during water sampling. Direct runoff and shallow groundwater discharge are derived from the solely agricultural watershed.

Soils in the study area:

The soils over the 21,000 hectare study area are classified as Dark Grey Wooded, Grey Wooded and Degraded Black Meadow Soils developed on a moderately calcareous till; medium textured lacustrine deposits, and shaly gravel outwash deposits (Ehrlich *et al*. 1958). More recently, Eilers and Lelyk (1990) describe these soils as Dark Gray Chernozems and Luvisols. Specifically, the Erickson and Meadowbrook Series are naturally fertile soils with good moisture retention capacity, a moderately good reserve of organic matter, and a soil reaction favourable to plant growth (Eilers and Lelyk 1990). The Waitville Series is also well-drained moderately naturally fertile soil with moderate to high moisture holding capacity and a soil reaction favourable to crop growth. The very well-drained Seech Series exhibits very low moisture-retention capacity and low organic matter. Low organic reserves make the Waitville and Seech soils responsive to nitrogen fertilization (Eilers and Lelyk 1990). In the very poorly drained depression sites (the potholes), Terric and Typic Mesisols composed mainly of organic materials at an intermediate stage of decomposition are common.

Agriculture is the primary land use in the study area; the most common enterprises being mixed farming and ranching with feed grains, oil seeds and forages. Residential, recreational and wildlife management areas are other minor types of land use in the PPLR.

The climate of the PPLR:

Normals. The climate of the PPLR is classified as humid continental (Dfb) – severe winter; moist all seasons; short warm summer with a definite summer precipitation maximum (Belke and McGinn 2003). The Wasagaming meteorological station (Figure 1b) has recorded a mean January temperature of –18ºC and a mean July temperature of 17ºC (Parsons and McGinn 1999). Highest values for both the maximum and minimum monthly temperature normals are recorded in July; lowest values in January (Parsons and McGinn 1999). Normally there is a 79-day frost-free period from June 11 to August 30 (Environment Canada 2006). Frosts however, have been recorded in every month of the normal growing season. Lake ice forms in late October with break-up normally taking place in May. The mean annual total precipitation of the region is 476 mm (Environment Canada 2000). Nearly 45 percent of this total falls as rain during the summer (June, July and August), representing approximately twice the winter snowfall accumulation (Parsons and McGinn 1999). Convectional activity is responsible for a large proportion of the summer rainfall generally as high intensity, short duration thunderstorms. Precipitation during the spring and autumn months is significantly greater than that received during the winter months but less than the summer rainfall totals.

May 1 to October 31 2006 Precipitation Regime. The 30-year normal total accumulated precipitation recorded at the Wasagaming Climatological station (Figure 1b) from May 1 to October 31 inclusive (the open-water season) is 407.3 mm (Environment Canada 2006). In the 2006 open-water period, 315.5 mm of precipitation accumulated at the Wasagaming site; 92 mm or 22.5 percent below normal (Figure 2). Most of the spring and summer precipitation fell as convectional rain in approximately seven rainfall events with two low pressure systems responsible for the September rainfalls (Figure 2). Significant convective rainfalls (an accumulated total of 10 mm or greater in 24 hours) occurred on May 24 (13 mm), May 28 (35.2 mm), June 5 (10 mm), June 18 (11.2 mm), July 21 (13.8), August 11 (13.8 mm) and August 24 (41.8 mm). September storms occurred from September 15 to 18 (49.2 mm) and September 24 to 28 (14.6 mm). On October 16, 12.2 mm of rain and water equivalent snow accumulated in the study area. The largest rainfall event occurred on August 24 to 25 when 43.0 mm accumulated in 48 hours. This amount was slightly less than the September 15 to 18 cyclonic storm (Figure 2).

Procedures and methodology:

The five pothole lakes were monitored for water chemistry from spring thaw to freeze-up. Sampling began on April 26, 2006, following break-up

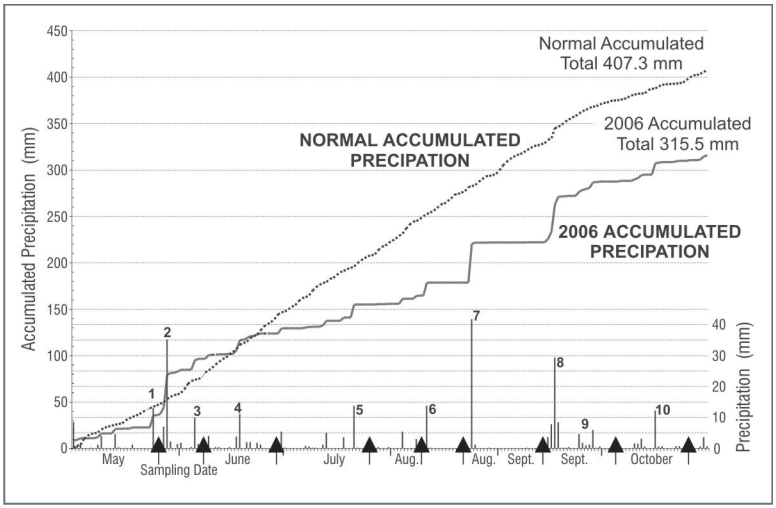


Figure 2: *The May 1 to October 31, 2006 precipitation regime.*
Source: Environment Canada, 2006

and during the spring freshet. Point water samples were collected from the epilimnion and measured for temperature, pH, conductivity, total dissolved solids (TDS), salinity and dissolved oxygen (DO). Ten dates (ordinal dates) constitute the open-water sampling period: April 26 (ordinal date 116), May 23 (143), June 8 (159), June 29 (180), July 26 (207), August 10 (222), August 22 (234), September 14 (257), October 5 (278) and October 26 (299). Winter ice cover formed on October 26.

Lake water samples were collected in 500 mL plastic bottles. Water samples were stored at 5ºC until laboratory analysis could be conducted. Total ammonia nitrogen, nitrate nitrogen and orthophosphate phosphorus concentrations were analyzed in the laboratory within three hours of sampling. Total phosphorus and total Kjeldahl nitrogen were analyzed in the laboratory as soon as possible following the sampling date.

Onsite instruments:

The Hach SensIon5 Conductivity Meter was used to record water temperature, electrical conductivity, total dissolved solids concentration and salinity. The Hach HQ20 Luminescent Dissolved Oxygen/pH Meter measured temperature, DO and pH.

Prior to preliminary sampling, instruments were calibrated and tested for working order. Temperature was measured by taking the average of the Hach SensIon5 Conductivity Meter and the HQ20 Luminescent Dissolved

Oxygen/pH Meter. Both meters have a temperature range from –10ºC to 105ºC with an accuracy of ± 0.3ºC for temperatures from 0°C to 70ºC (Hach 2000a, 2003). Total dissolved solids (TDS) were measured on-site using the Hach SensIon5 Conductivity Meter. The conductivity meter had a range from 0 to 50,000 mg L^{-1} with an accuracy equal to ± 0.5 percent of full scale (Hach 2000a). Electrical conductivity was measured using the Hach SensIon5 Conductivity Meter which had a range from 0 to199, 900 μS cm^{-1}. The accuracy of the conductivity meter is ± 0.5 percent of the range value. Salinity also was measured using the Hach SensIon5 Conductivity Meter. The salinity range is equal to 0 to 42 ppt ± 0.1 and converted to mg L^{-1}.

The Hach HQ20 Luminescent Dissolved Oxygen/pH Meter measures DO in two separate modes, namely milligrams per litre or percent saturation. Metered DO concentrations range from 0 to 20 mg L^{-1} or from 0 to 199.9 percent saturation. Accuracy of the meter is ± 0.1 mg L^{-1} for 0–8 mg L^{-1} samples, and ± 0.2 mg L^{-1} for greater than 8 mg L^{-1} (Hach 2003). The Hach HQ20 Luminescent Dissolved Oxygen/pH Meter also measured units of pH. The pH mode has a range from –2.00 to 19.99.

Laboratory procedures and methodologies:

Hach DR 890 Colorimeter Spectrophotometer employs pre-stored computer programs and established laboratory methodologies to analyze nutrient concentration in water samples. Ion concentrations are recorded in mg L^{-1}. Accuracy checks using Hach standard solutions were performed on the instrument. The DR 890 in combination with the Salicylate Reaction Method (employing reagent powder pillow packs) was used to measure the total ammonia nitrogen (NH_3-N + NH_4^+ -N) concentration. This instrument has a range of 0 to 0.5 mg L^{-1} and accuracy of ± 0.02 mg L^{-1} (Hach 2000b). Un-ionized ammonia or free ammonia nitrogen (NH_3-N) was calculated from the total ammonia nitrogen concentration, pH and water temperature (Emerson *et al*. 1975). Nitrate nitrogen concentration (NO_3^- -N) was evaluated using the Cadmium Reduction Method and the DR 890, with a range of 0 to 5.0 mg L^{-1} and an accuracy of ± 0.02 mg L^{-1} (Hach 2000b). The Ascorbic Acid Methodology was employed with the DR 890 to estimate orthophosphate or reactive phosphorus ion concentration ($PO_4^{—}$ -P). Using this methodology, the instrument has a range of 0 to 2.5 ± 0.03 mg L^{-1}.

The DR 890 in combination with a digestahl apparatus and the Acid Persulfate Method was employed to measure total phosphorus concentrations. For this methodology, the instrument had a range of 0 to 5.0 ± 0.08 mg L^{-1}. Total Kjeldahl nitrogen was evaluated using the Nessler

Method, a digestahl apparatus and the DR 890, with a range of 0 to 150 mg L^{-1} and accuracy of ± 2.0 mg L^{-1}.

For samples where ion concentrations exceeded the detection limits, the samples were diluted with deionized water and retested.

Results

Limnological regimes:

***The temperature regimes*.** The 2006 open-water temperature regime for the five sample lakes parallels mean ambient air temperatures (Figure 3a). Generally, lake water temperatures increase throughout the late spring to early summer season, reaching a maximum in late July, and then cool through August, September and October. The winter ice cover formed on October 26 (ordinal date 299). Open-water temperatures exhibited a mean of 16.0°C ± 1.0°C and were generally within suggested trout habitat range for all sample lakes (Table 1). Summer maximum water temperatures never exceeded the lethal maximum of 29°C or the maximum recommended temperature of 26°C (Table 1).

***The pH regimes*.** The sample pothole lakes recorded a mean open-water pH of 8.76 ± 0.26 (Figure 3b). These value are slightly above the recommended value (Table 1) but well below the lethal 9.8 pH units. Generally, pH in four of the five sample lakes (Grayling Lake, Rose Lake, Sand Lake and KT Lake) was moderately above neutral during the spring freshet (≈8.6). Warming temperatures facilitate photosynthesis and increase pH levels in these lakes to approximately 9.2 by late August (Figure 3b). In the fall, bacterial decomposition releases potential energy stored in chemical bonds of the organic carbon compounds. Oxidation of these compounds consumes DO and releases carbon dioxide. The carbon dioxide dissolves rapidly in the water forming carbonic acid ions and carbonate ions. These newly created ions gradually buffer the pH. The final sampling date recorded a mean pH value of 8.7.

The pH trend for Leda Lake was observed to decrease in the spring, spike significantly in early June to a potentially lethal 9.8 and then decrease into the fall (Figure 3b). Although not observed, it is possible that the June 29 spike in pH was initiated by a sewage overflow from the Erickson lagoon cells generated by a storm on June 4 to 5.

The total dissolved solids, electrical conductivity and salinity regimes. Total dissolved solids, electrical conductivity and salinity are proportional measures of dissolved solids and ion concentrations (Hem 1985).

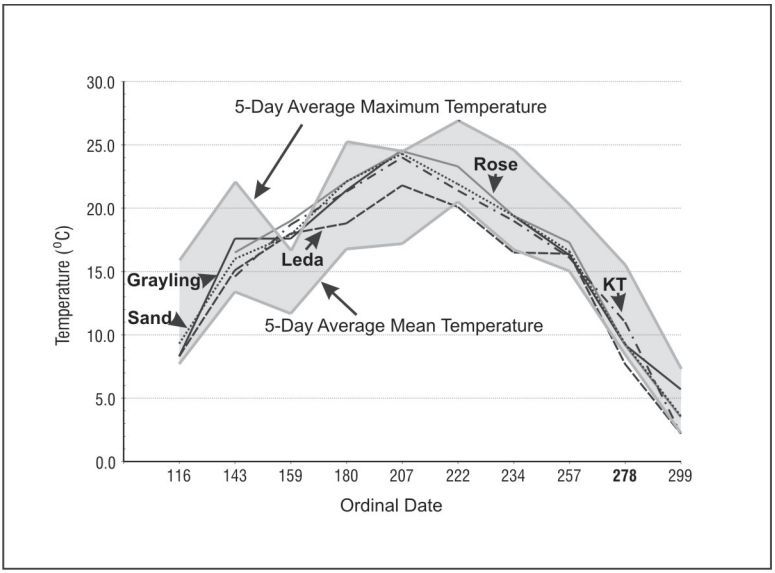


Figure 3a: *Open-water temperature regimes in the sample pothole lakes.*

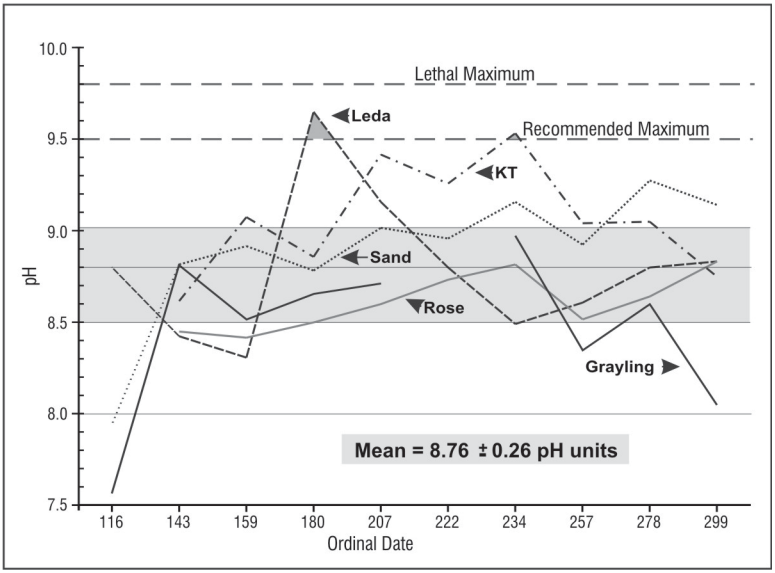


Figure 3b: *Open-water pH regimes in the sample pothole lakes.*

Consequently, the TDS regime and trend parallel the electrical conductivity and salinity trends.

The open-water seasonal TDS concentration regimes for the five sample lakes are illustrated in Figure 4a. Specific values are found in Tables 3 to 7. Three general patterns emerged. In Rose Lake and Grayling Lake, TDS concentrations are relatively constant throughout the sampling frame; mean of 61.5 mg L^{-1}. The TDS trends in KT Lake and Sand Lake were observed to decrease following the spring freshet, peak in early August and then, following a slight decrease, increase throughout the fall (Figure 4a). The third general pattern was common in Leda Lake and is described as oscillating. Total dissolved solids concentration exceeded 260 mg L^{-1} throughout May and early June, declined in late June and remained relatively constant throughout July (Table 6 and Figure 4a). TDS concentrations spiked on August 10, exceeding 390 mg L^{-1}, then declined sharply through August and September only to spike a third time on October 5 at 409 mg L^{-1} (Table 6 and Figure 4a).

The mean TDS concentration in the sample lakes was 170.1 mg L^{-1} ± 96.6 mg L^{-1} (Figure 4a). Individual mean TDS concentrations ranged from 61.1 ± 8.9 mg L^{-1} in Rose Lake (Table 4) to 180.5 ± 143.6 mg L^{-1} in Leda Lake (Table 6). Leda Lake recorded the highest TDS concentration (409.0 mg L^{-1} on October 5). With the exception of Leda Lake, maximum TDS values never exceeded 205 mg L^{-1}. Grayling, Rose and KT lakes registered fair growth potential for stocked trout (TDS less than 100 mg L^{-1}) whilst Sand and Leda lakes recorded good to excellent growth potential. None of the sample lakes recorded TDS concentrations indicative of toxic algal blooms.

Dissolved oxygen regimes. The open-water seasonal DO regimes for the five sample lakes are illustrated in Figure 4b. In general, DO concentrations were high following the spring freshet, decreased during June and July as water temperatures warmed and then increased throughout the late summer and fall (Figure 4b). The mean DO value for the five sample lakes was 8.54 ± 1.58 mg L^{-1} (Figure 4b).

Rose Lake, Sand Lake and KT Lake recorded DO levels greater than 5.0 mg L^{-1} throughout the open-water season (Figure 4b). Grayling Lake recorded a single DO measurement below 5.0 mg L^{-1} on July 26 (4.9 mg L^{-1}) (Table 3). Leda Lake recorded erratic readings throughout the sampling period; a high of 17.0 mg L^{-1} on June 29 and a low of 0.9 mg L^{-1} on July 26 (Table 6 and Figure 4b). DO concentrations in the lake peaked again on September 14 at 7.5 mg L^{-1} and then dropped to 2.3 mg L^{-1} on October 5. On October 26, the final sampling date, dissolved oxygen concentrations in the lake rose to 9.0 mg L^{-1} under a partial ice cover. Concentrations of DO

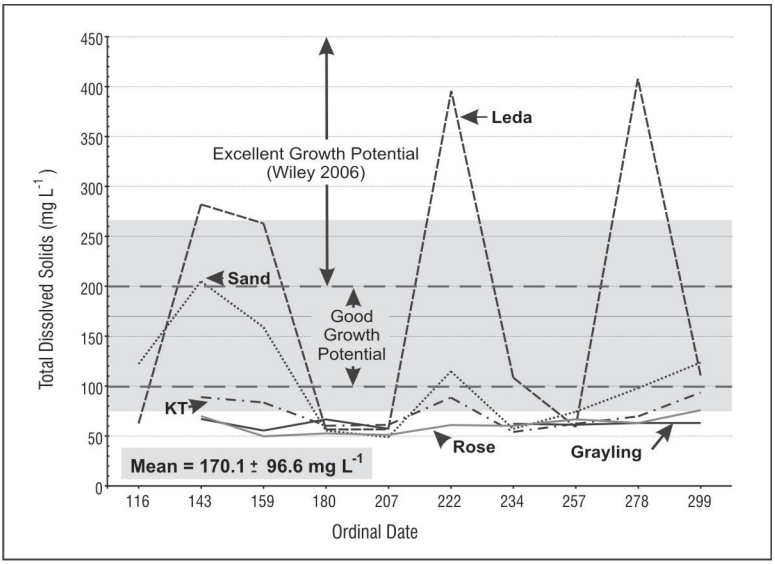


Figure 4a: *Open-water total dissolved solids concentration regimes in the sample pothole lakes.*

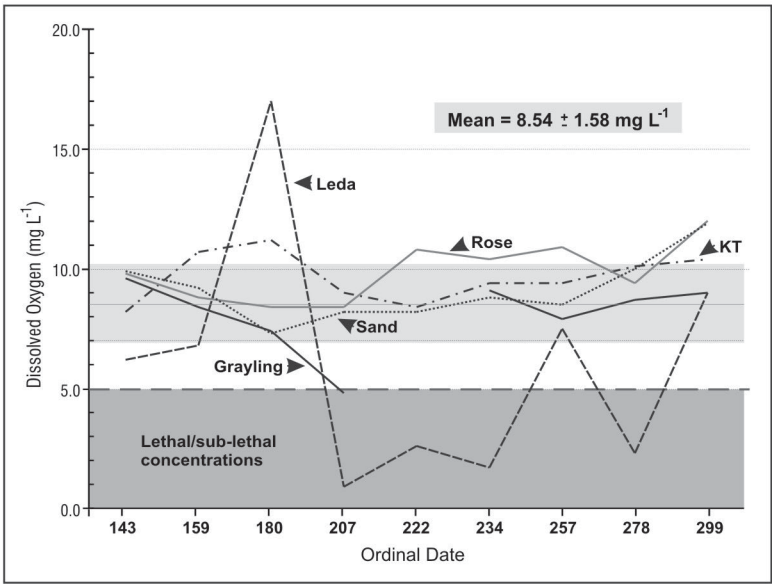


Figure 4b: *Open-water dissolved oxygen regimes in the sample pothole lakes.*

Table 3: *Limnological parameters and nutrient concentration data: Grayling Lake.*

Date		Temp.	pH	Conductivity	TDS	DO	DO	Salinity	NH_4^+	NH_3	NO_3^-	PO_4^{---}	TP	TKN
Calendar	**Ordinal**	**(°C)**		**(µS cm^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(% sat.)**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**
April 26	116	8.3	7.57						0.03	0.00	0.10	***0.27***		
May 23	143	17.6	8.80	140.6	67.0	9.6	110.4	0.10	0.10	0.01	0.30	***0.10***	0.60	110
June 8	159	17.6	8.54	116.9	55.6	8.4	91.7	0.10	0.17	0.02	0.25	***0.32***	0.32	50
June 29	180	21.4	8.67	140.1	66.7	7.4	89.4	0.10	0.20	***0.03***	0.00	***0.30***	0.30	20
July 26	207	24.6	8.71	120.4	57.3	***4.9***	63.7	0.10	0.05	0.01	0.15	***0.45***	0.46	0
August 10	222													
August 22	234	19.4	8.97	130.6	62.2	9.1	106.2	0.10	0.15	***0.03***	0.30	***0.11***	0.40	0
September 14	257	16.3	8.35	128.9	61.3	7.9	88.1	0.10	0.00	0.00	0.10	***0.15***	0.16	175
October 5	278	9.2	8.60	132.4	63.1	8.7	83.5	0.10	0.00	0.00	0.20	***0.34***	0.50	0
October 26	299	5.7	8.05	132.6	63.1	9.0	79.5	0.10	0.14	0.01	0.15	***0.08***	0.09	0
Maximum		24.6	8.97	140.6	67.0	9.6	110.4	0.10	0.20	***0.03***	0.30	***0.45***	0.60	175
Minimum		5.7	7.57	116.9	55.0	***4.9***	63.7	0.10	0.00	0.00	0.10	***0.08***	0.09	0
Mean		15.6	8.47	130.3	62.0	8.1	89.1	0.10	0.09	0.01	0.17	***0.23***	0.35	44
St. Dev.		6.4	0.43	8.4	4.0	1.5	14.7	0.00	0.07	0.01	0.10	0.13	0.17	65

Bolded italics identify concentrations that exceed US EPA and/or Manitoba Conservation guidelines.

Table 4: *Limnological parameters and nutrient concentration data: Rose Lake.*

Date		Temp.	pH	conductivity	TDS	DO	DO	Salinity	NH_4^+	NH_3	NO_3^-	PO_4^{---}	TP	TKN
Calendar	**Ordinal**	**(°C)**	**(none)**	**(µS cm^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(% sat.)**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**
April 26	116								0.31	0.00	0.20	***0.26***		
May 23	143	16.5	8.36	146.7	69.9	9.8	109.7	0.10	0.08	0.01	0.10	***0.08***	0.10	30
June 8	159	19.0	8.32	104.6	49.7	8.8	97.8	0.00	0.11	0.01	0.20	***0.17***	0.17	0
June 29	180	22.1	8.42	110.7	52.6	8.4	103.1	0.00	0.12	0.01	0.35	***0.12***	0.12	27
July 26	207	24.5	8.54	107.6	51.1	8.4	107.0	0.00	0.04	0.01	0.15	***0.54***	***1.70***	0
August 10	222	23.3	8.70	128.2	61.0	10.8	134.2	0.10						
August 22	234	19.4	8.80	126.6	60.2	10.4	121.2	0.10	0.10	0.01	0.25	***0.12***	***2.00***	156
September 14	257	17.3	8.44	140.3	66.8	10.9	123.0	0.10	0.00	0.00	0.40	***0.23***	0.10	0
October 5	278	9.2	8.59	132.4	63.1	9.4	86.2	0.10	0.00	0.00	0.15	***0.49***	0.40	19
October 26	299	3.5	8.82	159.0	75.9	12.0	99.5	0.10	0.10	0.01	0.35	***0.25***	0.16	0
Maximum		24.5	8.82	159.0	75.9	12.0	134.2	0.10	0.31	0.01	0.40	***0.54***	***2.00***	156
Minimum		3.5	8.32	104.6	49.7	8.4	86.2	0.00	0.00	0.00	0.10	***0.08***	0.10	0
Mean		17.2	8.55	128.5	61.1	9.9	109.1	0.07	0.09	0.01	0.24	***0.25***	0.59	29
St. Dev.		6.8	0.19	18.5	8.9	1.2	14.8	0.05	0.09	0.01	0.11	0.16	0.79	53

Bolded italics identify concentrations that exceed US EPA and/or Manitoba Conservation guidelines.

Table 5: *Limnological parameters and nutrient concentration data: Sand Lake.*

Date		Temp.	pH	conductivity	TDS	DO	DO	Salinity	NH_4^+	NH_3	NO_3^-	PO_4^{---}	TP	TKN
Calendar	**Ordinal**	**(°C)**	**(none)**	**(µS cm^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(% sat.)**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**
April 26	116	9.3	7.94	206.0	122.1			0.10	***0.60***	***0.03***	0.30	***0.51***		
May 23	143	16.0	8.80	424.0	205.0	9.9	110.2	0.20	***0.60***	***0.07***	0.30	0.00	0.00	58
June 8	159	17.9	8.92	330.0	159.0	9.2	101.2	0.20	0.31	***0.05***	0.25	***0.33***	0.33	54
June 29	180	22.1	8.76	116.7	55.5	7.3	89.4	0.10	***0.62***	0.00	0.20	***0.49***	0.90	42
July 26	207	24.3	9.04	102.9	48.8	8.2	105.1	0.00	0.06	0.02	0.40	***0.55***	0.11	0
August 10	222	21.9	8.97	239.0	114.8	8.2	99.8	0.10						
August 22	234	19.4	9.21	120.0	57.1	8.8	101.1	0.10	0.16	***0.05***	0.30	***0.31***	0.31	175
September 14	257	16.6	8.93	155.7	74.3	8.5	95.0	0.10	0.01	0.00	0.00	***0.35***	0.35	15
October 5	278	9.3	9.35	205.0	98.0	10.0	89.8	0.10	0.01	0.00	0.02	***0.51***	0.51	3
October 26	299	3.6	9.19	257.0	123.6	11.9	95.5	0.10	0.04	0.01	0.35	***0.23***	0.16	0
Maximum		24.3	9.35	424.0	205.0	11.9	110.2	0.20	***0.62***	***0.07***	0.40	***0.55***	0.90	175
Minimum		3.6	7.94	102.9	48.8	7.3	89.4	0.00	0.01	0.00	0.00	0.00	0.00	0
Mean		19.7	8.91	215.6	105.8	9.1	98.6	0.11	0.27	***0.03***	0.24	***0.36***	0.33	43
St. Dev		9.9	0.39	102.3	50.0	1.4	6.9	0.06	0.27	0.03	0.14	0.18	0.28	58

Bolded italics identify concentrations that exceed US EPA and/or Manitoba Conservation guidelines.

Table 6: *Limnological parameters and nutrient concentration data: Leda Lake.*

Date		Temp.	pH	conductivity	TDS	DO	DO	Salinity	NH_4^+	NH_3	NO_3^-	PO_4^{---}	TP	TKN
Calendar	**Ordinal**	**(°C)**	**(none)**	**(µS cm^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(% sat.)**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**
April 26	116	8.3	8.80	257.0	62.5			0.20	0.12	0.00	0.20	***0.24***		
May 23	143	15.1	8.33	581.0	282.0	6.2	67.4	0.30	0.12	0.01	0.15	***0.31***	0.30	118
June 8	159	18.0	8.19	542.0	263.0	6.8	76.5	0.30	0.15	0.01	0.40	***1.18***	0.80	81
June 29	180	18.8	***9.80***	119.0	56.6	17.0	198.6	0.10	0.05	0.00	0.15	***0.19***	0.19	78
July 26	207	21.8	9.21	119.1	56.7	***0.9***	11.2	0.10	0.11	***0.05***	0.15	***0.60***	0.57	9
August 10	222	20.1	8.78	611.0	397.0	***2.6***	31.0	0.30						
August 22	234	16.5	8.41	226.0	108.5	***1.7***	19.1	0.10	0.18	0.02	0.20	***0.55***	0.55	190
September 14	257	16.4	8.55	124.0	59.0	7.5	84.0	0.10	0.01	0.00	0.20	***0.72***	***3.10***	34
October 5	278	7.7	8.78	639.0	409.0	***2.3***	20.7	0.30	0.15	0.01	0.25	***0.45***	0.45	55
October 26	299	2.2	8.82	231.0	110.6	9.0	75.5	0.10	0.20	0.02	0.30	***0.30***	0.45	15
Maximum		21.8	***9.80***	639.0	409.0	17.0	198.6	0.30	0.20	***0.05***	0.40	***1.18***	***3.10***	190
Minimum		2.2	8.19	119.0	56.6	***0.9***	11.2	0.10	0.01	0.00	0.15	***0.19***	0.19	9
Mean		14.5	8.77	344.9	180.5	6.0	64.9	0.19	0.12	0.01	0.22	***0.50***	0.80	73
St. Dev.		6.3	0.47	220.5	143.6	5.0	57.6	0.10	0.06	0.01	0.08	0.31	0.95	60

Bolded italics identify concentrations that exceed US EPA and/or Manitoba Conservation guidelines.

Table 7: *Limnological parameters and nutrient concentration data: KT Lake.*

Date		Temp.	pH	conductivity	TDS	DO	DO	Salinity	NH_4^+	NH_3	NO_3^-	PO_4^{---}	TP	TKN
Calendar	**Ordinal**	**(°C)**	**(none)**	**(µS cm^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(% sat.)**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**	**(mg L^{-1})**
April 26	116													
May 23	143	14.6	8.56	186.0	88.9	8.2	89.4	0.10	0.10	0.01	0.15	***0.36***	0.40	88
June 8	159	18.7	9.11	175.0	83.6	10.7	119.3	0.10	0.19	***0.04***	0.10	***0.56***	0.60	2
June 29	180	21.3	8.85	126.7	60.3	11.2	134.5	0.10	0.12	0.02	0.20	***1.13***	***1.00***	40
July 26	207	24.0	9.52	107.9	61.2	9.0	113.8	0.00	0.15	0.00	0.05	***0.60***	***1.18***	0
August 10	222	21.4	9.33	185.1	88.5	8.4	101.1	0.10						
August 22	234	19.0	***9.66***	113.9	54.1	9.4	108.1	0.10	0.12	0.00	0.15	***0.65***	0.65	164
September 14	257	16.1	9.07	130.7	62.2	9.4	103.3	0.10	0.02	0.00	0.10	***0.80***	0.42	63
October 5	278	11.0	9.08	146.3	69.7	10.1	99.0	0.10	0.01	0.00	0.45	***0.70***	***1.33***	138
October 26	299	2.2	8.72	195.7	93.6	10.4	83.9	0.10	0.04	0.00	0.40	***0.38***	***1.58***	0
Maximum		24.0	***9.66***	195.7	93.6	11.2	134.5	0.10	0.19	***0.04***	0.45	***1.13***	***1.58***	164
Minimum		2.2	8.56	107.9	54.1	8.2	83.9	0.00	0.01	0.00	0.05	***0.36***	0.40	0
Mean		16.5	9.10	151.9	73.6	9.6	105.8	0.09	0.09	0.01	0.20	***0.65***	0.90	62
St. Dev.		6.6	0.36	33.9	15.1	1.0	15.4	0.03	0.06	0.01	0.15	0.25	0.44	64

Bolded italics identify concentrations that exceed US EPA and/or Manitoba Conservation guidelines.

in Leda Lake were generally below the critical sub-lethal/lethal value throughout the summer and early fall (Figure 4b).

The nutrient regimes (lake specific):

Barica (1975, 26) noted that the nutrient regimes of pothole lakes in the Erickson-Elphinstone region "vary considerably throughout the year and are governed by biological processes taking place in both the winter and summer." Consequently, the results of the 2006 nitrogen and phosphorus nutrient regimes and associated limnological parameters are reviewed according to the specific sample lake.

***Grayling Lake*.** In this study, Grayling Lake is considered a control lake. Unlike the other sampled pothole lakes, Grayling Lake has a permanent second order inlet stream and an operational outlet. The lake flushes. There is little anthropogenic activity around the lake, no agriculture in the lake watershed, no urban or rural development around lake shores and minimal recreational use. A National Park picnic area and self-contained washroom facility is located within 30 m of the lake. Some boat activity (no motors) occurs on the lake. There is a native fish population in the lake.

Date specific limnological and nutrient parameters are summarized in Table 3 and illustrated in Figures 3 to 7. Grayling Lake recorded a mean water pH value of 8.47 ± 0.43 (Table 3), a value slightly outside the recommended range but well below the lethal 9.8 pH units (Table 1).

Total dissolved solids concentration was constant throughout the open-water season (mean of 62.0 ± 4.0 mg L^{-1}), and provided fair growth potential (Table 1). The maximum TDS concentration was recorded on May 23 at 67.0 mg L^{-1} (Table 3).

Dissolved oxygen concentrations in the lake decreased as water temperatures increased, then increased as temperatures cooled in the fall (Figure 4b). The mean DO concentration was calculated to be 8.1 ± 1.5 mg L^{-1}, a value well above the sub-lethal/lethal limit of 5.0 mg L^{-1}. However on July 26, DO concentrations in the lake dropped to 4.9 mg L^{-1}, the minimum recorded value and to a sub-lethal/lethal level (Table 3). On this date, the warmest lake water temperature was recorded.

The total ammonia concentration in Grayling Lake was relatively constant ranging from 0.0 mg L^{-1} on September 14 and October 5 to a maximum of 0.20 mg L^{-1} on June 29 (Table 3). The calculated mean concentration was 0.09 ± 0.07 mg L^{-1}. Total ammonia concentrations never exceeded the 0.5 mg L^{-1} US EPA maximum concentration limit. On June 29 (180) and August 22 (234) however, un-ionized ammonia concentrations (NH_3-N) exceeded the Manitoba Conservation guideline of 0.02 mg L^{-1}.

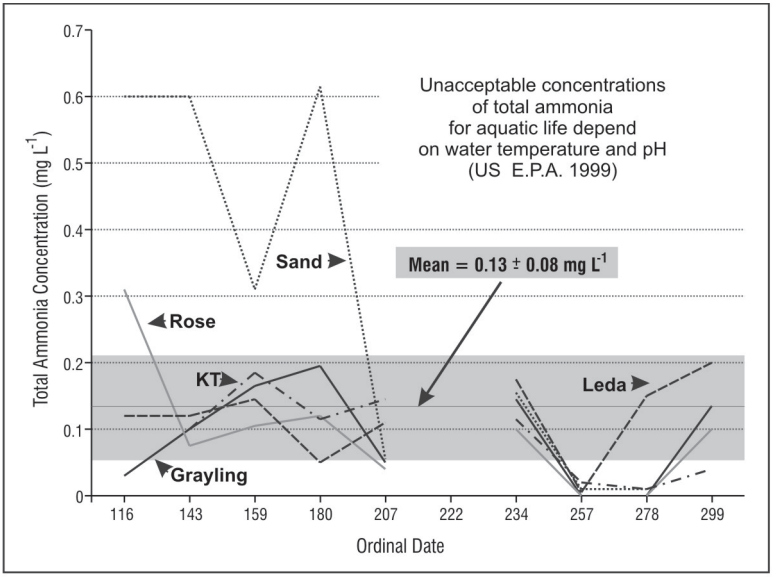


Figure 5a: *Open-water total ammonia concentrations in the sample pothole lakes.*

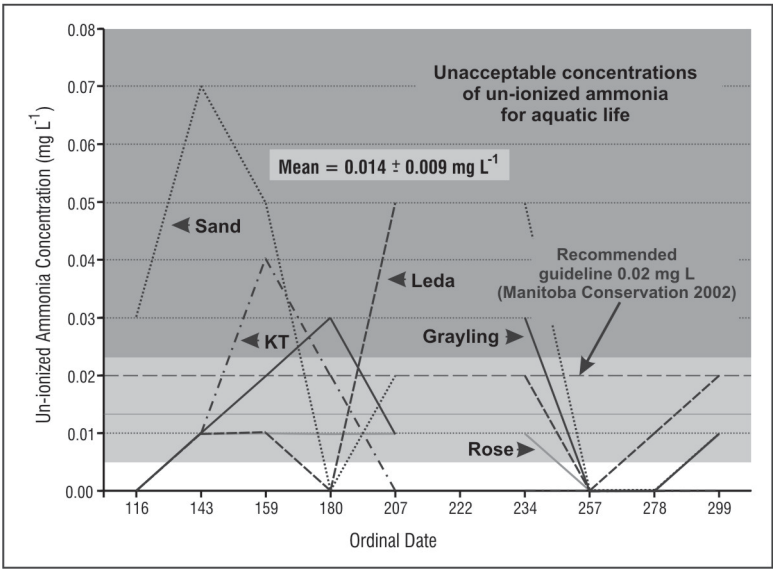


Figure 5b: *Open-water un-ionized ammonia concentrations in the sample pothole lakes.*

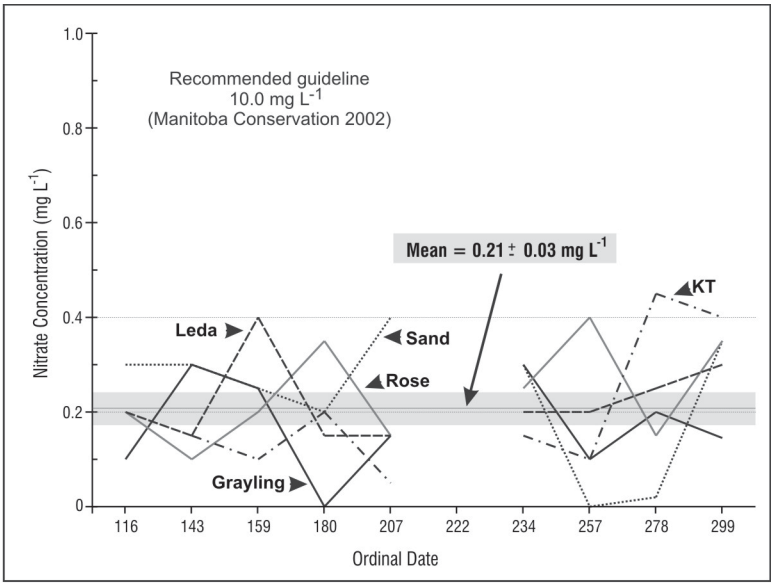


Figure 6a: *Open-water nitrate concentrations in the sample pothole lakes.*

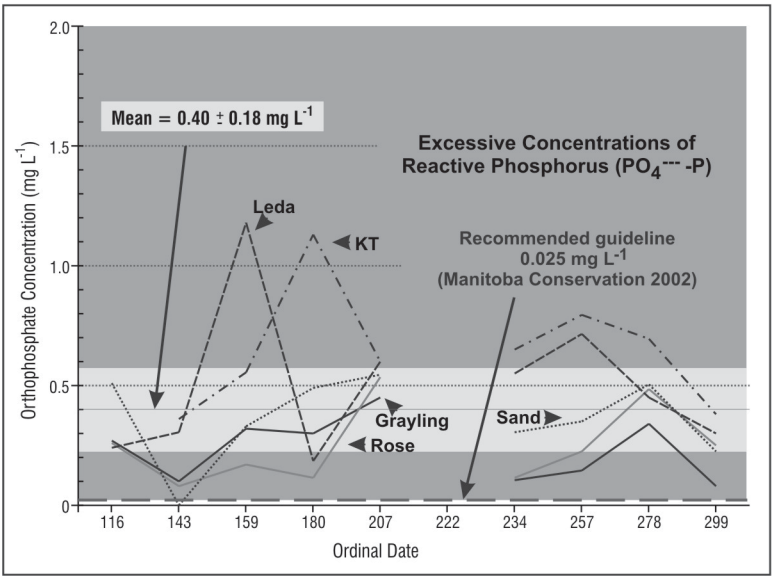


Figure 6b: *Open-water orthophosphate concentrations in the sample pothole lakes.*

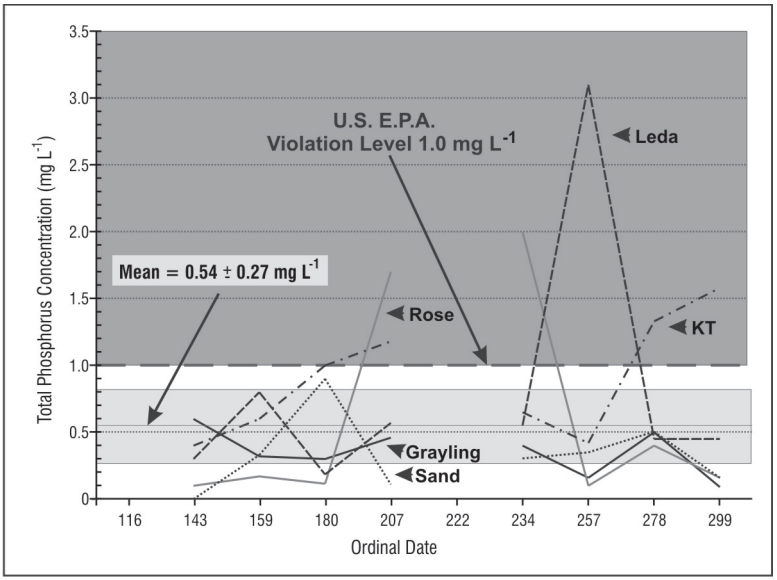


Figure 7a: *Open-water total phosphorus concentrations in the sample pothole lakes.*

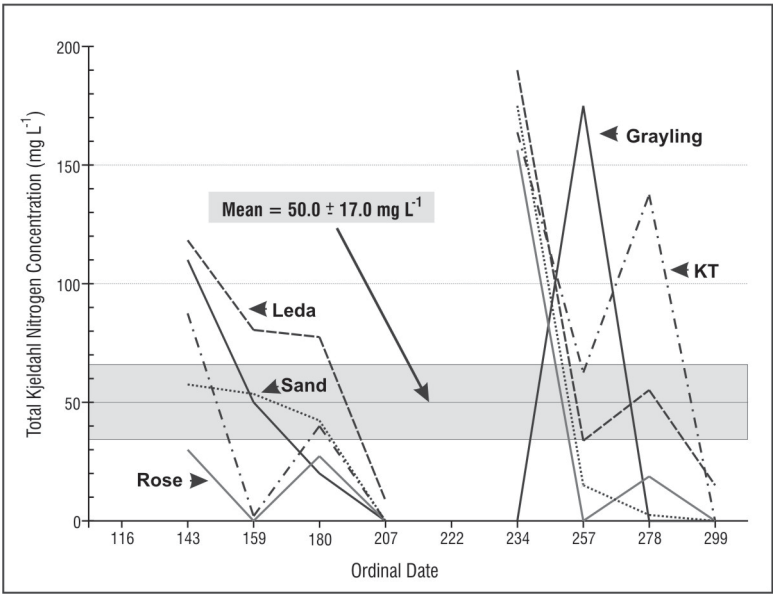


Figure 7b: *Open-water total Kjeldahl nitrogen concentrations in the sample pothole lakes.*

Such concentrations are considered sub-lethal/lethal with respect to fish and other aquatic organisms (Table 3).

Nitrate nitrogen concentrations were constant throughout the open-water season with a calculated mean nitrate ion concentration of 0.17 ± 0.10 mg L^{-1} (Table 3). Maximum concentrations occurred on May 23 and August 22 (0.3 mg L^{-1}) and the minimum on June 29 (0.0 mg L^{-1}) (Table 3). Throughout the sampling frame, nitrate nitrogen concentrations in the lake never exceeded the Manitoba Conservation guideline of 10.0 mg L^{-1} (Figure 6a).

Orthophosphate (soluble reactive phosphorus) concentrations also were relatively constant throughout the open-water season, ranging from 0.08 mg L^{-1} on October 26 to a high of 0.45 mg L^{-1} on July 26 (Table 3 and Figure 6b). The mean PO_4^{-}- P concentration of the lake was 0.23 ± 0.13 mg L^{-1} (Table 3). During this study, orthophosphate concentrations exceeded the Manitoba Conservation recommended guideline of 0.025 mg L^{-1} on every sampling date (Table 3). There appears to be no anthropogenic source of phosphate other than a sealed washroom facility. Belke *et al.* (2002) however, report that high concentrations of airborne soluble reactive phosphate are being deposited in early winter snowfalls in Riding Mountain National Park and Schindler *et al*. (1976) point out that atmospheric concentrations of phosphorus can be very significant in lakes with small drainage basins.

The mean total phosphorus concentration measured in Grayling Lake was 0.35 ± 0.17 mg L^{-1} (Table 3). TP ranged from a minimum value of 0.09 mg L^{-1} recorded on October 26 (299) to a peak of 0.60 mg L^{-1} on May 23 (143) (Table 3 and Figure 7a). The US EPA recognizes total phosphorus concentrations exceeding 1.0 mg L^{-1} in rivers and streams as a violation level (Van der Leeden *et al.* 1990, 500, Table 7.7). Throughout the 2006 open-water season, Grayling Lake never exceeded the US EPA total phosphorus violation level.

Total Kjeldahl Nitrogen (TKN) is defined as the sum of the organic nitrogen compounds and total ammonia. Since organic nitrogen may be dissolved or suspended particulate matter in water, concentrations are susceptible to extreme agitation. Consequently, local high velocity winds with gusts exceeding 30 km h^{-1} can initiate mixing and sediment re-suspension resulting in increasing TKN concentrations. TKN concentrations in all the sample pothole lakes declined from spring highs to near zero on July 26, then spiked significantly on August 22 to levels of 160 to 200 mg L^{-1} and returned to near the mean concentration by mid September. Two days before the August 22 spike, mean winds of 20 to 30 km h^{-1} from the northwest with gust to 37 km h^{-1} were recorded at the

Wasagaming Climatological station and a funnel cloud was reported west of Clear Lake (Environment Canada 2006).

TKN concentrations in Grayling Lake ranged from 0 mg L^{-1} on July 26 (207), August 22 (234), October 5 (278) and October 26 (299) to 175 mg L^{-1} on September 14 (257). It is worth noting that the August 22 wind generated spike characteristic of the other sample lakes did not occur in the forest-surrounded Grayling Lake.

In Grayling Lake, where a native fish population survives, water quality and habitat conditions generally meet the recommendations summarized in Table 1.

Rose Lake. The Rose Lake watershed consists of large wetlands and marsh zones to the south, and a steep slope to the north and east. Two residents are located on the western bay. There is no apparent agricultural runoff entering the lake. Instead, the primary anthropogenic impact is associated with the Lakewood Hills Golf Course, which lies to the north and east of the lake along one-third of the riparian buffer length. Buffer width in this region is approximately 10 m. The other two-thirds of riparian buffer length is surrounded mainly by tree species and wetlands. No boating activity occurs on the lake although the shore residents own canoes.

Table 4 summarizes the limnological and nutrient parameters recorded for Rose Lake. The calculated mean water temperature was 17.2°C ± 6.8°C and the maximum temperature of 24.5°C was recorded on July 26 (Table 4). Mean water pH was 8.55 ± 0.19. This value is slightly outside the recommended range but well below the lethal 9.8 pH units (Table 1). Water temperatures and pH are favourable for stocked rainbow and hybrid trout habitat.

Total dissolved solids concentration was generally constant throughout the 2006 open-water season registering a mean of 61.1 ± 8.9 mg L^{-1} and providing fair growth potential (Table 1). The maximum TDS concentration was recorded on October 26 at 75.9 mg L^{-1} (Table 4).

Dissolved oxygen concentrations in Rose Lake ranged from 8.4 mg L^{-1} to 12.0 mg L^{-1} (Table 4). The open-water mean concentration was 9.9 ± 1.2 mg L^{-1} with the maximum DO concentration recorded on October 26 (12.0 mg L^{-1}). DO concentrations were above 5.0 mg L^{-1}, the sub-lethal/lethal critical level for fish and other aquatic organisms, throughout the open-water season (Figure 4b).

During the open-water season, total ammonia concentrations in Rose Lake never exceeded the 0.5 mg L^{-1} US EPA standard, and toxic free ammonia never exceeded the 0.02 mg L^{-1} Manitoba Conservation guideline (Figures 5a and 5b). Total ammonia measurements in the lake ranged from 0.0 mg

L^{-1} on September 14 and October 5 to 0.31 mg L^{-1} on April 26 (Table 4). Mean total ammonia concentration was 0.07 ± 0.09 mg L^{-1} with the mean un-ionized ammonia concentration calculated at 0.1 mg L^{-1} (Table 4).

Rose Lake recorded a maximum nitrate nitrogen concentration on September 14 (0.40 mg L^{-1}) and a minimum on May 23 (0.10 mg L^{-1}) (Table 4). The mean NO_3^--N concentration in the lake was 0.24 ± 0.11 mg L^{-1}. Nitrate nitrogen concentrations never exceeded the Manitoba Conservation guideline of 10.0 mg L^{-1} during the 2006 open-water season.

Orthophosphate phosphorus concentrations in Rose Lake ranged from 0.08 mg L^{-1} on May 23 to 0.54 mg L^{-1} on July 26 (Table 4). The mean water $PO_4^{—}$-P concentration was 0.25 ± 0.16 mg L^{-1}. Orthophosphate phosphorus concentrations in the lake exceeded the recommended guidelines on every sampling date (Figure 6b).

Rose Lake recorded a mean total phosphorus concentration of 0.59 ± 0.79 mg L^{-1} and exceeded the US EPA total phosphorus violation levels on July 26 (1.70 mg L^{-1}) and August 22 (2.00 mg L^{-1}) (Table 4 and Figure 7a). Storm runoff from Lakewood Hills Golf Course following rainfall events may have contributed to the phosphorus violation concentrations.

Total Kjeldahl Nitrogen concentration regime in Rose Lake followed the general trend for all sample pothole lakes. TKN concentrations ranged from 0 mg L^{-1} on June 8 (159), July 26 (207), September 14 (257) and October 26 (299) to 156 mg L^{-1} on August 22 (234) (Table 4 and Figure 7b). A significant spike occurred on August 22 (Table 4).

In Rose Lake, water quality and habitat conditions meet the recommendations for stocking rainbow and hybrid trout. Electro-mechanical-pneumatic aeration during the ice-cover season is required.

Sand Lake. Sand Lake receives surface runoff from the surrounding forest region and has a documented sub-surface spring (McGinn 2000). Six cottages/homes are located around the lake, four of which are on the steep eastern shoreline. A farmstead including livestock is located in the headwater region of the intermittent inlet stream and cropped fields contribute overland flow runoff to the southern shore. Sand Lake is used for water skiing.

Limnological and nutrient parameters recorded for Sand Lake are summarized in Table 5 and the specific regimes illustrated in Figures 3 to 7. Water temperatures parallel mean ambient air temperature. The maximum water temperature was measured on July 26 at 24.3°C (Table 5); the mean water pH value was 8.91 ± 0.39. Water temperatures and pH are favourable for rainbow and tiger trout stocking.

Total dissolved solids concentration during the open-water season was variable, increasing through May, declining in June and relatively

constant throughout July (Figure 4a). TDS spiked on August 10 to a concentration of 114.8 mg L^{-1} (Table 5 and Figure 4a). The mean TDS concentration was 105.8 ± 50.0 mg L^{-1} (Table 5) and provided good growth potential (Wiley 2006).

Dissolved oxygen concentrations in Sand Lake ranged from 7.3 mg L^{-1} to 11.9 mg L^{-1} with a calculated mean DO concentration of 9.1 mg L^{-1} (Table 5). DO concentrations were above sub-lethal/lethal critical level established by US EPA and Manitoba Conservation throughout the open-water season (Figure 4b).

Mean total ammonia concentration in Sand Lake was 0.27 ± 0.27 mg L^{-1}, ranging from 0.01 mg L^{-1} on September 14 and October 5 to 0.62 mg L^{-1} on June 29 (Table 5). During the open-water season, total ammonia concentrations in the lake exceeded the 0.5 mg L^{-1} US EPA limit during the freshet and early summer. Un-ionized ammonia (NH_3-N) exceeded the Manitoba Conservation (2002) guideline from the beginning of the study until September 14. Ammonia sources are probably associated with the septic systems attached to the six residences and farmstead (barnyard) runoff.

Mean nitrate nitrogen concentration in Sand Lake was 0.24 ± 0.14 mg L^{-1} (Table 5). The maximum NO_3^--N concentration was measured on July 26 (0.4 mg L^{-1}) with the minimum recorded on September 14 (0.0 mg L^{-1}) (Table 5). Nitrate nitrogen concentrations in the lake never exceeded the Manitoba Conservation guidelines on any sampling date (Figure 6a).

Orthophosphate ($PO_4^{—}$-P) concentrations ranged from 0.0 mg L^{-1} on May 23 to 0.55 mg L^{-1} on July 26 with a mean concentration of 0.36 ± 0.18 mg L^{-1} (Table 5). Orthophosphate phosphorus concentrations in Sand Lake exceeded the recommended guidelines on every sampling date, except May 23 (Figure 6b).

Sand Lake recorded a mean water total phosphorus concentration of 0.33 ± 0.28 mg L^{-1} (Table 5). TP concentrations ranged from 0.0 mg L^{-1} to 0.90 mg L^{-1} (Table 5) and did not exceed the US EPA total phosphorus violation levels at any time throughout the sampling period (Figure 7a).

Total Kjeldahl Nitrogen concentration regime followed the general trend for all sample pothole lakes. TKN concentrations ranged from 0 mg L^{-1} on July 26 (207) and October 26 (299) to 175 mg L^{-1} on August 22 (234) when a significant spike was recorded (Figure 7b).

While the temperature, TDS and DO open-water regimes favour trout rearing water quality and habitat, Sand Lake has periodic sub-lethal spikes in pH and concentrations of un-ionized ammonia during the summer. The high concentrations of soluble reactive phosphorus and total phosphorus in combination with shallow depth could result in the growth of toxic algal

blooms during heat spells. Consequently, the hypereutrophic lake is not suitable for trout stocking.

Leda Lake. Leda Lake derives its water from snowmelt and natural runoff and multiple anthropogenic sources. Natural and agricultural runoff enters the lake from the west and south. Stormwater runoff from the town of Erickson drains directly into Leda Lake. Sewage lagoons located to the south of Erickson are periodically drained and/or accidentally overflow into Leda Lake through a system of wetlands, pothole lake 103 and a first order inlet stream. No boating activity occurs on Leda Lake.

Table 6 summarized the limnological and nutrient parameters recorded for Leda Lake. The calculated mean temperature for the 2006 open-water season was 14.5 ± 6.3°C and the maximum water temperature occurred on July 26, 21.8°C (Table 6). The pH regime for Leda Lake was observed to decrease in the spring, spike significantly in June to a potentially lethal 9.8 and then decrease into the fall (Figure 3b). Mean pH was 8.77 ± 0.47 pH units.

Total dissolved solids concentration was variable throughout the open-water season (Figure 4a). The mean TDS concentration was 180.5 ± 143.6mg L^{-1}, good growth potential and the maximum concentration of 409.0 mg L^{-1} recorded on October 5 (Table 6).

Dissolved oxygen concentrations in the lake also fluctuated throughout the open-water season, recording a high of 17.0 mg L^{-1} on June 29 and a low of 0.9 mg L^{-1} on July 26. The mean DO concentration in Leda Lake was 6.0 ± 5.0 mg L^{-1}. DO concentrations less than 5.0 mg L^{-1} were measured on July 26, August 10, August 22, and October 5 (Figure 4b).

During the open-water season total ammonia concentrations in the lake never exceeded the 0.5 mg L^{-1} US EPA standard. However, toxic free ammonia (NH_3-N) equalled or exceeded the Manitoba Conservation guideline on July 26 (207), August 22 (234) and October 26 (299) (Figure 5b). Total ammonia concentration ranged from 0.01 mg L^{-1} on September 14 to 0.20 mg L^{-1} on October 26 (Table 6). The mean total ammonia concentration was 0.12 ± 0.06 mg L^{-1} (Table 6).

Leda Lake recorded a maximum nitrate nitrogen concentration on June 8 (0.4 mg L^{-1}); the minimum concentration was measured on June 29 and July 26 (0.15 mg L^{-1}) (Table 6). NO_3^--N concentrations never exceeded the Manitoba Conservation guidelines (Figure 6a).

Orthophosphate concentrations in Leda Lake were variable, ranging from 0.19 mg L^{-1} on June 29 to a high of 1.18 mg L^{-1} on June 8 (Table 6 and Figure 6b). Mean $PO_4^{—}$-P concentration in Leda Lake was 0.50 ± 0.31 mg

L^{-1} and date specific concentrations were significantly higher than the recommended 0.025 mg L^{-1}limit throughout the sampling period (Figure 6b).

Mean total phosphorus concentration measured in the lake was 0.80 ± 0.95 mg L^{-1}. The highest TP concentration of 3.10 mg L^{-1} occurred on September 14 (Table 6 and Figure 7a). On this date, Leda Lake exceeded the US EPA total phosphorus violation level (Figure 7a).

Total Kjeldahl Nitrogen concentrations ranged from 9 mg L^{-1} on July 26 (207) to 190 mg L^{-1} on August 22 (234) (Table 6). Relatively high concentrations were recorded in May, June and August with low concentrations in the summer months of July, September and October (Figure 7b).

Variability in the DO concentration, TDS concentration and pH may be associated with sewage lagoon releases, and urban stormwater runoff. Belke and McGinn (2003) found spikes in soluble reactive phosphorus and total ammonia associated with agitated water releases from a sewage lagoon.

Leda Lake is hypereutrophic (TP>0.096 mg L^{-1}; Carlson 1977) and has periodic sub-lethal spikes in pH, concentrations of un-ionized ammonia and lethal DO concentrations during the summer. The high concentrations of soluble reactive phosphorus and total phosphorus could result in the growth of toxic algal blooms during heat spells. Consequently, the lake is not suitable for trout stocking.

KT Lake. KT Lake receives surface runoff from the surrounding agricultural region to the north and east. Provincial Highway 10 bends around the lake to the west (Figure 1b). There are no livestock held in the watershed and there is no boating activity on the lake. Table 7 summarizes the limnological and nutrient parameters recorded for the lake.

Water temperatures parallel mean ambient air temperature (Figure 3a). The mean water temperature during the open-water season was 16.5°C ± 6.6°C with the maximum water temperature of 24.0°C occurring on July 26. KT Lake recorded a mean lake water pH value of 9.10 ± 0.36. Maximum pH occurred on August 22 at 9.66 pH units (Table 7). Water temperature and pH in KT Lake are tolerable for rainbow and tiger trout habitat.

Recorded total dissolved solid concentrations values in the lake were relatively consistent throughout the open-water season registering a mean of 73.6 ± 15.1 mg L^{-1} (Table 7 and Figure 4a) and providing fair growth potential for stocked trout (Wiley 2006).

Measured DO concentrations in the lake increased in the spring and summer and decreased into the fall. Mean DO concentration was 9.6 ± 1.0 mg L^{-1}, ranging from 8.2 mg L^{-1} on May 23 to 11.2 mg L^{-1} on June 29.

Measured DO concentrations in KT Lake were above sub-lethal/lethal critical level of 5.0 mg L^{-1} throughout the open-water season (Figure 4b).

During the open-water season, total ammonia concentrations in the lake never exceeded the 0.5 mg L^{-1} US EPA limit. However, free (un-ionized) ammonia (NH_3-N) equalled or exceeded the Manitoba Conservation guideline (0.02 mg L^{-1}) in June (Figure 5b).

In KT Lake, nitrate nitrogen concentrations never exceeded the Manitoba Conservation guidelines (Figure 6a). The mean NO_3^--N concentration in KT Lake was 0.20 ± 0.15 mg L^{-1}; the maximum concentration of 0.45 mg L^{-1} was recorded on October 5 with the minimum concentration of 0.05 mg L^{-1} on July 26 (Table 7).

Orthophosphate phosphorus concentrations ranged from 0.36 mg L^{-1} on May 23 to high of 1.13 mg L^{-1} on June 29 and the calculated mean concentration was 0.65 ± 0.25 mg L^{-1} (Table 7). $PO_4^{—}$ - P concentrations in KT Lake were greater than Manitoba Conservation's recommended guidelines on every sampling date (Figure 6b).

Total phosphorus ranged from a minimum value of 0.40 mg L^{-1} recorded on May 23 to the peak of 1.58 mg L^{-1} measured on October 26. The mean total phosphorus concentration measured in the lake was 0.90 ± 0.44 mg L^{-1}. KT Lake equalled or exceeded the US EPA total phosphorus violation level (1.0 mg L^{-1}) on June 29, July 26, October 5 and October 26 (Figure 7a).

Total Kjeldahl Nitrogen concentration regime in KT Lake followed the general trend for all of the sample pothole lakes. The mean TKN concentrations in the lake was 62 ± 64 mg L^{-1}. TKN ranged from 0 mg L^{-1} on July 26 and October 26 to 164 mg L^{-1} on August 22. Three significant spikes occurred; June 29, August 22 and October 5 (Figure 7b).

Water temperatures, total dissolved solids and DO concentrations favour trout stocking in KT Lake. However, a relatively high pH, periodic spikes in alkalinity and sub-lethal concentrations of un-ionized ammonia during the summer, are detrimental to fish stocking. High concentrations of soluble reactive phosphorus and total phosphorus could result in the growth of toxic algal blooms during heat spells. This hypereutrophic lake is marginally suitable for fish stocking. Cyclic summer aeration may alleviate adverse water conditions and prevent the growth of toxic algal blooms. Winter aeration is required during the ice-cover season.

Comparative statistical analysis:

The Wilcoxon Matched-Pairs Signed-Ranks Test was used to compare the seasonal trend in three critical limnological parameters (pH, TDS and DO) and four nutrient regimes (total ammonia, nitrate, orthophosphate and total Kjeldahl nitrogen) in the sampled pothole lakes. The Null Hypothesis (H_0) stated that there is no significant difference ($\alpha = 0.05$) in

the specified regime (*e.g.*, TDS) between selected lakes (*e.g.*, Rose Lake and Sand Lake).

Results of the Wilcoxon matched-pairs signed-ranks test:

Table 8 summarizes the results of the 70 Wilcoxon matched pairs signed ranks tests for Grayling Lake, Rose Lake, Sand Lake, Leda Lake and KT Lake. There was no significant difference in any of the seven tested regimes (pH, TDS, DO, NH_4^+-N, PO_4^{--}-P, NO_3^--N and TKN) between Rose Lake and Grayling Lake (Table 8). These two lakes are limnologically the same. Similarly, there is no significant difference between the seven tested regimes in Sand Lake and Leda Lake, and Leda Lake and KT Lake (Table 8). In KT Lake, a significantly greater orthophosphate (PO_4^{--}-P) concentration occurs than was measured in Sand Lake (Table 8). Otherwise, KT Lake and Sand Lake also are limnologically the same.

While Grayling Lake and Rose Lake have statistically similar limnological and nutrient regimes both lakes differ limnologically from Sand Lake, Leda Lake and KT Lakes with respect to at least two and as many as five of the measured parameters (Table 8). Sand, Leda and KT

Table 8: *Results of the Wilcoxon matched-pairs signed-ranks test.*

	Grayling Lake	Rose Lake	Sand Lake	Leda Lake	KT Lake
Grayling Lake	X	0	4 (+)DO, (+)NO_3 (+)NH_4, (+)PO_4	2 (+)PO_4, (+)TKN	3 (+)pH, (+)DO (+)PO_4
Rose Lake	X	X	5 (+)pH, (+)TDS (+)NH_4, (+)PO_4 (+)TKN	3 (?)TDS (+)PO_4 (+)TKN	5 (+)pH, (+)TDS (+)PO_4, (?)NO_3 (+)TKN
Sand Lake	X	X	X	0	1 (+)PO_4
Leda Lake	X	X	X	X	0
KT Lake	X	X	X	X	X

Legend	
3	number of significantly different regimes
(?)pH, (+)DO	limnological parameters that are significantly different
(?)NH_4, (?)PO_4	nutrient regimes that are significantly different
(+, ?)	direction sign of the significant difference (greater, less than)

lakes have significantly greater soluble reactive phosphorus concentrations than either Rose Lake or Grayling Lake (Table 8). In addition, Sand Lake contains significantly more total ammonia, Leda Lake higher concentrations of total Kjeldahl nitrogen and KT Lake is significantly more alkaline (higher pH) than Rose and Grayling Lake (Table 8).

The results of the Wilcoxon test indicate that of the permanent pothole lakes, Rose and Grayling Lake have statistically similar limnological and nutrient regimes. Sand, Leda and KT lakes, while limnologically different than Grayling and Rose lakes, can be grouped as having statistically similar limnological and nutrient regimes.

Summary

Rainbow and tiger trout species have become the preferred species for stocking small shallow polymictic, eutrophic lakes subject to winter-kill and periodic summer-kill. Electro-mechanical-pneumatic aeration during the ice-cover season is required and periodic summer aeration/agitation may be required to offset summer nutrient loading and temperature induced stress on the fish population by breaking up anaerobic strata.

This study examines the limnological and nutrient regimes of four potential sport fishery pothole lakes in the Prairie Pothole Lake Region (PPLR) of southwestern Manitoba. Four pothole lakes and a control lake were sampled on 10 separate dates throughout the open-water season in 2006. On-site instruments recorded seasonal trends in seven limnological parameters and samples were collected for laboratory analysis. In the laboratory, five macronutrient regimes were analyzed.

Seasonal observations in the five lakes suggest that an accumulation of nutrients and organic biomass accompanied by increased levels of productivity occurs in the wetlands and shallow kettle-hole depressions south of Riding Mountain National Park.

Water quality and habitat conditions in Rose Lake were statistically similar to those of the control lake and meet the recommendations for stocking of rainbow and tiger trout. In Sand, Leda and KT lakes, however, high concentrations of soluble reactive phosphorus and total phosphorus could result in the growth of toxic algal blooms during heat spells. Cyclic summer aeration is required to alleviate adverse water conditions and prevent the growth of toxic algal blooms.

Sand Lake has periodic sub-lethal spikes in pH and concentrations of un-ionized ammonia during the summer. Consequently, Sand Lake may support summer stocking of rainbow trout for local harvest, but is not suitable for a trout sport fishery.

Leda Lake is hypereutrophic and has periodic sub-lethal spikes in pH, concentrations of un-ionized ammonia and lethal dissolved oxygen concentrations during the summer. Leda Lake is not suitable for trout stocking.

Water temperatures, TDS and DO concentrations favour trout stocking in KT Lake. However, a relatively high pH and periodic spikes in alkalinity and sub-lethal concentrations of un-ionized ammonia during the summer, are detrimental to fish stocking. Consequently, KT Lake while marginally suitable for fish stocking cannot be recommended as a sport fishery lake.

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Cashing in on resources, social and cultural capital: the role of local markets in the Great Southern district of Western Australia

George Curry, Curtin University, Western Australia (*g.curry@exchange.curtin.edu.au*)
Niels Fold, University of Copenhagen, Denmark (*nf@geogr.ku.dk*)
Roy Jones, Curtin University (*r.jones@curtin.edu.au*)
John Selwood, University of Winnipeg (*j.selwood@uwinnipeg.ca*)

Abstract: This paper focuses on the role of local fairs and markets in building upon and exploiting the physical resources and social and cultural capital of Albany and Denmark, two towns in the Great Southern district of Western Australia. It builds on earlier work of the team that has examined some of the drivers of local change in the region (*e.g.*, Selwood *et al.* 1996; Curry *et al.* 2001). That work shows how in the recent past the region has experienced several waves of innovative in-migrants who have largely transformed the traditional forestry and agricultural economic base of the area with the introduction of new crops and a variety of services catering to a growing tourism industry and early retirees to the district. Partly in response to these changes and also influenced by more global trends in social values, such as organic farming and the increasing emphasis on sustainable local economies, Albany and Denmark, the two most important towns of the area, have recently established periodic local markets which are catering to both the local population and to the growing regional tourism market. As such, they support the thesis that 'creativity' is an important and necessary ingredient in the development of rural communities. The marshalling of this creativity is a manifestation of social and cultural capital at work.

Key words: *markets, sustainable economies, regional development, tourism, social and cultural capital, creativity*

Introduction

A special focus of the investigation will be the role of social and cultural capital in enhancing the southwest district of Western Australia's attractiveness both to tourists and to actual and potential new residents. It builds on earlier work that has examined some of the drivers of local change (Selwood *et al.* 1996; Curry *et al.* 2001; Selwood and Tonts 2003) and a growing appreciation in these earlier works that social and cultural capital have played an important role in the evolution of diversity and change in the region's population and economy. Furthermore, one manifestation of these changes has been the growth of markets, here as elsewhere in favourably endowed agricultural regions, firmly based on elements of local production. This paper investigates the characteristics and the role of local fairs and markets in building upon and exploiting the social and cultural capital of the district.

The paper's main argument broadly parallels Richard Florida's (2002, 2005) contention that, in certain metropolitan regions, there are concentrations of high-tech workers, artists, musicians, gays and 'high bohemians,' or a 'creative class,' who are associated with an environment both producing and reflecting higher levels of economic development. This environment, in turn, will attract more creative people, as well as businesses and capital. Florida is by no means the first to have recognised the importance of cities as centres of creativity. Peter Hall, for example, in his massive tome, *Cities and Civilization*, devotes much of its content to this theme (Hall 1998). However, others have been quick to point out that this rationale can be extended beyond the metropolitan context to include less populated, though characteristically well-favoured regions. Indeed, Sorensen demonstrates that creativity exists to a very significant degree in the Australian rural environments he has investigated. He also insists that creativity must go hand in hand with adaptability if creativity is to find acceptance and flourish. Sorensen is adamant that "residents at the spatial margin have to try harder to keep up with the rest of the world" (Sorensen 2007, 22). Furthermore, it is likely that the impact of creative innovations can be more profound in smaller communities than in larger centres. Recent social and demographic changes in the relatively isolated southwestern corner of Western Australia present the opportunity to investigate this thesis.

The objectives then, are: first, to demonstrate that Florida's detractors have a valid claim in that the 'creative class' is not confined to metropolitan areas; to show that creativity can be manifested through the exploitation of social and cultural capital; to demonstrate how this works using the growth of periodic local markets as case study examples; to remind readers

that such markets have had similar functions for millennia; and, finally, to show that they are now widely acknowledged to be another weapon in the competitive world of place promotion.

The research for this paper is an extension of earlier work completed by the research team in the southwest of Western Australia that has tracked the region's transition from a relatively traditional agricultural and resource based economy into one that is more diverse and based increasingly on tertiary activities. This paper deals specifically with the recent creation of periodic markets that reflect this transition. The methodology involved fieldwork that permitted the compilation of a complete inventory of the markets' offerings, and to observe the markets, their stallholders, and their patrons in operation. These observations were supplemented by formal interviews with principal actors and promoters of the two markets, along with informal conversations with other participants among the stallholders and their clients.

The Lower Southwestern District of Western Australia

Western Australia's 'Lower Great Southern' district (Figure 1), occupies the area roughly centred on Albany, with its population of about 35,000 making it the largest city in the region. However, it should be noted that the city boundary now incorporates the recently amalgamated Shire of Albany. The former Town of Albany's population was closer to 20,000, whereas the district's total population at the 2006 Census was 52,593 (Australian Bureau of Statistics (ABS) 2007a); Government of Western Australia 2008). The Lower Great Southern district is an extensive area of some 14,828 km^2 that spans a heavily forested area to the west around the much smaller town of Denmark, with its population of approximately 4,000 people (ABS 2007b). The district's borders extend north and east into the significantly drier wheat belt, with the Southern Ocean defining its southern boundary. It is a highly diverse region, distinguished by unique landscapes and natural vegetation, along with a wide variety of human activities that reflect its natural features and chequered history. The area still contains vestiges of its original Aboriginal occupance, but the contemporary landscape is far different from its appearance when the first European settlers arrived in 1827. These settlers established an outpost at Albany, but the region soon lost its colonial importance to the more centrally located administrative capital of the state at Perth, some 400 km to the north-west. For most of the state's recent history the Great Southern district remained at the periphery of the more densely settled area to the north, although it continued to contribute to the state's economy in a number of



Figure 1: *The Great Southern region and its location relative to Perth.*
Source: Reproduced with permission of Great Southern Development Commission

ways. Because of its scenic beauty and other attractions, this part of the country has, from its early days, enjoyed some considerable popularity as a tourism destination. The forests have been an invaluable resource both for their timber and as an amenity. Agriculture in its varied forms has made an important contribution too. However, its uniqueness, the peripheral location and what Blainey (1968) has dubbed the 'tyranny of distance' has given a sense of identity and allegiance to the local population and generated in it a source of social capital (Western Australian Planning Commission 2007).

This 'social capital' first emerged during the earliest days of European settlement, once the initial ruthless exploitation of the magnificent forests had run its course. The remaining pioneers, bolstered by newcomers to the land, had to fight desperately hard to overcome the isolation and harsh conditions that prevailed on the remote south coast. They then managed to survive the Great Depression and the difficult days of Group

Settlement which introduced new settlers, but taxed the pioneers to the limit, driving out all but the most tenacious of the settlers (Brunger and Selwood 1997; Brayshay and Selwood 1998). More recently, successive waves of newcomers have migrated into the district, drawn there by the inherent beauty and distinctiveness of the area, bringing with them a variety of different lifestyles and skills. Although the newcomers have not always blended readily into the existing community, their commitment to the region has nevertheless led to a strengthening of the social networks and has contributed significantly to the wealth of the area. Furthermore, this inflow is now occurring at an accelerated pace and the continued flow of migrants into the district has brought with it a rapidly increasing range of ideas and innovations that are being incorporated into the local economy and social activities (Selwood *et al.*1996; Curry *et al.* 2001). Given that the population of the Lower Great Southern district increased by another 9.2 percent between 2001 and 2006, this trend is continuing (ABS 2007c).

The main purpose of this paper is to illustrate how the periodic, largely local produce based markets of Albany and Denmark are reflections of the effective employment of this expanding social capital in widening the attractions of the two communities and how this has in turn been instrumental in creating additional social capital in them. As a result, they have contributed significantly to the development of those communities, especially through encouraging incoming migrants and increased visitor numbers. The former have brought with them a diversity of skills as well as other forms of capital, while the latter are making an increasing contribution to the support of new enterprises that include the establishment of local markets. These, in effect, represent a form of commodification of elements of social and cultural capital as well as the merchandising of material products.

The Nature of Social and Cultural Capital

Social and cultural capital are complex concepts, given to a variety of different understandings, approaches and forms of analysis. A very useful recent overview of the notion of social capital is available through the work of the Canadian Government's Policy Research Initiative as ably reported in Franke's paper *The Measurement of Social Capital* (Franke 2005). Franke's review of the literature, which builds on the seminal works of people such as Bourdieu (1986), Colman (1998) and Putnam (1995a, 1995b, 2000), also indicates that worthwhile studies have emanated from the UK, USA, Canada and Australia in particular. In analyzing the many pieces of research and writing on the topic, Franke concludes that the best

way of defining the concept is to use a comprehensive, broadly encompassing definition which takes into account the myriad ways in which social capital is made manifest at different levels of activity:

> *Social capital refers to social networks that may provide access to resources and social support* (Franke 2005, 7).

Franke shows how social capital operates at different levels: the individual, the group and the community scale, thus making three levels of analysis possible, although they are interconnected:

- cognitive (micro) – individual predispositions (practices and beliefs)
- structural (meso) – the structure and activities of local groups that create new opportunities
- institutional (macro) – the elements of the local context that promote or impede collective action

Figure 2 indicates how social capital can be conceptualized within a wider context. It operates and is influenced to greater or lesser degree by the totality of the surrounding environment, which includes the cultural, political, legal, institutional, economic, social, and physical conditions, along with other complementary forms of capital, for example, financial. The strength or weakness of social capital is then determined by the characteristics of individuals and the organizations and institutions that are available to them. Social capital's effectiveness is then reflected in the variety of outcomes and the ways in which they may be identified. Figure 2 clearly indentifies the interconnectivity and interdependencies between social capital and other, non-monetary forms of capital. Although not specifically mentioning them, the figure incorporates elements of cultural capital as well.

The now quite extensive literature dealing with these concepts supports the foregoing conclusions and reinforces claims that they can be important contributors to development. In particular, Jim Macbeth, in his most helpful discussion of Social, Political and Cultural Capital (SPCC), does a sterling job of illustrating their close and overlapping relationships, and in offering a clear exposition of the nature of cultural capital and the forms it can take that are of particular relevance to this study, he places them squarely in the fields of tourism and regional development (Macbeth *et al*. 2004). Drawing on another comprehensive review of the associated literature by Mendis (1998) and also the work of Jeannotte (2003), Macbeth and co-authors argue that:

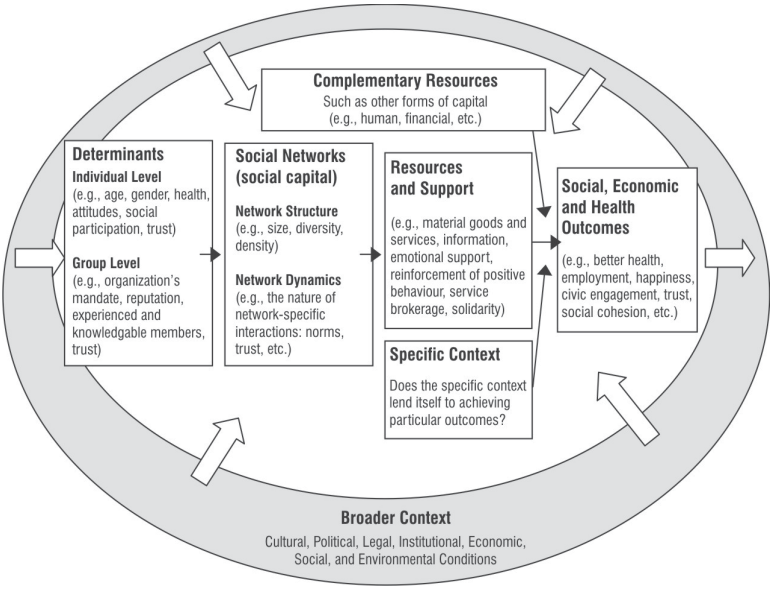


Figure 2: *Social capital within its wider context.*
Source: Reproduced with permission of Policy Research Initiative, Government of Canada from original by Franke (2005, 9)

> Cultural capital is defined as the resources that can be drawn on by people and includes both cultural activities and artefacts. Thus cultural capital involves a range of aspects including ideologies, performing and spectating, architectural and historic heritage, forms of artistic enterprise, and cultural products such as CDs, books and art works. Also included in this definition are forms of sport and religion. Culture is an important resource. It represents the accumulated capital of generations of skilled, creative, and innovative people and is made up of the historical record of our societies; it can be a source of inspiration for creativity and innovation (Macbeth *et al.* 2004, 216).

Following both Mendis and Jeannotte, Macbeth *et al.* insist that "cultural capital may determine the *quality* of social capital" (Jeannotte, 2003, 39). Others, for example, Bourdieu (1986) and Zweigenhaft (1992) have argued that there is a tendency for more wealthy communities to boast higher levels of cultural capital as well as economic capital. In other words, they benefit from a derived comparative advantage which can build upon itself. Moreover, Jeannotte's citations of and acceptance of research demonstrates how ". . .engaging people in community arts

activities is a popular and effective community development process; that is, engaging in cultural (capital) activities strengthens social capital" (Macbeth *et al.* 2004, 516). Conversely, it must be remembered that these mechanisms can operate to the disadvantage of communities if or when members of a community break into competing factions with different ideologies, objectives or views as to how to realise their goals (Tonts 2005). The dangers of insensitive tourism orientated developers and government agencies co-opting and commodifying cultural capital to the detriment of the subject communities and their sustainability are also underlined (Macbeth *et al.* 2004, 518).

This necessarily abbreviated synopsis does only limited justice to the complex conceptual aspect of the research. Recent data now gathered by the ABS and published in their Community Profile Series (ABS 2007b, 2007d, 2007e) identify and give an accounting of a number of the commonly employed variables used to evaluate levels of social capital in communities. However, due to space constraints, this study is concerned only to identify the broader historical and regional environmental contexts and then to illustrate, through case study examples, how they are operating in the local markets of Albany and Denmark. Thus, it is useful to remind the reader of just how important markets have been to the development of communities in the past.

The Historical Importance of Markets

Fairs and markets have been an integral component of not only economic activities, but other community attractions, such as sporting and cultural events and entertainments, since time immemorial. They were features of cities of the Classical Period, being essential components of the Greek agora and Roman forum (Mumford 1989). They have also been credited with the resurgence of urban centres in the Medieval world (Pirenne 1925), while their continued importance is reflected in the development of market functions and urban systems as highlighted in the work of Walter Christaller (1933), writing of cities in a European context, as well as the extensive literature on central places that has followed (Berry and Pred 1961; Marshall 1996).

The creation of, or, more accurately, the restoration of fairs and local producer markets after years of decline, has been part of a wider contemporary development of place marketing in the increasingly competitive world of inter-city and regional tourism and economic development (Kotler *et al.* 1993; Ward and Gold 1994). At the metropolitan scale, no self-respecting major centre has for decades been without its

convention and trade centre and many cities have recently invested millions of dollars in building newer and grander complexes to host trade shows and the like. In Western Australia, Metropolitan Perth now boasts one of these, the Perth Convention Exhibition Centre, opened in 2004 at a cost of $220 million (Perth Convention Centre 2008). As elsewhere, the convention centre, frequently featuring locally produced items, has become an integral component in the city's place marketing.

Similar efforts are being made at a more local scale and with smaller places, particularly as places and place promoters have taken up the practice of 'branding' themselves and using local products, festivals and events as their unique selling points (Hall and Sharples 2008). The growth of 'food tourism,' with its strong emphasis on featuring locally produced foods and regional menus is but one example of this (Kneafsey and Ilbery 2001; Selwood 2003). The revival of farmers' markets has been another manifestation of these trends as illustrated in the works of Feagan *et al.* (2004) in Canada, Coster (2004) in Australia, and Guthrie *et al.* (2006) in New Zealand, with Hall and Sharples' (2008) recent work now providing a comprehensive overview of the place of farmers' markets and similar events in the marketing spectrum. The selling of other speciality products has also been carried along in this revitalization of the market phenomenon. Several outstanding examples of world famous markets in London, England, that have undergone transformation and rejuvenation can be cited as evidence of such trends. Both Covent Garden and Spitalfields have experienced major restructuring and revival. Another market of more immediate relevance to this study is Borough Market, London's oldest surviving produce market, originally a wholesale market, but now acknowledged as one of London's finest retail food markets specializing in locally specific and organic produce (Figure 3) (Borough Market 2008). Nevertheless, it does not quite meet the stringent requirements of the United Kingdom's National Farmers' Retail & Markets Association (FARMA) which requires that "farmers, growers or producers from a defined local area are present in person to sell their own produce, direct to the public. All products sold should have been grown, reared, caught, brewed, pickled, baked, smoked or processed by the stallholder" (FARMA 2008). It is these criteria which are now becoming increasingly important in positioning places and their local markets and thereby attracting their clientele. It is within this now global framework, that the local markets of Albany and Denmark must be contextualized.



Figure 3: *A stall at London's Borough Market.*
Photograph: J. Selwood, 2007

The Lower Great Southern's Local Markets

Several communities in Western Australia's southwest now boast periodic markets devoted to the sale of a variety of products, many of them locally produced. Not many of the products featured at the Albany and Denmark markets are truly indigenous to the area, or even to Australia. Most of the so-called Australian products have been introduced to the district and many, the temperate fruits, for example, are definitely exotic to the Antipodes. Furthermore, significant amounts of product are manufactured outside of the region and marketed through sellers who have obtained their goods from international/global agencies. It can also be said that many, if not most, of the producers/sellers are relative newcomers to the area. The southern districts have also benefited greatly from the importation of crops, other innovations and technology that have boosted local production immensely, whether from indigenous or from the introduced materials and by way of the in-migrants. Among the more significant developments in the area under study have been the growth of tourism and the spawning of a variety of new agricultural products and craft industries to supplement the pre-existing relatively traditional farming sector (Curry *et al.* 2001). With the assistance of a number of state agencies, such as the Department of Agriculture and Food, the Western Australian Tourism Commission, Great Southern Development Commission and Great Southern Regional Marketing Association, these are being very

effectively harnessed and exploited by non-government agencies such as the Albany Farmers Market (AFM) and the Denmark Community Market (DCM), two recently established markets which have taken advantage of the strong sense of community and co-operation that has evolved in the district. Their efforts have encouraged producers to showcase their output and supported promotions of the district.

As their names would suggest, the markets of Denmark and Albany are rather different in their emphases and content. Not to be confused with the much older and larger scale market connected to the Denmark Arts Festival, Denmark's Community Market has been in place for a shorter period of time, commencing operations in 2006. It is a local initiative, started with a minimum of external support as a commercial endeavour by Amelia Lymburn, a recent migrant to the community from the Eastern States. This market offers local agricultural and seafood produce for sale, as well as a wider variety of non-food products, many of which are the output of local craftspeople, but some of them originating elsewhere in Australia, or even overseas. On the other hand, Albany Farmers Market, operating since 2002 with substantial government and non-governmental support, emerged from a group of local farm producers and is devoted almost exclusively to marketing locally grown fresh and processed agricultural products.

Denmark Community Market

Drawing extensively on her considerable experiences in working at markets in the Eastern States, Amelia worked basically from scratch in Denmark to develop interest and participation in her community market project. Being a relative newcomer and initially not having an extensive network of locals to call on, in recruiting stallholders, she called every enterprise listed in the local directory, offering them space at the market. Through an association with the Cub Scout leader, she was able to secure a venue for the market at the Scout Hall, renting their facilities for the occasion. From there, the operation grew as converts also helped recruit participants. Advertising has been mainly through placing posters at strategic locations around the community and through Amelia's work with an advertising agency. Working without remuneration, she and her partner were responsible for virtually all of the management and 'donkey work' until she was forced to slow down because of a pregnancy. Since then, maintenance of the market has fallen to a group of volunteers who have recently formalised their activities through incorporation (Lymburn 2008; Lovelace 2008). It is therefore clear that an 'outsider' was the first to recognise and harness the latent cultural capital in the community, then

the network of participants subsequently created has strengthened the community's social capital.

The essence of Denmark's Community Market is revealed by its website (Denmark Community Markets 2007):

> Our Community Market is all about creating opportunites (*sic*)…For locals to promote their goods and services! For tourists to see what we have to offer!
> For local musicians to perform! For people to catch up with one another!
> For non-profit groups and charities to inform us about their cause!

The organizers place considerable emphasis on the market's contribution to community building. To quote again from their website:

> Children are such a big part of our community, we have so much to keep your kids busy while you enjoy the market! At our seating area outside under the trees, there are colouring books and pens, toys and puzzles to keep little hands busy while you sit back and watch the entertainment!

The market's inclusiveness is also reflected in the five diverse groups into which the stalls are categorized: food products, crafts, healthy living, entertaining and relaxation, and attractions for the kids. Figure 4, taken on market day, provides supporting evidence for the website's claims, whereas the five categories help define and reinforce Denmark's image as a place with a distinctive, inclusive community, embracing a variety of lifestyles, producing a wide range of local bush and ocean products, along with agricultural, homeopathic remedies and other goods and services especially attractive to less conventional tastes and alternative lifestylers. The local population is enthusiastically urged to participate as contributors, customers or both in a wide range of offerings (Denmark Community Market 2007). Its founder's vision was to create an attractive gathering point where people could enjoy themselves, but which would generate income for herself, the stallholders and to the community (Lymburn 2008).

After an initial burst of enthusiasm, with up to 30 stallholders participating, the number of regulars has declined somewhat to about 15. Unfortunately, the market's location has been determined by agreement with the local Scout Hall which accommodates the market on affordable financial terms. However, its location is less central and convenient than it could be. Because of this and other marketing opportunities, fewer fresh food producers now attend the Denmark market. Another factor is that a perceived demand for second-hand, or 'trash and treasure' stalls cannot



Figure 4: Scenes from Denmark Community Market.
Source: Reproduced with permission of Denmark & Districts Market, formerly Denmark Community Market

be satisfied owing to a prior agreement with the Scouts that prevents the market from competing with the Scouts' own annual fund raising 'bring and buy' sale. Nevertheless, the market caters to a few hundred patrons, continuing to operate year-round, generally on alternate Sundays, but monthly during the slow winter months when visitor numbers are lower. Ironically, the characteristically informal, casual behaviour of the stallholders, one of the market's strengths, is also seen as a disadvantage in that patrons cannot always be assured that certain products will regularly be available. However, the core group of stallholders has now taken over market operations, determined to keep it operating as much as a community meeting place and social event, as for its profitability (Lovelace 2008). Thus the market, based on the initiative and creativity of a single individual, and despite its setbacks, continues to demonstrate its role in both exploiting and building on the social and cultural capital of the local community.

Albany Farmers Market

In contrast, the Albany Farmers Market (AFM), established somewhat earlier, has received more institutional support, operates according to stricter guidelines, gives every indication of being a viable commercial endeavour and definitely serves a much larger market area. According to the Great Southern Regional Marketing Association's (GSRMA) website:

> The markets were established by two very hard-working voluneer (*sic*) board members, Ms Pam Lincoln and Ms Debra Hartmann, with support from the GSRMA board and a growers committee. … Pam & Debra spent 10 months prior to the first market … planning and organising a workshop to bring together growers and key stakeholders, establishing market guidelines, organising insurance, a venue and a raft of other essentials (GSRMA 2007 www.greatsoutherntastewa.com/farmersmarket.html).

It is also important to note that Pam Lincoln was another relative newcomer, both to farming and to the district. She had formerly been in the health field and, while there, had gained a very good knowledge of funding agencies and 'grantsmanship.' The expertise she brought with her was instrumental in tapping these outside sources for start-up monies and in getting the market off the ground (Lincoln 2008). The GSRMA has now given over the operation of the market to an independent group that is self-managed, funded and owned by the producers themselves. They employ a part-time co-ordinator, Ian Haines, whose responsibilities are "to administer the market operation, promote the markets and recruit new

producers" (AFM 2007). It is important for the research objectives to note that Ian Haines, although a longer term migrant, is another of the innovators to make Albany his home. Haines makes the legitimate claim to have been the first restaurateur in the community to feature 'fine dining' on his menu at a time when Australian cuisine was more reminiscent of the worst in English cooking (Haines 2008). The Albany Farmers Market is a member of the GSRMA and also the Australian Farmers' Markets Association (AFMA). Another part of Haines' mandate is to operate in accordance with the aims, objectives and guidelines lain out by these bodies. To quote the AMFA:

> A Farmers' Market is a predominantly fresh food market that operates regularly within a community, at a focal public location that provides a suitable environment for farmers and food producers to sell farm-origin and associated value-added processed food products directly to customers (AFMA 2003).

Following the criteria established by the senior organizations, the Albany market management encourages local sustainable production and added value. This is borne out by the offerings of all the 30 or so stalls at the market, all of which featured locally produced fresh or processed products. The market management also has the objectives of educating consumers and regenerating community spirit, making the claim that:

> Many customers now rely on the markets for their major weekly shop because of the comprehensive range and sustained quality of produce, enjoying the wonderful interaction with the producers, whilst at the same time enjoying the camaraderie and delight of catching up with old friends! (Albany Farmers Market 2007).

It was clear from field work that these objectives were being actively addressed. After considering several locations in and around the city, the market organisers obtained space in the centre of town, which although somewhat cramped, has become the market's permanent home. Producer stall expansion has been limited by space needs, but it has also been through controlled competition, the selection of appropriate complementary products, and quality control. In contrast to Denmark's Community Market, Albany's Farmers Market has rejected several aspiring stallholders because they failed to meet the more stringent product requirements. Ian Haines, maintains that there is a strong degree of mutual support among the stallholders of Albany's market, with operators offering advice and assistance to others in the group when needed (Haines 2008). The stallholders and patrons were indeed observed to be generally cheerfully

engaged in quite animated conversation, with operators enthusiastically discussing the distinctive characteristics of their products. Producers are delighted to by-pass what many regard as the depredations of the large, corporate food wholesalers and retailers and to receive better prices for their output, which even if not organically produced, is generally very labour intensive.

The weekly market appears to be enjoying considerable success, attracting as many as 4,000 people to the Saturday morning event and adding significantly to the number of shoppers, both locally and from the surrounding district (Haines 2008). According to the local Shire's Planning Officer, Juliet Albany, the Albany Farmers Market has become a 'must see' event for visiting tourists and she, herself, now urges both friends and relatives to take in the market when they come to Albany (Albany 2008). Another measure of the market's success has been its recent receipt of *Vogue Australia's* Entertainment and Travel, Produce Award as 'Best Farmers Market in Australia 2008,' giving it countrywide publicity (Albany Farmers Market 2008). Thus, regardless of the different origins and development of Albany's market, just as in the Denmark example, it has successfully exploited the district's physical and human resources and strengthened the social capital of the community. In adding to its attractiveness as a tourist destination, the Albany Farmers Market also augments the locality's cultural capital.

Discussion and Conclusion

The Albany and Denmark markets are contemporary illustrations of social and cultural capital at work. However, they are, in effect, carrying out the function and roles of traditional local and regional markets that have existed almost since time immemorial. They exploit local resources, marketing largely locally grown or processed goods and commodified cultural capital in a personalised and often festive environment. In turn, they feed upon themselves to expand the amount of social capital available to the community. That is, they contribute not just to the economies of communities, but importantly, they support community by providing an environment for people to socialise, to share their experiences and to exploit them in constructive and sustainable ways. Where only a few years ago the markets did not exist, now they do, along with their networks of producers and those who patronise them.

Given that Denmark's market has a more localised trade area and its stallholders are drawn almost entirely from the town, the market functions primarily as a lower order service and an internal social support for the

townspeople, although there is undoubtedly some benefit derived from the seasonal holidaymakers and second home owners who virtually triple the town's population during the summer months (Curry *et al.* 2001). Conversely, the temporary residents and tourists enjoy the supplementary attractions already provided by the town. Albany's larger and more specialised market draws on a wider territory for its products, providing an outlet for local producers to market their often speciality goods directly to consumers. In doing so, they more effectively exploit the cultural capital of the area, shorten the food supply chain and can contribute to the area's economic and social sustainability (Feenstra 2002; Sage 2003; Hall and Sharples 2008). The higher number of tourists and other visitors to Albany provide greater support to these efforts and thereby further reinforce the area's cultural capital.

More research is needed to evaluate the relative impact of the markets on the very different sized economies of the two places. Further work is also needed to investigate people's attitudes and what they as individuals feel that they have benefited from their market experiences. It also needs to be said that the research revealed that there have been negative reactions and disagreements associated with some of the market developments. However, it is difficult to provide specific examples of this while protecting people's confidences and anonymity. Whereas the ABS data on community profiles can disclose something of the nature and frequency of attachments people have as they network among themselves and the outside world, only 'hands on' research can unveil the true nature of social and cultural capital within a community. The ABS statistics, by their nature, do little to reveal the contributions of individuals. However, this study reaffirms Florida's thesis that innovators attract innovators. Just as important, as Sorensen and others have insisted, it underlines the fact that the 'creative class' is not concentrated only in metropolitan areas. Rural districts and small towns can also be major beneficiaries. It was newcomers attracted to the Great Southern district because of its physical and social environment who were most immediately responsible for the establishment of the Denmark and Albany markets.

The two communities are now using news of those markets as they engage in place promotion, incorporating them in their websites in their efforts to create individuality for their respective communities. Ironically, this is now occurring globally as thousands of other communities are taking similar action. However, because of their inherent physical and cultural differences, it is likely that communities will continue to feature at least some characteristics unique to themselves. It is to be hoped that the resurgence of local markets is not just a passing fad and that the populace will maintain an interest that translates into a demand for products coming

from the nearby vicinity. A return to the personalised exchanges between producer and consumer as afforded by the less formal local market also marks a welcome alternative to the supermarkets of the multi-national corporations.

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Weyburn-Big Muddy field trip

Bernard D. Thraves, University of Regina
(*Bernard.Thraves@uregina.ca*)
Ulrike Hardenbicker, University of Regina
(*Ulrike.Hardenbicker@uregina.ca*)

The principal destination of the field trip is the Big Muddy Badlands in the vicinity of Castle Butte (Lat. 49° 132 Long. 105° 132). Travel proceeds westwards from Weyburn and follows a counter-clockwise route across the Missouri Coteau (Figure 1). The Coteau trends northwest to southeast and marks the transition between the Saskatchewan Plain (second prairie level) and Alberta Plain (third prairie level). East of the Coteau elevations range between 450 and 650 m; west of the Coteau elevations exceed 650 m. The field trip progresses through parts of eight rural municipalities (RMs) and stops briefly at several towns and villages enroute.

This field guide is divided into two sections. In the first section, selected general characteristics of the region's physical and human geography are presented. The second section provides notes on features and communities found along or near to the route of the field trip including Big Muddy Valley. Distances given are for travel by road from Weyburn Inn (outward) or Castle Butte (return), and are approximate. Elevations indicated are interpreted from 1:50,000 scale topographic maps. For convenience, the label 'Willow Bunch Lake' is adopted to identify the geographic setting of the field trip as this is the caption used on 1:250,000 topographic and other maps of the area. A list of maps used in association with the field trip is provided at the end of the field guide.

Physical Geography

Geology and Geomorphology:

The bedrock geology and stratigraphy of the Willow Bunch Lake region have been described by Parizek (1964). Grey, montmorillonitic clays and shales of the Bearpaw Formation form the bedrock surface in the

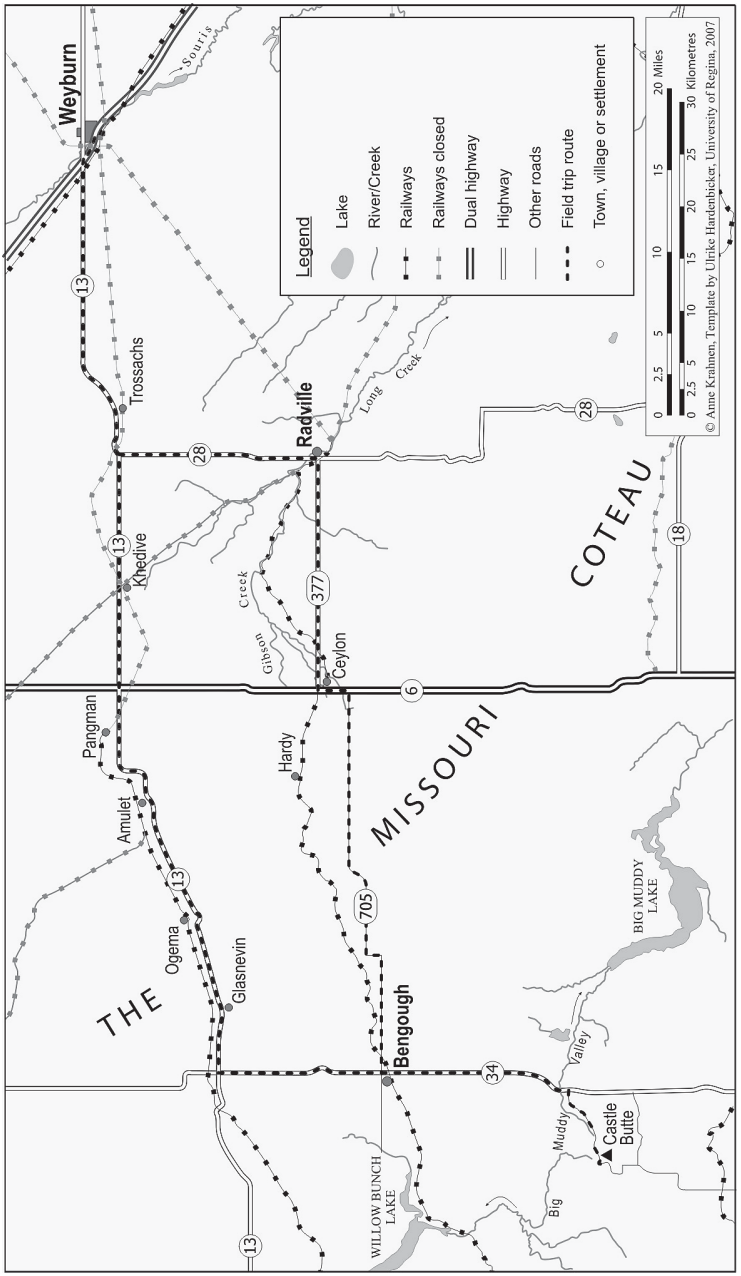


Figure 1: *Route map of the Big Muddy Field Trip.*

extreme north-east portion of the area and are covered by younger deposits. The Whitemud Formation is composed of inter-bedded, light grey sands, silts and sandy clays. These sediments are exposed along the Big Muddy Valley. Tertiary deposits are represented by the Upper Ravenscrag and Wood Mountain Formations, with the former being widespread in the area. These sediments consist of fine grained sands, silts or sandy clays, and lignite.

During the Pleistocene, the entire region was covered by continental ice sheets and the present surface deposits are largely of glacial origin. Those encountered on the route of the field trip include areas of glacio-lacustine deposits, glacial till, stagnant ice moraine, ice-shoved (ridged) moraine and outwash deposits (Figure 2). The remaining surface deposits consist of pre-glacial bedrock or post-glacial deposits.

The transition from the Saskatchewan Plain to the Alberta Plain is gradual rather than pronounced except between Ceylon and Radville where the route crosses ice-shoved hills. Several such features, including the Cactus Hills and Dirt Hills, are arrayed across southern Saskatchewan in association with the Missouri Coteau and other uplands. These hills form one of the most distinct glaciotectonic features in North America (Aber 1993). The Missouri Coteau is a northeast-facing bedrock escarpment which stretches around 1,300 km from eastern South Dakota over North Dakota and Saskatchewan into eastern Alberta. The Coteau is a remnant upland consisting of Paleocene sediments that resisted extensive erosion during the middle and late Tertiary and was subsequently overlain by a thick cover of Quaternary sediments.

Climate:

The Willow Bunch Lake region has a 'prairie' climate that exhibits increasing aridity as one proceeds west and south of Weyburn (Hare and Thomas 1979). Annual moisture deficits account for the natural grassland vegetation which is replaced by small trees along the margins of some waterbodies. Coronach is the closest meteorological station to the Big Muddy Valley in the vicinity of Castle Butte. Climate normals for Coronach for 1971–2000 indicate daily average temperatures of –12.8°C for January and 18.7°C for July. On average, daily maxima exceed 30°C on seven days in each of July and August. Precipitation averages 414.1 mm (16.33) per annum with 191.8 mm (7.63) or 46.3 percent received as rainfall from May to July. High summer temperatures when combined with extreme precipitation events (*i.e.*, thunderstorms, hail) reduces the effective supply of moisture to support plant growth.

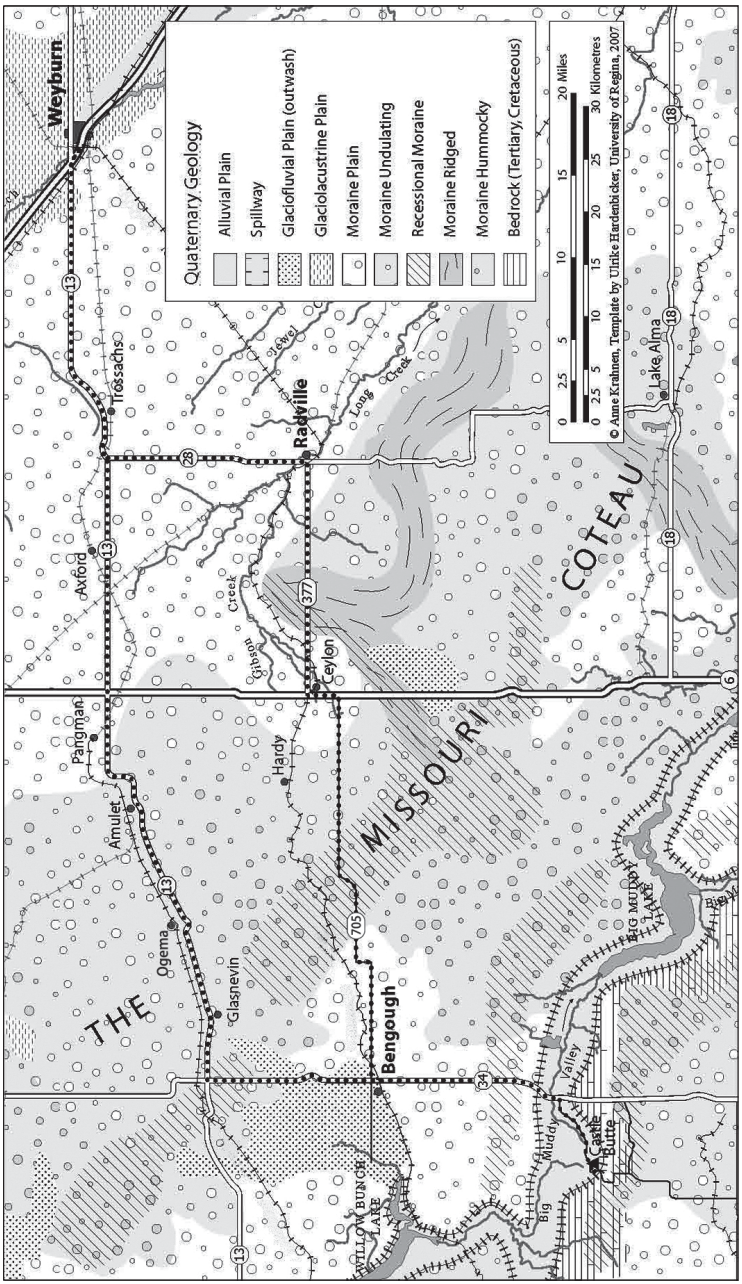


Figure 2: *Quaternary geology and geomorphology of the Willow Bunch Lake region.*

Soils:

The Missouri Coteau marks an approximate boundary between the Dark Brown and Brown Soil Zones in this part of Saskatchewan. Brown Soils dominate the drier (more arid) south-western section of Saskatchewan. The brown colour indicates the relatively low organic matter content of the soils. Crop yields have varied more widely and severe droughts have occurred more frequently in the Brown Soil Zone than in the rest of the agriculturally settled areas of the province.

As elsewhere in Canada, the Canada Land Inventory (CLI) has classified the region's soils according to their suitability for agriculture. Class 1 soils (no significant limitations in use for crops) are not found in the region. Class 2 and 3 soils (moderate and moderately severe limitations, respectively) are found more or less equally with Class 4 and 5 soils (severe and very severe limitations, respectively). Collectively, Class 2 to 5 soils account for most soils in the region. Class 6 soils (capable only of producing perennial forage crops) are found in a few restricted sites such as the side valleys (coulees) of Big Muddy Valley. In such locations adverse topography and erosion tend to limit agricultural potential. The regional representation of this classification system is illustrated on the CLI's 'Soil Capability for Agriculture' map for Willow Bunch Lake (72 H).

Vegetation:

The route of the field trip crosses a transitional environment from the Moist Mixed Grassland ecoregion to the Mixed Grassland ecoregion (Figure 3). The boundary between these ecoregions approximates the alignment of the Missouri Coteau. Most of the Moist Mixed Grassland is cultivated. Native grasses such as northern wheatgrass (*Elymus lanceolatus*) and needle grass (*Hesperostipa comata*) along with deciduous shrubs such as chokecherry (*Prunus virginiana*) and wolfwillow (*Elaeagnus commutata*) are largely confined to non-arable pasture lands (Fung 1999, 160–162). Less of the Mixed Grassland ecoregion is cultivated. Wheatgrasses and speargrasses again dominate where native grassland is found, but under more arid conditions shrubs and trees are much less common. In general, native vegetation mostly occurs on rolling, hilly or eroded lands, on sandy, gravelly or stony deposits or in slough areas or saline flats, all of which are unsuitable for cultivation. Such areas are usually used both for grazing and hay. The largest acreage of native vegetation occurs in the rolling and hilly areas of the Missouri Coteau Upland.

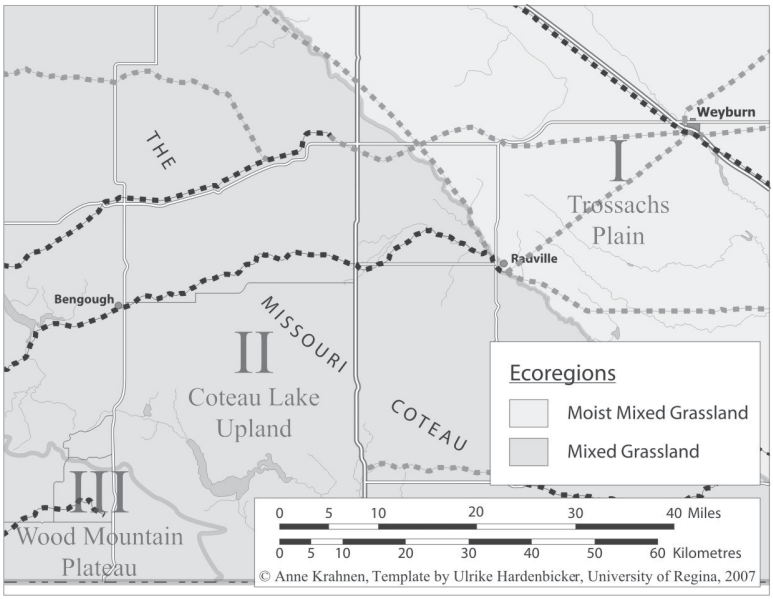


Figure 3: *Ecoregions in the Willow Bunch Lake region.*

Hydrology:

The Missouri Coteau forms a major drainage divide between waters that drain eventually to either Hudson Bay or the Gulf of Mexico. However, over much of the Coteau drainage is to small, local drainage basins or sloughs. Permanent watercourses with well-defined streams or creeks are few. This drainage form is dictated by the pitted and rolling topography of the moraine deposits which dominate the landscape. Characteristic topography of this type is best observed along Hwy 705 between Bengough and Ceylon and is illustrated on the Hardy (72 H/7 1:50.000) topographic sheet.

Human Geography

Population:

The route of the field trip passes through a predominantly agricultural region that reflects many of the characteristics of long-term population decline associated with restructuring of the rural economy. In all RMs, population peaked by 1931 or earlier (Table 1). Peak populations in villages and towns occurred in the two decades after World War II. The post-War

Table 1: *Population change in the Weyburn-Big Muddy region.*

	Populaton Count								Population Change (%)	
	1916	1931	1946	1961	1976	1991	2001	2006	1991-2006	2001-2006
Census Division No. 2	29,386	42,831	35,295	33,760	27,418	24,186	21,635	20,363	-15.8	-5.9
Rural Municipalities										
Weyburn No. 67	1,843	1,809	1,438	1,434	1,223	885	864	888	0.3	2.8
Brokenshell No. 68	1,265	1,175	852	629	489	348	317	324	-6.9	2.2
Norton No. 69	1,703	1,772	1,094	742	529	346	267	248	-28.3	-7.1
Key West No. 70	1,671	2,382	1,681	1,125	800	514	385	309	-39.9	-19.7
Bengough No. 40	1,586	1,683	1,233	844	637	467	382	337	-27.8	-11.8
Happy Valley No. 10	631	738	653	509	315	222	174	174	-21.6	0
The Gap No. 39	1,267	1,507	1,034	809	453	320	280	245	-23.4	-12.5
Laurier No. 38	1,316	1,592	1,129	945	679	471	402	350	-25.7	-12.9
City, Towns and Villages										
Weyburn (C)	3,050	5,002	7,003	9,101	8,892	9,673	9,534	9,433	-2.5	-1.1
Khedive (V)[1]	114	95	112	123	76	21	n/a	n/a	n/a	n/a
Pangman (V)	116	136	146	260	208	248	255	200	-11.9	-21.6
Amulet (V)[2]	47	62	70	47	n/a	n/a	n/a	n/a	n/a	n/a
Ogema (T)	276	402	395	458	432	383	292	304	-31.1	4.1
Bengough (T)	190	328	337	613	603	527	401	337	-37.1	-16.0
Hardy (V)[3]	n/a	57	111	76	36	18	n/a	n/a	n/a	n/a
Ceylon (V)	188	270	286	288	259	163	105	90	-51.1	-14.3
Radville (T)	621	1,005	859	1,067	1,008	846	735	755	-25.4	2.7

Highlighting denotes the date of peak population for the census dates shown.

[1]Restructured into the RM of Norton, January 1, 2002

[2]Restructured into the RM of Norton, January 1, 1965

[3]Restructured into the RM of The Gap, January 1, 2000

n/a - not available

Sources: Based on CSO (1918); DBS (1949, 1962); Statistics Canada (1977, 1992, 2007a)

peak and subsequent decline is explained by the baby boom of the 1950s and early 1960s and sustained rural-urban migration.

Virtually all jurisdictions have exhibited population loss during recent census intervals. Among RMs, only Weyburn and Brokenshell recorded population growth between 2001 and 2006. This growth reflects localized counterurbanization along the Regina-Estevan corridor (Hwy 6 and Hwy 39). In the RM of Happy Valley, population stabilized between 2001 and 2006 but at an all-time low. In other RMs, population losses exceeded 10 percent between 2001 and 2006, and well in excess of 20 percent between 1991 and 2006. Population losses have taken place in most nucleated settlements. Weyburn's population peaked in 1991 but has since declined, if modestly, during two of three census intervals. Among towns and villages, modest growth occurred in Ogema and Radville between 2001 and 2006, but in both cases growth followed sustained periods of population decline. In Bengough, population decline has been continuous since 1961. Despite promotion of tourism under the banner of 'Gateway to the Big Muddy,' the town has been unable to combat the drift of population to larger urban centres. It now has barely half its 1961 population. The rate of decline in villages has been equally dramatic. Ceylon now has less than one-third of its peak population of 1961.

It should be noted that these data do not reflect the potential for population growth linked to recent expansion in Saskatchewan's resource economy. Much of this expansion is based in the oil and gas sector. If sustained, it is likely to boost the populations of Weyburn and Radville, but is much less likely to affect communities such as Pangman and Bengough which are tied more closely to the agricultural sector.

Agriculture:

Collectively, farms focusing on wheat farming (28.2%), other grain farming (21.4%), and beef cattle ranching (30.4%) account for four out of five farms in the region (Table 2). Generally, wheat and other grain farming is more prevalent at lower elevations west of the Coteau and in the north of the region (RMs of Laurier and Key West), with ranching dominating east of the Coteau and in the south of the region (RMs of Bengough and Happy Valley). Grain farms tend to be more common in areas with Class 2 and 3 soils but are replaced by ranches on Class 4 and 5 soils. However, this relationship is far from perfect. By farm type, the most diversified farming area is the RM of Weyburn. Much of the RM has Class 2 soils, but other factors, including proximity to Weyburn and good highway (Hwy 39) and rail (Soo line) connections to more distant markets, are probably at least as important in explaining this diversity. Farms specializing in oilseed production are important here. Other notable specializations include dairy

Table 2: Farms classified by predominant activity, 2006.

Rural Municipality	Dairy cattle and milk production	Beef cattle ranching and farming, including feedlots	Hog and pig farming	Chicken and egg production	Sheep farming	Apiculture	Horse and other equine production	Livestock combination farming	All other misc. animal production	Soybean farming
Weyburn No. 67	2	34	-	-	1	-	8	4	3	1
Brokenshell No 68	-	30	-	1	1	1	5	5	-	-
Laurier No 38	-	27	-	-	1	1	2	2	-	-
The Gap No 39	-	31	-	-	1	-	1	4	-	-
Bengough No 40	-	74	-	-	-	-	1	4	-	-
Happy Valley No 10	-	36	1	-	-	-	-	1	1	-
Key West No 70	-	34	1	-	-	-	1	2	-	-
Norton No 69	-	31	-	-	-	1	2	1	-	-
Total farms by type	2	297	2	1	4	3	20	23	4	1
Percent farms by type	0.2	30.4	0.2	0.1	0.4	0.3	2.0	2.4	0.4	0.1

Rural Municipality	Oilseed (except soybean farming)	Dry pea and bean farming	Wheat farming	Other grain farming	Potato farming	Fruit and tree-nut farming	Floriculture production	Hay farming	All other misc. crop farming	Total farms by RM
Weyburn No. 67	30	1	38	51	-	2	3	15	4	197
Brokenshell No 68	4	-	28	19	-	1	-	5	0	100
Laurier No 38	6	1	42	19	-	-	-	3	3	107
The Gap No 39	4	1	29	29	1	-	1	6	1	109
Bengough No 40	-	3	33	24	-	-	-	4	1	144
Happy Valley No 10	-	1	12	5	-	-	-	1	-	58
Key West No 70	8	1	59	34	-	-	1	4	1	146
Norton No 69	11	2	35	28	-	-	-	1	4	116
Total farms by type	63	10	276	209	1	3	5	39	14	977
Percent farms by type	6.4	1.0	28.2	21.4	0.1	0.3	0.5	4.0	1.4	100

Highlighing denotes the modal type of farm in each rural municipality.

Source: Based on Statistics Canada (2007b)

farms, fruit and tree nut farming, and floriculture. Land use in the Big Muddy Valley is mostly devoted to ranching, although crops such as oats and peas are grown.

Farm size varies considerably across the region (Table 3). Whereas the modal size of farms is 1,120 to 1,599 acres, approximately one in seven (13.5%) farms are 179 acres (approximately one quarter section) or less whilst one in three (36.3%) farms are 1,600 acres (10 quarter sections) or larger. Small farms are most common in the RM of Weyburn, where one in four (24.9%) are 179 acres or less, and in the RMs of Brokenshell and Key West. Generally, the greatest concentration of large farms (or ranches) is located in the RMs of Happy Valley, Bengough and The Gap. Cattle ranching is the dominant agricultural activity in these RMs. In Happy Valley, 50 percent of farms are 1,600 acres or larger.

Perhaps the most visible indicator of rural restructuring in Saskatchewan has been the demise of the country elevator. In 1932, the number of licenced elevators in the province peaked at 3,240 (Thraves 2007). By 1970, this number had declined gradually to 2,732. Of these, 34 could be found in the 10 communities along the route of the field trip (Table 4). Since 1970, the number of elevators has declined precipitously. Today, only three of the 34 elevators remain standing and in operation. All are owned and operated by local farmer organizations rather than by large elevator companies. Long-term change in the rural economy including the closure of railway branch lines, such as the Canadian National (CN) line between Weyburn and Willow Bunch, provides an explanation for the demise of country elevators.

Weyburn to Castle Butte, Big Muddy Valley

0 km - Weyburn Inn (elev. 564 m)

.1 km

Immediately on leaving Weyburn Inn, the road crosses the Soo line and Souris River in quick succession. The Soo line forms part of the Canadian Pacific (CP) railway network. It runs southeast from Moose Jaw, through Weyburn and Estevan before crossing the Canada-US border at North Portal where it provides connections to the American Midwest. The Souris River flows southeast through Weyburn and Estevan, crosses into North Dakota southeast of Oxbow, then turns north, re-crosses the border into Manitoba south of Melita and eventually forms a tributary of the Assiniboine River.

Table 3: Farms classified by size (acres), 2006.

Rural Municipality	< 10	10 - 69	70 - 129	130 - 179	180 - 239	240 - 399	400 - 559	560 - 759	760 - 1,119	1,120 - 1,599	1,600 - 2,239	2,240 - 2,879	2,880 - 3,519	3,520 and over	Total farms by RM
Weyburn No. 67	3	10	6	30	4	26	13	16	24	21	21	7	5	11	197
Brokenshell No 68	2	5	0	7	4	11	4	9	9	15	7	9	4	14	100
Laurier No 38	2	2	0	7	1	6	7	5	13	11	20	13	9	11	107
The Gap No 39	1	0	1	16	0	8	8	3	12	14	14	7	6	19	109
Bengough No 40	1	1	0	8	0	9	10	6	19	27	21	17	9	16	144
Happy Valley No 10	0	0	1	2	1	2	1	3	4	10	5	8	2	19	58
Key West No 70	2	1	1	16	1	11	15	14	26	15	17	11	5	11	146
Norton No 69	0	1	0	6	0	10	10	16	15	21	5	15	6	11	116
Total farms by size	11	20	9	92	11	83	68	72	122	134	110	87	46	112	977
Percent farms by size	1.1	2.0	0.9	9.4	1.1	8.5	7.0	7.4	12.5	13.7	11.3	8.9	4.7	11.5	100
Cumulative percent farms by size	1.1	3.2	4.1	13.5	14.6	23.1	30.1	37.4	49.9	63.6	74.9	83.8	88.5	100.0	

Highlighing denotes the modal size of farms in each rural municipality.

Source: Based on Statistics Canada (2007b)

Table 4: *Licenced grain elevators, 1970.*

Community	Railway	Elevator company	Capacity (tonnes)[1]
Weyburn	CP	Federal Grain Limited 1	2,202
	CP	Federal Grain Limited 2	2,580
	CP	Inter Ocean Grain Co. Ltd. 1	2,722
	CP	Inter Ocean Grain Co. Ltd. 2	4,191
	CP	Saskatchewan Wheat Pool A	789
	CN	Saskatchewan Wheat Pool B	4,735
	CP	Saskatchewan Wheat Pool C	2,096
	CP	United Grain Growers Ltd.	2,858
Khedive	CP	Federal Grain Limited	1,546
	CP	Saskatchewan Wheat Pool	1,968
Pangman	CP	Federal Grain Limited 1	1,353
	CP	Federal Grain Limited 2	667
	CP	Saskatchewan Wheat Pool	2,531
Amulet	CP	Saskatchewan Wheat Pool A	1,442
	CP	Saskatchewan Wheat Pool B	1,279
Ogema	CP	Federal Grain Limited	1,788
	CP	Saskatchewan Wheat Pool	2,994
Glasnevin	CP	Federal Grain Limited	1,279
	CP	Saskatchewan Wheat Pool	1,442
Bengough	CN	Federal Grain Limited 1	2,041
	CN	Federal Grain Limited 2	1,306
	CN	Parrish & Heimbecker Ltd.	2,286
	CN	Saskatchewan Wheat Pool	2,449
Hardy	CN	National Grain 1968 Ltd.	1,524
	CN	Saskatchewan Wheat Pool	1,769
Ceylon	CN	Parrish & Heimbecker Ltd.	2,509
	CN	Saskatchewan Wheat Pool A	743
	CN	Saskatchewan Wheat Pool B	1,957
	CN	United Grain Growers Ltd.1	1,524
	CN	United Grain Growers Ltd.2	2,082
Radville	CN	National Grain 1968 Ltd.	2,749
	CN	Saskatchewan Wheat Pool	5,144
	CN	United Grain Growers Ltd.1	3,184
	CN	United Grain Growers Ltd.2	2,422

Highlighting denotes elevators still operating in summer 2007.
[1] 1 tonne = 36.744 bushels of wheat

Source: Based on CGC (1970)

.1 km

Turn right (north) onto Hwy 39.

2.8 km

At the junction of Hwy 39 with Hwy 13, turn left (west) onto Hwy 13. Among other things, Weyburn promotes itself as the 'Largest Inland Grain Gathering Point in Canada.' Immediately on turning onto Hwy 13, the inland terminals of Saskatchewan Wheat Pool (42,600 tonnes) and Pioneer Grain Company Limited (21,700 tonnes) are visible to the right (north) across the fields. Weyburn Inland Terminal (105,500 tonnes), Saskatchewan's second largest grain terminal, is located immediately south of Weyburn. All three terminals are located on the Soo line. Hwy 13, the Red Coat Trail, is the continuation of Manitoba's Hwy 2. In Alberta, it becomes Hwy 501. The name of the highway commemorates the 1874 expedition of the North-West Mounted Police.

Weyburn is located close to the southeastern extremity of Glacial Lake Regina. After turning onto Hwy 13, this environment is quickly left behind as the highway rises gradually and traverses moraine deposits of the Trossachs Plain, part of the Saskatchewan Plain. Dark Brown alluvial soils of the glacial lake bed are replaced by Dark Brown Solonetzic soils of medium to fine texture, developed on glacial till derived in part from Cretaceous marine shales. The parent material of these soils is olive grey to greyish brown in colour, and sandy clay loam to heavy clay loam and clay in texture. They are moderately calcareous and usually moderately to strongly saline.

13.8 km

The highway crosses into the RM of Brokenshell. The RM boundary approximates the transition from lake bed to glacial till and from Class 2 and 3 soils to Class 4 and 5 soils. The topographic map (Trossachs 72 H/9 1:50,000) shows the highway traversing a shallow depression in the plain. Excess water in Class 4 soils is identified as a significant limiting factor for agricultural activity. From this vicinity westwards to approximately 10 km beyond Trossachs the land rises about 75 m. Class 4 and 5 soils predominate with much of the land being in rough pasture or perennial forage crops. These soils extend along the route of the field trip to near the intersection of Hwy 13 and Hwy 6 a few km east of Pangman (Willow Bunch Lake 72 H 1:250,000).

26.6 km - Trossachs Gospel Camp

In this vicinity the Trossachs Plain is represented as an undulating dissected glacial till plain sloping from 700 m (2,125 feet) in the south-west

to 630 m (1,925 feet) in the north-east. Waters from the plain drain northward through the Moose Jaw and Avonlea Creeks to the Qu'Appelle Valley. The wooded area to the right of the road marks the course of Brokenshell Creek. It flows in a general northeasterly direction and drains to intermittent lakes.

29.0 km - Trossachs

An area with Class 5 soils to the right of the road opposite Trossachs (elev. 604 m) is signed 'PFRA/Permanent Cover Program/Clinton Goodwin' pasture. Saskatchewan has two pasture programs; one operated by the province, the other by the Prairie Farm Rehabilitation Administration (PFRA). In this vicinity, PFRA pastures are more common with approximately 25 of them marking the northwest-southeast alignment of the Missouri Coteau.

33.5 km

At the junction of Hwy 13 with Hwy 28, continue on Hwy 13. Grain and oilseed crops are prominent.

45.2 km

The highway crosses into the RM of Norton. Class 4 soils are dominant but grain and oilseed crops occupy much of the nearly level plain.

46.5 km - Forward (elev. 648 m)

A 'Point of Interest' on the left-hand (south) side of the highway describes the history of Forward. Initially, the village was established on a site 4.8 km northeast of this location. Incorporated took place in 1910. In 1913, the entire town was relocated to this site at the junction of Canadian Pacific Railway (CPR, later CP) and Canadian Northern Railway (CNoR) lines. The commemorative plaque claims that a thriving community with an extensive range of services and a population of nearly 1,200 developed. However, the census record shows that subsequent to relocation the population peaked at 67 in 1916 and declined continuously thereafter to a low of 23 in 1946. Forward declined because an elevator was not built and other communities along the railways provided competition. The village was restructured into the RM of Norton in 1947 and the last house was removed from the site in 1966.

50.2 km - Khedive (elev. 649 m)

A wooded area approximately 2 km south of the highway marks the location of Khedive. The community was incorporated as a village in 1916 following the arrival of the CPR. Its population reached an initial peak of

114 in 1916, declined during the 1920s and 1930s, but recovered to a post-World War II peak of 153 in 1956. Since then the population has declined continuously with the community's total demise made inevitable by CP's closure in 1995 of its Assiniboia Subdivision between Weyburn and Pangman. In 2002, Khedive was restructured into the RM of Norton. Today, a few people still live in the community and mail service is provided. Stabler and Olfert (2002) classify Khedive among the smallest of Saskatchewan's 'minimum convenience' centres. This status places the community in the lowest of six tiers in Saskatchewan's central place hierarchy.

56.9 km

From the intersection of Hwy 13 and Hwy 6 the road rises appreciably (about 25 m) in the direction of Pangman (Pangman 72 H/10 1:50,000). This change in elevation marks the transition from the moraine deposits of the Trossachs Plain to the undulating to hummocky stagnant ice moraine of the Missouri Coteau Upland.

61.4 km - Pangman (elev. 690 m; pop. 200)

Pangman was incorporated as a village in 1911. It serves as the administrative centre and main agricultural service centre for the RM of Norton. In 1990, the community was classified as a 'full convenience' (5^{th} tier) centre (Stabler and Olfert 2002). Subsequent decline in its population and level of service provision has seen its status reduced to that of a 'minimum convenience' (6^{th} tier) centre.

Pangman marks the eastern terminus of the Great Western Railway (GWR). GWR operates on 705 km (438 mi) of former CP tracks in southwest Saskatchewan. It is Saskatchewan's longest shortline railway and hauls rail cars to and from 40 siding locations including the elevators at Pangman and Ogema. Railcars are interchanged with CP Rail at Assiniboia and Swift Current. The railway started operations in 2000. In 2007, it obtained a service agreement with Red Coat Road and Rail (RCRR) to operate on 115 km (71 mi) of track between Pangman and Assiniboia. GWR's head office is located in Shaunavon.

RCRR is an organization consisting of representatives from communities along the rail line including the villages of Pangman, Ogema and Viceroy, and the RMs of Norton, Key West, Bengough, Excel and Lake of the Rivers. It purchased the track between Pangman and Assiniboia from CP in 1999.

West of Pangman, the Ogema Plain, part of the Missouri Coteau Upland, slopes from 820 m (2,500 feet) on the south to 770 m (2,350 feet) on the north. It is a roughly undulating and gently rolling till moraine and lacustrine

plain with drainage confined to local depressions. Class 3 soils extend as far as the junction of Hwy 13 with Hwy 34, north of Bengough. Grain and oilseed crops are dominant.

68.5 km

Railway sidings mark the site of Amulet, one of the 40 locations served by the GWR.

69.3 km - Amulet (elev. 724 m)

A 'Point of Interest' on the left-hand (south) side of the highway outlines the history of Amulet. The village was incorporated in 1911 and developed a range of services including a hotel, post office, bank, school, rink and two elevators. The population peaked in 1951 at 68 but by then services were in decline. The school was closed in 1961 and in 1965 the village was restructured into the RM of Norton.

A line of trees to the right-hand (north) side of the highway marks the abandoned right of way of CP's Amulet Subdivision. This 62 km (38.5 mi) branch line provided service to Crane Valley until abandonment in 1998.

76.8 km

Hwy 13 crosses into the RM of Key West.

82.4 km - Ogema (elev. 726 m; pop. 304)

The town of Ogema (Cree for 'big chief') was incorporated in 1911. It serves as the administrative centre for the RM of Key West and promotes itself as a progressive community with a high level of volunteerism. Provision of agricultural services provides the economic base of the community. Like Pangman, its central place status has declined from 'full convenience' (5th tier) to 'minimum convenience' (6th tier). Until recently, Ogema had two elevators (Table 4). The one remaining and former Saskatchewan Wheat Pool elevator (2,994 tonnes) is now owned and operated by local farmers. It is used for seed cleaning prior to planting or shipping, and as a storage and loading facility for rail producer cars. North of Ogema, Big Sky Farms Inc. operates an intensive livestock facility which was the first 5,000 sow, farrow to finish operation in Canada.

The war memorial bears the names of 43 persons killed in World War I. This large number points to the great personal sacrifice made by many small communities in Saskatchewan. During the early decades of the 20th century, most of Saskatchewan's population resided in villages and small towns such as Ogema and Pangman and their adjoining rural areas. Settlement was recent and, in some communities, ties with Europe, particularly the UK, were strong.



Figure 4: *CPR station and Ogema Elevator on Red Coat Road and Rail line at Ogema.*
Photograph: B.D. Thraves

West of Ogema cattle are more evident on gently rolling land.

91.7 km - Glasnevin (elev. 736 m)

Signage along the highway and railway announces the approach of Glasnevin. The community was likely named after a part of Dublin, Ireland. There is no record that Glasnevin was ever incorporated as a village.

97.8 km

At the Junction of Hwy 13 with Hwy 34 turn right (south) onto Hwy 34. For the next 3.5 km the route crosses Maxwellton End Moraine (Parizek 1964). The moraine slopes from 870 m (2650 feet) in isolated highs to 755 m (2,300 feet) on the north and west, 822 m (2,500 feet) on the south and 780 m (2,375 feet) on the east as a gently to strongly rolling till moraine. The area is characterised by local lacustrine plateaus, ridged moraines and outwash plains with drainage confined to local depressions. The landscape then changes to open plain sloping from 780 m (2,375 feet) in the north-west to 740 m (2,250 feet) in the south. This signifies a large glacial outwash area with little surface drainage that continues as far as Bengough. In negotiating the terrain between Hwy 13 and Bengough, the highway crosses alternating bands of Class 3 and Class 5 soils. Corresponding

bands of arable and range land are observed. Much of the soil in the outwash area is designated as Class 5.

101.2 km

The highway crosses into the RM of Bengough.

108.5 km

A large saline lake on the right-hand side (west) of the highway is indicative of surface water quality in this environment.

115.4 km

On approaching Bengough the highway crosses a disused railway line. This line was built by the CNoR around 1911. The CNoR was consolidated as part of the Canadian National Railway (CNR, later CN) in 1923. The former Saskatchewan Wheat Pool elevator is now owned by local farmers. Grain is transported to and from this point by truck. 'Plans' exist to re-open the railway so that grain can be shipped from Bengough to the Soo line at Weyburn.

115.7 km - Bengough (elev. 686 m; pop. 337)

Bengough was incorporated as a village in 1911 and as a town in 1958. As with other villages and small towns in rural Saskatchewan, its population has fluctuated in response to World War I, the economic uncertainties of the 1930s and, more recently, general restructuring of the rural economy. Since attaining a post-World War II peak of 695 in 1966, Bengough's population has declined to 337 in 2006. The community provides a range of services including a health centre, a K-12 school, and services in support of agriculture and local tourism. Bengough proclaims itself the 'Gateway to the Big Muddy.' Inexplicably, the community is not classified by Stabler and Olfert (2002) in their analysis of central places in Saskatchewan but its size and range of services suggest 'minimum convenience' (6^{th} tier) status.

116.0 km - Big Muddy Coal Mining exhibit

The exhibit notes that lignite seams in the Big Muddy Valley were recorded by geologist George Mercer Dawson, a member of the 1873 North American Boundary Commission. Mining using open pit and tunnelling methods dates from this period. Most mining was conducted by farmers working alone or in groups with production geared to personal or community needs. When homesteading in the Bengough area commenced about 1906, the value of coal over cow chips was soon recognized. Coal burned longer, provided more heat and was prized especially as a winter fuel. 'Coal mining bees' became popular. The era of farmer-owned and

operated mines lasted until 1950. Today, coal is mined by dragline methods from large open pits near Coronach. This coal supplies the Poplar River Power Station which produces one-third of the electricity generated in Saskatchewan.

South of Bengough, Hwy 34 crosses an area with Class 3 soils for approximately 10 km. Grain crops are dominant with some canola, sunflowers and peas. Beyond this, the route approaches the Big Muddy Valley over gentle to moderately steep rolling moraine (knob and kettle) deposits with maximum elevation estimated at 740 m (Bengough 72 H/6 1:50,000). Permanent streams are few but several (*e.g.*, those at 900578 and 994570) drain in a southerly direction to Big Muddy Creek and, in due course via the Missouri and Mississippi Rivers, to the Gulf of Mexico. Somewhere in the jumbled topography of the moraine, the route crosses a major drainage divide.

123.0 km

For the next 3 km, the highway crosses the poorly developed Harptree End Moraine (Parizek 1964).

129.0 km

Big Muddy Valley sign (elev. 724 m).

131.2 km

Hwy 34 crosses into the RM of Happy Valley and descends to the Big Muddy Valley, an abandoned glacial spillway. The late Cretaceous Whitemud Formation is clearly exposed in valley slopes to the left-hand side of the highway.

132.8 km

Hwy 34 crosses a small stream, Big Muddy Creek (elev. 671 m). Ahead, Mesozoic (251–265 mya) rocks are exposed in the north-facing slopes. The Ravenscrag Formation forms the top 10 m below the upland surface and sits atop the Whitemud Formation ('Grey Facies').

134.0 km

Before reaching the southern flank of the valley, a gravel road leads off to the right (west). The route proceeds in a westerly direction and passes a prominent landslide (Figure 5) and several sites where both the Whitemud and Ravenscrag Formations are exposed (Figure 6).



Figure 5: *Rotational landslide on north-facing slope of the Big Muddy Valley about 500 m west of Hwy 34.*
Photograph: U. Hardenbicker, 24 June 2006



Figure 6: *Whitemud and Ravenscrag Formations, Big Muddy Valley.*
Photograph: B.D. Thraves, 22 June 2007

135.8 km

The road crosses the first of two cattle grids.

139.3 km

The road forks. Take the right-hand fork and cross the second cattle grid. Castle Butte (elev. 760 m) is clearly in view. The butte, a popular landmark of the Big Muddy Valley, was given province-wide prominence in 1970 when SaskTel chose a photograph of it for their provincial directories. Images of the butte appear in publications promoting tourism.

141.0 km

Before crossing the third cattle grid, a dirt track leads off to the left and uphill towards the butte.

Big Muddy Valley

The cross-sectional form and general dimensions of the Big Muddy Valley reflect its origin as a glacial spillway. The valley is cut into bedrock with numerous exposures occurring both in the main valley and in the tributary gullies or coulees. The oldest formation represented in the area is the Whitemud, a clay-sand deposit of late Cretaceous age. In many cases the sharp break of slope at the butte-valley floor interface (gravity slope-wash slope) corresponds to the upper limit of the Whitemud. The greater part of the valley walls is developed in the Upper Ravenscrag formation (Parizek 1964). Variations in slope form, resulting from the differential resistance of various beds to erosion, have produced excellent examples of badlands topography.

Badlands are characteristic of some semi-arid environments and are typified by sparse vegetation and high rates of erosion. Fluvial erosion is too rapid to permit plant growth and soil formation. High erosion rates, very thin soil or weathered bedrock, unconsolidated or very poorly cemented materials and a rugged dissected topography are the typical characteristics of badlands. For badlands to form, the land must be composed of alternating layers of hard and soft rocks and sediments. When easily eroded material is topped by more resistant material, such as bentonitic shale, the more resistant horizontal layers protect the less resistant deposits, such as unconsolidated sandstone (Figure 7). The primary agent of weathering and erosion is usually water. Rain in semi-arid regions often falls in sudden, heavy showers. The Canadian prairies provide a natural setting for the geological evolution of such erosional landscapes especially where Cretaceous formations are exposed.



Figure 7: *Bentonitic dark grey mudstone with typical popcorn surface forming very gentle slopes whereas the underlying grey sandstone showing rills and pipes forms very steep often vertical slopes.*
Photograph: U. Hardenbicker, 24 June 2006

In the Big Muddy Valley, the valley sides have been deeply dissected by a series of 'subsequent' gullies orthagonal to the main valley and formed by head-ward erosion. These tributary valleys are separated by narrow, sinuous interfluves which often retain prairie sod on their summits. Generally, the interfluves decline in altitude towards the main valley floor and in places they have been breached by secondary gullying to form a series of isolated buttes extending into the valley. Castle Butte is the most prominent of these (Figure 8). It forms an isolated knoll completely detached from the ridge and is thus subject to erosion on all sides (Drew 1972).

Commonly observed grasses in the vicinity of Castle Butte include porcupine grass (*Stipa spartea*), needle and thread (*Stipa comata*), blue gamma (*Bouteloua gracilis*), june grass (*Koeleria macrantha*) and sand reed grass (*Calanovilfa longifolia*). Forbs include prairie sage (*Artemisia ludoviciana*), pasture sage (*Artemisia frigida*), silver sage (*Artemisia cana*) (Figure 9), winterfat (*Eurotia lanata*) prairie cornflower (*Ratibida columnifera*), purple prairie clover (*Petalostemon purpureum*), yellow umbrella-pant (*Eriogonum flavum*), rabbitbrush (*Chrysothamnus*



Figure 8: *Castle Butte, Big Muddy Valley.*
Photograph: B.D. Thraves, 9 September 2007



Figure 9: *Silver sage in association with prairie cornflower and purple prairie clover, Big Muddy Valley.*
Photograph: B.D. Thraves, 21 July 2007

nauseosus) and hairy golden aster (*Chrysopsis villosa*). Brittle prickly-pear cactus (*Opuntia fragilis*) is also present.

Castle Butte to Weyburn

0 km

Retrace the route from Castle Butte to Hwy 34 and north through Bengough.

26.3 km

At the junction of Hwy 34 and Hwy 705, turn right (east) onto Hwy 705.

27.8 km

Hwy 705 crosses the CNoR (CN) railway line. Rusted, gravel-choked rails indicate abandonment.

28.9 km

A shelter belt parallels the right-hand (south) side of the road. Other shelterbelts are visible at distance trending either east-west or north-south and appear to parallel property lines or road allowances. It is doubtful that prevailing winds exhibit the same regularity in direction.

30.9 km

A sign on the right-hand (south) side of the road reads 'Agriculture and Agri-Food Canada/Funded through the Prairie Grain Roads Program.' In the absence of a functioning railway, Hwy 705 serves as an important link in transporting grain to the elevator at Bengough.

31.3 km

A sign on the left-hand (north) side of the road reads 'RM 40 Soil Conservation Co-op Tree Shelter Belt (PFRA assisted)'. Shelter belts, generally running north-south, are visible on both sides of the road.

39.3 km

A salt-encrusted slough is viewed to the left of the road. In early summer, brightly coloured red samphire or glasswort (*Salicornia rubra*) grows at the margins of the pond (Figure 10).

42.3 km - Edna Lake

The lake can be seen at distance from the right-hand (south) side of the road. This is a relatively large water body and provides water for range



Figure 10: *Salt encrusted slough with red samphire beside Hwy 705 near Bengough.* Photograph: B.D. Thraves, 21 July 2007

cattle. A number of smaller lakes or sloughs are observed on this stretch of highway. Most are saline and quite shallow with evaporation reducing them to mud flats by late summer.

47.0 km

Hwy 705 winds north then east over an area of stagnant ice moraine with pronounced rolling topography and numerous saline sloughs (Hardy 72 H/7 1:50,000). Soils in this area are identified as Class 5. Ranching is more evident than arable farming.

50.4 km

The route crosses into the RM of The Gap.

58.7 km

At this point Hwy 705 intersects Hwy 211. A left turn here would lead to the village of Hardy (elev. 741 m). The village was founded around 1910 on the route of the CNoR. Its population peaked at 111 in 1946, but declined thereafter. By 1981, the population had slumped to 28. In 2000, the village was restructured into the RM of The Gap. By that time Hardy was classified

among the smallest of Saskatchewan's 'minimum convenience' or (6th tier) centres (Stabler and Olfert 2002). A minimal postal service is still provided to the village.

67.1 km

Turn left (north) at the junction of Hwy 705 and Hwy 6 and proceed in the direction of Ceylon.

69.5 km

Turn right off Hwy 6 onto Main Street passing The Gap Recreational Centre and Ceylon School on the left.

70.0 km - Ceylon (elev. 712 m; pop. 90)

Ceylon was founded in 1910 and incorporated as a village in 1911. The Ceylon Hotel (1912) and Ceylon United Church (1918) date from this era. By 1916, the community had a population of 188. This dipped to 184 in 1921, then recovered before dipping again in the mid 1930s. Population growth resumed during and after World War II to reach a long-term high of 332 in the mid 1960s. This period coincided with the tail end of the baby boom and the annexation of land from the adjoining RM of The Gap. Relative prosperity was signified by the community's classification as a 'full convenience' (5th tier) centre (Stabler and Olfert 2002) and the presence of five elevators operated by four elevator companies. Since the 1960s, Ceylon's population has drifted downwards to a long-term low of 90 in 2006. The village is now re-classified as a 'minimum convenience' (6th tier) centre. Nevertheless, it remains the largest community in The Gap and serves as its administrative centre. Ceylon has declined despite its good local water supply (see below) and the presence of a small pocket (about 4 sections) of Class 2 soils formed on glacio-lacustrine deposits in the immediate vicinity of the village. Decline is evident in the boarded-up businesses along Main Street (Figure 11).

At the junction of Main Street and 1st Ave. W. turn left (northwest), pass St. Joseph's church (1951) and proceed to the junction with Hwy 6. Turn right (north) onto Hwy 6, cross the railway line, turn right again onto Hwy 337 and proceed in the direction of Radville.

72.5 km - Ceylon Dam and Regional Park

The dam and reservoir were developed as a joint project of Canada, Saskatchewan, the RM of The Gap and the Village of Ceylon. Notably, design and construction were supervised by the PFRA. Opened in 1984, the project was developed to serve the village of Ceylon and surrounding



Figure 11: *Main Street, Ceylon.*
Photograph: B.D. Thraves, 22 June 2007

area. Saskatchewan Parks and Renewable Resources (Fish and Wildlife Development Fund) conducts reservoir aeration to enhance fish life. The reservoir was formed by the damming of Gibson Creek. It flows from the reservoir in a northeasterly direction through The Gap before joining Long Creek 2 km north of Radville. The disused CNoR (CN) line follows a similar route.

74.5 km

Hwy 337 re-crosses the disused railway.

77.0 km

A steeper gradient and rolling topography is encountered for about 7 km as the highway crosses ice-shoved hills of the Radville area (Aber 1993). Change in elevation is never more than a few tens of metres but these hills provide a dramatic contrast to parts of the prairie landscape dominated by the near level topography of glacial lake plains (*e.g.*, Glacial Lake Regina).

80.0 km - Duce Oil Ltd of Estevan (elev. 730 m)

Numerous pump jacks are visible on both sides of the highway. Several are new and suggest recent expansion in this oilfield.

84.0 km

Hwy 337 crosses into the RM of Laurier at 670 m and descends to the Saskatchewan Plain.

93.3 km

Turn right (southeast) into Beckwell Avenue. Proceed four blocks, then turn left onto Main Street in the direction of the CNoR railway station at the junction of Main Street and Railway Avenue.

Radville (elev. 632 m; pop. 755)

Like many towns and villages in Saskatchewan, Radville was first settled upon arrival of a railway. In 1910, Radville was established as a divisional point on CNoR's route between Brandon and Lethbridge. Incorporation as a village (1911) and then as a town (1913) soon followed. The community once served as an intersection of CN's branch lines between Weyburn-Willow Bunch and Moose Jaw-Goodwater. The railway station is the only surviving CNoR second class station in Saskatchewan. In 1984, the structure was designated a municipal heritage property. Today, Radville serves as the administrative centre for the RM of Laurier and is classified as a 'full convenience' (5^{th} tier) centre. It boasts over 100 businesses including a hospital, high school and public swimming pool. Tourism, based on hunting and fishing, and the provision of services to the oil industry are important elements of the local economy. The town is also famed for its association with Saskatchewan's potash industry as it was here in 1942 that potash was first discovered in salt core from the Norcanols Radville No. 1 well.

93.7 km

From the railway station, turn right (southeast) onto Railway Avenue, proceed to the next junction, turn left across the railway track and head north on Hwy 28.

95.7 km

On leaving Radville, Hwy 28 crosses Long Creek. The creek rises in intermittent lakes of the Souris River Plain approximately 30 km northwest of Radville, flows in a southeasterly direction following the alignment of

the Coteau, and crosses briefly into the US southwest of Estevan before re-entering Canada where its lower reaches are dammed to form the Boundary Dam Reservoir.

100.0 km – Galarneau Farms Inc.

In the early 1980s, this family-owned farm was one of the first to introduce organic farming to Saskatchewan (Harel 2006). Focusing on the production of 'identity-preserved' organic wheat, especially kamut, it now provides processing operations for over 80 contract producers including some in Alberta. Processing focuses on primary cleaning and bagging of kamut, hard spring wheat, other grains and oilseeds. Kamut is a high protein wheat with good weather resistance. Most is shipped to Italy where it is milled for use in a wide range of products including bread, pasta, breakfast cereals and cakes. The main market for all organic products is Europe.

101.7 km

Hwy 28 crosses into the RM of Brokenshell

105.0 km - Brokenshell # 2 PFRA pasture (3,299.5 ha)

The pasture extends for approximately 5 km along the right-hand (east) side of the highway and marks a transition from Class 4 to Class 5 soils. Grain and canola crops occupy Class 4 land on the left-hand (west) side of the highway.

111.5 km - Brokenshell Apiaries

The apiaries were founded in 2004 and were identified in the 2006 agricultural census (Table 1). Sale of honey is advertised.

115.1 km

At the junction of Hwy 28 with Hwy 13, turn right (east) onto Hwy 13 and proceed to Weyburn.

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Pangman 72 H/10, edition 3
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