PRAIRIE PERSPECTIVES:
GEOGRAPHICAL ESSAYS

Edited by
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Volume 2, October 1999

John G. McConnell (1935-1999)

John McConnell is reading the terms of reference for the John McConnell bursary. The two students with John, Lennie Holowaychuk and Kristi Fedec, were instrumental in organizing his bursary. This social gathering took place on December 6th 1998 at Diane and Lawrence Martz's home in Saskatoon.

Professor John G. McConnell was born in Toronto in 1935. In 1964, John received his Master's degree in Geography from the University of Toronto. He joined the recently founded Department of Geography of the University of Saskatchewan in the same year. For over 34 years, John was an active and valued member of the University of Saskatchewan. Within a short time, John not only accepted the Prairie environment, he embraced it. He became knowledgeable about the wildlife of the province and enjoyed leading hunting and fishing expeditions to all parts of the province.

John was a strong supporter of the Prairie Division of the Canadian Association of Geographers. By serving on our executive, he also helped shape our regional organization. Members of the PCAG will recall his thoughtful and constructive comments at our annual meetings. John was an outstanding teacher and, in 1999, he was awarded the prestigious Master Teacher Award for the University of Saskatchewan. John touched many students and colleagues and is fondly remembered by them. Largely through John's efforts, the Geography Department became the home for the Land Use and Environmental Studies interdisciplinary program. John died quietly on September 5, 1999 after a long battle with cancer. Some 500 people paid their final respects to John McConnell at his Memorial Service held on September 12. While John knew of his illness shortly after attending the 1997 CAG meeting in St. John's, he continued to teach and play a role in departmental affairs. For example, John and his wife Gail, attended the 1998 PCAG meeting in Watrous. In the same year, the members of the Environmental Studies Student Association honoured John by establishing a bursary in his name. Friends who wish to remember John are asked to make a donation to the John McConnell Bursary at the University of Saskatchewan.

R. Bone,
University of Saskatchewan

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Printed by
University of Winnipeg
Printing Services

ISBN 0-9694203-3-1

Introduction

The University of Saskatchewan hosted the 1998 Annual Meetings of the Prairie Association of Geographers in Manitou Springs. This second edition of the Prairie Perspectives is reflective of the diversity of papers presented at the meetings and the range of research interests found within the discipline of geography.

The lead paper of this volume provides a macro level investigation of the changing nature of core-periphery migration patterns in Canada. Akwawua's findings suggest that although the phenomenon of core periphery migration has occurred at a provincial level, a redefinition of this phenomenon is required at a national level. The paper by Smith, McGregor and Lehr continues the study of migration patterns within Canada at a micro scale, with an analysis of Ukrainian migration and settlement in southwestern Manitoba. The purpose of their investigation is to analyze the utility of GIS in historical geographic investigations.

Three papers out of Brandon follow which examine various aspects related to agriculture. Street and Wiseman explore the usefulness of GIS in aiding agriculturalists, particularly examining the issues related to the adoption of these technologies. McGinn and Bryant provide an analysis of drought periods experienced in the Palliser Triangle region of South-western Manitoba. The drought periods were determined using Palmer's Drought Severity Index and Thornthwaite's Climatological Water Balance. Their examination determined that the recollection of drought by agriculturalists is closely related to the actual severity of drought events. Everitt and Gill's paper provides an historical account of the development and evolution of grain terminals in Canada, beginning with the Lakehead development and culminating in the expansion to the west coast terminals. Although not directly concerned with agricultural issues, the final paper within a rural context is provided by Ofosuehene's comparative analysis of rural community development strategies between Saskatchewan and North Dakota.

Two examinations of lake environments were conducted by Greengrass et.al and by Parsons and McGinn. The first provides an in depth analysis of Waldsea Lake, one of the most studied saline lakes in Western Canada. Their analysis utilizes new techniques to determine the chemical and hydrological fluctuations within the lake, and what drives these changes over time. Parsons and McGinn examine the fluctuation of water levels in Riding Mountain National Park, determining that a cyclic pattern of water fluctuation does exist. Their research accounts for several variables contributing to this pattern.

Two studies were conducted dealing with public perception. The first of these by Haque *et.al*, examines the conflict resolution process surrounding water infrastructure development in three different case study locations. Morton, Haque and Wiseman's paper concerns the role of public perception of risk associated with a chemical industry in Brandon. Both studies emphasize the need for open communication and education.

Three tourism related papers follow the previous discussion. The first is Everitt and Welsted's examination of incipient mass tourism in the Lake Chapala Region of Mexico. Both Fedec and Archibold and Repko and Everitt's papers provide an analysis of river corridor use for recreational purposes within the cities of Saskatoon and Brandon respectively.

This year's publication is nicely rounded out by Sylvestre's theoretical examination of the role of geography in gerontological studies. She argues that gerontological geographers must return to the roots of Vidal and his conceptualization of the interconnectedness between society and the environment.

I would like to extend my sincere gratitude to Weldon Hiebert for all his help and hard work, and to John Selwood and John Lehr for all their assistance and for providing us with the initial Prairie Perspectives format.

Rhonda Koster
Saskatoon, 1999

Changing patterns of core-periphery migration in Canada, 1961 – 1991

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Abstract: In this paper, census data for the period 1961 to 1991 are used to analyze the changing pattern of core-periphery migration in Canada. The historical dominance of the country by the core regions of Ontario and Quebec up to the 1960s was reversed in the 1970s when those two regions lost population through net migration. The peripheral regions, notably the provinces of British Columbia and Alberta, served as the receiving areas for migrants. The 1980s saw another reversal of the migration trend with the core regions registering positive net migration. Only one of the core regions, that is, the province of Ontario, accounted for this revival of the core through net migration gains. The analysis shows that at the provincial level, the phenomenon of core-periphery migration occurred in Canada. The provincial migration trends are indicative, however, of "a continuously changing pattern" rather than "a clean break with the past". The core province of Quebec suffered net migration loss throughout the study period. British Columbia although included in the periphery never lost its attraction for migrants. The inclusion of British Columbia in the periphery of Canada seems outdated and a redefinition of the core region of the country is warranted.

Introduction

The direction of internal population migration in North America and the developed countries has not been constant over time. For instance, in 1982 Vining and Pallone put forward the thesis that the century-long migration towards high-density core regions was over in the developed world. It was found that the 1970s saw a population turnaround and net migration and population growth favoured the non-metropolitan areas (Vining and Pallone 1982). This phenomenon has come to be known as core-periphery migration, which represents a new spatial patterning in migration (Berry 1988).

The concept of core-periphery migration refers to the turnaround in population concentration whereby there was positive net migration to a nation's core region in the 1960s and negative net migration to that same core area in the 1970s. Berry (1988) points out that the phenomenon of core-periphery migration is no different than his concept of counterurbanization that has been observed in North America and other more developed countries (MDCs). Counterurbanization is a process of population deconcentration from urban to rural areas, and is effected mainly through migration. Migration has important consequences for spatial population redistribution especially in the developed countries, where the rate of natural population growth has fallen below replacement levels (Feichtinger and Steinmann 1992). In the MDCs the most important factor in spatial population distribution is migration. The study of the changing migration patterns in an area, is therefore, an important research objective with both theoretical and policy implications. Theoretically, it is relevant to examine the extent to which internal migration patterns in Canada portray a core-periphery directional bias, as evidenced in the U.S. and other developed countries. From the policy perspective, changing population movements have important consequences for public planning and delivery of social services (Rosenburg *et al*. 1989).

A large body of literature has documented the patterns, volume, characteristics, and incidence of the migration phenomenon in Canada (see for example Shaw 1985; Field 1988; Liaw 1990). As Joseph *et al.* (1988) rightly point out however, relatively little previous research has been done with the specific goal of examining migration in terms of core-periphery shifts in Canada. The dearth of studies in this area implies that the phenomenon of core-periphery migration in Canada is not clearly understood, nor are the policy implications concisely articulated. Joseph *et al.* (1988) are justified in their call for an evaluation of the role of the migration component in the population turnaround.

The study by Cochrane and Vining (1996) for the MDCs also included Canada. Like other developed countries, Canada's core region declined in terms of migration in the 1970s. A major limitation of Cochrane and Vining's (1996) approach is the way in which they defined core-regions; a definition that they also generalised to Canada. They state that “the core regions of a country are those regions which are economically and politically dominant: they contain the principal cities of the country and have traditionally experienced high rates of net migration from other less urbanised, peripheral regions. The identification of these regions poses little difficulty and should be not controversial” (Vining and Pallone 1982: 340).

The use of this *traditional* definition of the core region of Canada still persists in the literature (Reed 1995) but it might no longer be tenable if the core-periphery shifts of migration are carefully documented. This study attempts to provide empirical evidence from Canada to supplement the earlier works of Vining and Pallone (1982). Specifically, the objective is to analyze the internal migration patterns in Canada from 1961-1991 and determine whether the patterns fit into their core-periphery framework. Since the data analyzed extend beyond the 1980s, it might be possible to also assess the temporary or permanent nature of the core-periphery shifts. A secondary objective of the analysis is to demonstrate that discernible shifts in core-periphery migration patterns render the traditional definition of Canada’s core-periphery outdated (especially in view of contemporary political developments in the country). Data for the analysis are extracted from the censuses of Canada and the post-censual estimates of population published by Statistics Canada, 1992.

Following this introduction, a review of previous studies is presented in section 2, after which the traditional definition of Canada’s core-periphery is outlined in section 3. The changing pattern of interprovincial migration is analysed in section 4, and in section 5 empirical evidence is adduced for core-periphery shifts in migration. Section 6 presents the conclusion and suggests some directions for future research.

Review of Previous Studies

In view of the large body of literature on Canadian migration (see for example, Liaw 1990; Shaw 1985; Simmons 1980), a comprehensive review of the subject is beyond the scope of this paper. This brief review is necessarily highly selective and focuses on relevant studies that have bearing on the topic. Most previous studies have concentrated on rural population growth, rural-urban population transfers, metropolitan and non-metropolitan migration, and migration within the urban hierarchy (Keddie and Joseph 1991; Davis 1990; Field 1988; Joseph *et al*. 1988; Parenteau 1982; Simmons 1980).

Using census data at the national and provincial levels, Parenteau (1982) analyzed the changes in rural and urban population in Canada between 1971 and 1976. He found that there was a decline in the rates of urbanization and a revival in the population growth of the rural areas during the study period. Field (1988) employed data from the 1976 Census of Canada to examine the migration links between the rural-urban hierarchies during the period 1971-1976. Field found that "domestic migration patterns in Canada revealed a substantial net transfer of population from all levels of the urban hierarchy to the rural sector" (1988: 55). Simmons (1980) similarly shows that net migration to the largest cities in Canada rapidly declined between the late 1960s and early 1970s. These patterns of internal migration shifts are similar to the population turnaround in the U.S. in the 1970s when the rural and non-metropolitan areas gained population at the expense of the urban areas (Fuguitt and Brown 1990).

In an assessment of the applicability of the population turnaround concept to Canada, Joseph *et al*. (1988) employed census data and focused specifically on rural population growth from 1961-1981. Although their study did not consider the relative contribution of migration vis-à-vis natural increase to rural population growth, their findings are relevant to this study. This is because with declining birth rates in all areas of the country, a large proportion of the growth of the population can be attributed to net migration. For instance, Keddie and Joseph (1991) point out that during the 1976-1981 period, the province of British Columbia recorded a population growth rate of 11.3 per cent but the contribution of net migration to this growth was nearly double that of natural increase.

The study by Joseph *et al*. (1988) found that the period 1971-1981 saw the rural areas registering a higher population growth rate than the urban areas. Keddie and Joseph (1991) found that the early 1980s pointed to an increase in urban population growth. It must be pointed out that these changing growth trends are reflective of the changing population growth trends at the provincial and national levels. In an analysis of the growth and distribution of the Canadian population, Termote (1987) noted that between 1966-1971 and 1971-1976, there was a reversal of interprovincial migration that favoured the four eastern (Atlantic or Maritime) provinces and the three Prairie Provinces. Further, Termote (1987: 42) states that the 1971-1976 period was "characterized by a strong deterioration of Ontario's migration balance." This changing migratory trend corroborates the findings of Cochrane and Vining (1996) for the MDCs.

In sum, it might be said that past studies point to large differences in rural-urban population growth as well as considerable shifts in the internal migration patterns in Canada. The empirical evidence shows further that the phenomenon of counterurbanization or metropolitan dispersal of population was observed in the Canadian urban scene. An analysis of population shifts at the provincial level between 1961 and 1991 within the framework of core-periphery migration will go a long way to supplement the findings in the above literature review. Before we undertake an analysis of the migration data however, it is necessary to turn attention first to the core-periphery of Canada, as traditionally defined.

Defining Canada's Core-Periphery

The concept of core-periphery is used inter-changeably with other concepts such as heartland-hinterland, metropolis-hinterland, centre-periphery or centre-margin (McCann 1982). The concept describes the unequal relations between regions, or rural and urban centres, such that the core or heartland dominates the periphery or hinterland in terms of human and natural resources and socio-economic development. Friedmann (1973) defines hinterlands as regional sub-systems that stand in a relationship of economic, political and cultural *dependency* to a heartland. Anderson (1988:

8) points out that a useful distinction between heartland and hinterland can be made by identifying the central Canadian industrialized core as the heartland and the rest of the country as the hinterland.

The core region of Canada has thus been traditionally defined as comprising the two provinces of Quebec and Ontario. As Anderson (1988) points out "Canada's industrial core is described as a region extending from Windsor through the Toronto area and northeast along the St. Lawrence River to Montreal and Quebec City" (1988: 2-3). This definition of the heartland is described as Canada's *Main Street* (Yeates 1975). Walker (1990: 43) states that "at an early stage in Canada's economic history a national scale core-periphery had emerged with the core centring on the Quebec-Windsor corridor and dominated by Montreal and Toronto." Statistical data on the volume of domestic exports of Canada show that from January to November 1997, 68 percent of Canada's exports originated from the two core regions of Quebec and Ontario; but Ontario alone accounted for 50 percent of the exports (Appendix 1). The statistics in Appendix 1 demonstrate that Quebec's share of total exports declined from 20 percent in 1974 to 18 percent in 1997.

The standard definition of Canada's core-periphery is shown in Figure 1. As already noted, Quebec and Ontario form the core regions; the western, northern and Atlantic Provinces are all considered as peripheral to the centre. In the analysis that follows, the periphery is subdivided into the Maritimes (Newfoundland, Prince Edward Island, Nova Scotia, and New Brunswick), the Prairies (Manitoba, Saskatchewan and Alberta), and British Columbia (BC).[1] This categorization of the periphery is in line with previous studies and is intended to facilitate the analysis.

Generally, in the core-periphery model, there is a concentration of socio-economic development efforts in the core. Since most migrations are economically motivated (Shaw 1985), the usual direction of migration flow is from the periphery to the core of a country. This is because most migrants seek to avail themselves of the socio-economic opportunities in the core area. Empirical evidence shows that the historical pattern of internal migration in Canada was positive net migration to the core regions of Ontario

***Figure 1**: Provinces and Core Region of Canada (1961-1991).*

and Quebec from 1901 to 1961, although Quebec experienced a net loss in the period 1911-1921 and also in 1941-1951 (Stone 1969; George 1970). In the next section the 1961 to 1991 data on internal migration patterns among the provinces of Canada are analysed to ascertain if the traditional definition of core-periphery relationship is applicable in a Canadian context.

Net Interprovincial Migration in Canada, 1961-1991

Data on net interprovincial migration are analyzed in Table 1. It can be seen from this table that during the period 1961-1966 all provinces, with the exception of Ontario and British Columbia, registered negative net migration. In the 1966-1971 period Alberta joined Ontario and British Columbia as the provinces that gained population through positive net migration. During the two time

Table 1: *Interprovincial migration in Canada, 1961-1991.*

Province	1961-66	1966-71	1971-76	1976-81	1981-86	1986-91
Newfoundland	-15,213	-19,344	-1,856	-18,983	-15,051	-15,971
P.E.I.	-2,970	-2,736	+3,754	-829	+751	-711
Nova Scotia	-27,125	-16,396	+11,307	-7,140	+6,895	+2,117
New Brunswick	-25,679	-19,596	+16,801	-10,351	-3,931	-5,246
Quebec	-19,866	-122,735	-77,610	-156,496	-81,254	-40,382
Ontario	+85,369	+150,712	-38,559	-57,827	+121,767	+72,318
Manitoba	-23,470	-40,690	-26,828	-42,218	-2,634	-36,454
Saskatchewan	-42,094	-81,398	-40,753	-9,716	-2,974	-66,079
Alberta	-1,984	+32,008	+58,571	+186,364	-31,676	-41,438
British Columbia	+77,747	+114,966	+92,285	+122,625	+7,382	+138,860
Yukon & NWT	-3,360	-3,072	+3,213	-5,430	-3,141	-2,780

Source: Statistics Canada, 1992

periods of 1961-66 and 1971-76, Quebec registered negative net migration. In fact, throughout the entire period under study from 1961 to 1991 Quebec, one of the core provinces, lost population through net migration.

Table 1 further demonstrates that in the 1971-76 period, the Maritime Provinces of Prince Edward Island (P.E.I.), Nova Scotia, and New Brunswick recorded positive net migration as opposed to the previous time periods 1961-66 and 1966-71, when they suffered negative net migration. The other two provinces recording positive net migration during the 1971-76 period were the western provinces of Alberta and British Columbia. It is significant to note that during 1971-76 and the 1976-81 inter-censual periods, both Ontario and Quebec (the core regions) registered negative net migration.

A remarkable feature of Table 1 is the net migration figures for the 1976-81 period. During that period all the provinces, except the two western provinces of Alberta and British Columbia, recorded negative net migration. The data for the 1981-86 period reveal that the provinces registering positive net migration were Ontario, British Columbia, and two Maritime Provinces of P.E.I. and Nova Scotia. In the 1986-91 period, all the provinces except Ontario and British Columbia lost population through migration. The figures in Table 1 indicate that British Columbia is the only province to demonstrate a consistent pattern of positive net migration.

In sum, these statistics demonstrate a considerable amount of change in interprovincial migration patterns during the 1961-1991 period. Although Joseph *et al*. (1988) found no evidence in support of a population turnaround at the rural scale of analysis, Table 1 reveals that at the provincial level, there was a complete reversal in the pattern of internal migration during the period under study. It must be pointed out that the shifts in internal migration patterns may be more clearly discerned and appropriately analyzed at the provincial level where as Walker (1990: 43) rightly points out "data availability is so much better." The core-periphery migration shifts, which support the notion of a population turnaround, are further analyzed in the next section.

Core-periphery Migration: Empirical Evidence

Data on internal migration to the core regions of Canada from the 1961 to 1991 censuses are summarised in Table 2. These figures demonstrate that in the 1960s there was positive net migration to the core areas; that is, the core areas gained population through net migration. As already noted however, the core region of Quebec suffered net migration loss during the entire period (1961-1991). The net migration gain in the core region can be attributed to the positive net migration experience in Ontario, which appears to be the most important province in the core area in terms of population dynamics.

Table 2: Net migration to the Canadian core region, 1961-1991.

Period	Quebec	Ontario	Total
1961-66	-19,866	+85,369	+65,503
1966-71	-122,735	+150,712	+27,977
1971-76	-77,610	-38,559	-116,169
1976-81	-156,496	-57,826	-214,322
1981-86	-81,254	+121,767	+40,513
1986-91	-40.382	+72,318	+31,936

Source: Calculated from Table 1.

The analysis in Table 2 clearly indicates that in the 1970s the core areas of Canada recorded negative net migration in the magnitude of negative 116,169 in 1971-76 and negative 214,322 in the 1976-81 period. Both Quebec and Ontario registered negative net migration during the 1970s. This pattern is a clear reversal of the trend in the 1960s when Ontario accounted for the positive net migration to the core areas. Another migration reversal occurred again in the 1981-86 and 1986-91 periods, when the core again recorded positive net migration. During both periods however, Quebec experienced negative net migration, so that the core gains were entirely due to Ontario.

The negative net migration to the core areas during the 1970s supports a reversal in the direction of the pattern of internal migration in the developed countries during that period (Cochrane and Vining 1996; Vining and Pallone 1982). During the 1970s the dominance of the core regions declined, albeit temporarily. In his comments regarding the Canadian situation, Termote (1987: 33) states, “the regional pattern of the 1970s is characterized by an important decline in the ‘demographic power’ of the two central provinces (Quebec and Ontario), which until the 1960s dominated Canada’s demographic structure.” Based on the demographic criteria, a more specific assessment might be to urge for a redefinition of Canada’s core-periphery, since the concept is a popular model for examining the movement of people and it is also a framework used to describe Canada’s regional economic development. The question that arises then, is in what direction was the flow of out-migration from the core regions in the 1970s?

In Table 3, data on net migration to the core areas are compared with net migration to the periphery provinces. An analysis of this data clearly reveals the volatile and changeable nature of migration patterns in Canada. During the 1961-66 and 1966-71 periods, the peripheral regions (except for British Columbia) lost population (to the core) through negative net migration. The reversal of the migration pattern in the 1971-76 and 1976-81 periods, already noted, is clearly borne out in Table 3. Except for the Prairies, which recorded negative net migration in 1971-76, the periphery gained population through positive net migration. This

Table 3: *Net migration to core and periphery, 1961-1991.*

	Core		Periphery		
Period	Quebec	Ontario	Maritimes	Prairies	B.C.
1961-66	-19,866	+85,369	-71,005	-67,548	+77,747
1966-71	-122,735	+150,712	-58,099	-90,080	+114,966
1971-76	-77,610	-38,559	+30,006	-9,010	+92,285
1976-81	-156,496	-57,826	-37,303	+134,430	+122,625
1981-86	-81,254	+121,767	-15,267	-37,284	+7,382
1986-91	-40.382	+72,318	-24,045	-143,971	+138,860

Source: Calculated from Table 1.

demonstrates that the direction of internal migration was from the core to the periphery.

In the 1976-81 period, while the Prairies experienced a positive net migration gain, the Maritimes suffered negative net migration. There was yet another migration reversal during the 1981-86 and 1986-91 periods. The core gains, again due to Ontario, during these periods contrast sharply with the losses suffered by the periphery. The core (specifically Ontario) seems to have bounced back and attracted more migrants at the expense of the periphery, except for British Columbia. The net migration gain achieved by British Columbia, which is supposed to be included in the periphery, has already been noted. In fact throughout the entire period under study (1961 to 1991), the province of British Columbia gained population through core-periphery migration. It seems that the inclusion of the province of British Columbia in the periphery appears to be an anomaly because of its attractive power for migrants.

The changing pattern of internal migration is said to be due in large measure to the changing economic performance of the various provinces in the country (Walker 1990). A very good example of this is the case of the Prairie province of Alberta, which attracted migrants during the oil boom years between 1971-76 and 1976-81 (see Table 1).

In summary, the analysis in Table 3 clearly indicates that the phenomenon of core-periphery migration occurred in Canada during the 1970s. A shift in the trend occurred however, in the early 1980s, to favour the core region of Ontario, with the core regaining its dominant position. It is significant to note that Quebec (considered a core province) constantly experienced migrant loss, while British Columbia (considered peripheral) consistently attracted migrants. In the light of this changing trend Walker (1990: 54) states, “the core-periphery structure in Canada is not as clear-cut as it was 20 years ago and could either strengthen or weaken in the future.”

Conclusion and Implications for Future Research

This paper has explored the shifting direction of internal migration patterns in Canada during the 1961-1991 period. It was shown that core-periphery migration occurred during the 1970s and that there was a reversal of the trend in the 1980s to the province of Ontario, the most dominant core area. It is possible that the revival of the core region of Ontario might extend beyond the 1990s. It is clear that within the core region, Ontario stands out as the towering figure over its ailing neighbour, Quebec. In the periphery, the province of British Columbia exerts a dominating influence and is able to continuously draw a large number of migrants.

This has implications for Canadian regional policy. Sooner or later policy analysts will have to address the issue whether British Columbia should still be regarded as a periphery region, one dependent on an ailing core area. In this context, future research needs attempt a redefinition of Canada’s core-periphery structure or articulate a “multi-polar core” concept. This is necessary because the analysis has shown that Vining and Pallone’s (1982) definition of the core region as one that experiences high rates of net migration, does not apply to Quebec.

Previous studies of core-periphery migration saw the 1970s core region migration loss as a “clean break with the past” (Vining and Pallone 1982). The findings in this study indicate that no clean break with the past occurred in Canada. Rather we have what might be called “continuously changing patterns” or what Mera (1988) calls “migration cycles.” Migrants move in response to perceived economic opportunities. As the economic circumstances of the various provinces change, so too will the direction of internal migration flows.

In a country as large as Canada, interprovincial distances are lengthy. The changing patterns of core-periphery migration revealed in this paper imply that the migrating actors travel over very long distances. The relevant research question for geographers is, do long distances influence migrant decisions? In his study of Canadian population distribution, Termote (1987: 42) concludes "physical distance does not always play a dominant role in interprovincial migration behaviour." How then do we model aggregate migration flows? Do we continue to use the traditional gravity model approach of relating migration and distance? Or do we adopt the "needs" approach and relate migration to opportunities, knowing that migrants are influenced more by economic opportunities? This can be posed as an empirical research question, involving a field survey, to investigate migrants' views on the relative importance of linear distance in destination selection.

Appendix 1

Volume of Total Domestic Exports by Province, January to November, 1974 and January to November, 1997.

Province	Total Exports Jan-Nov, 1974		Total Exports Jan-Nov, 1997	
	Thousands of Dollars	% of Total	Millions of Dollars	% of Total
Newfoundland	447,112	1.6	2,269.3	0.9
P.E.I.	16,183	0.1	2,824.2	1.1
Nova Scotia	524,219	1.8	338.0	0.2
New Brunswick	690,787	2.4	4,967.4	2.0
Quebec	5,703,531	20.0	45,752.7	18.0
Ontario	10,888,539	38.1	127,938.7	50.3
Manitoba	468,830	1.6	6,388.4	2.5
Saskatchewan	746,951	2.6	8,815.4	3.5
Alberta	3,719,698	13.0	30,048.3	11.8
British Columbia	5,229,393	18.3	24,518.7	9.6
Yukon & NWT	na	na	437.5	0.2
Total	28,558,913	100.0	254,348.6	100.0

Source: Statistics Canada, 1997

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Frontier settlement as a dynamic process: using GIS to map the Ukrainian settlement frontier in southeastern Manitoba

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Abstract: Beginning in 1896 immigrants from western Ukraine settled in the Stuartburn district of southeastern Manitoba. The lands occupied by these settlers were often sub-marginal and included large tracts of swampland. To determine the process and tempo of land occupation a time series of maps showing the progress of frontier settlement was created using GIS. This paper describes and evaluates the methodology employed in producing this time series of maps. The extent of Ukrainian settlement is plotted on a bi-annual basis from 1896 to 1940.

Introduction

In 1892 the first small group of Ukrainian settlers to enter Canada took homestead land in east-central Alberta. For the next three years practically all Ukrainians who came to Canada followed this first group to Alberta and settled alongside their compatriots, laying the foundations of what would eventually become the largest Ukrainian settlement in the West. It was not until 1896 that Ukrainians settled elsewhere in the West (Kaye 1964). One of the first groups of settlers to do so chose to select their homesteads in Manitoba, east of the Red River in the bush country that lies immediately north of the international boundary (Lehr 1988)

They wished to settle near to the Mennonite reserves where they could secure employment to raise capital for the development of their farms but this proved to be impractical as there was not sufficient vacant land near to the Mennonites, certainly not a contiguous area that could accommodate a settlement of twenty families or more (NAC Wendelbo 1896). Further east, beyond the valley margin was a vast unsettled area of "bush country," which had been surveyed but not settled. Sir Richard Cartwright had managed to acquire several sections of land east of the Red River on which he ran cattle and there was a scattering of settlers to the east of Cartwright's lands who were then at the very limits of settlement. To the Ontario border and beyond, the land was virtually empty.

In 1896 an initial settlement of some 94 Ukrainian immigrants in 28 families settled in Township 2 Ranges 6 and 7 East (Kaye 1975). This colony grew, through chain migration, to over 1500 families by 1920, and eventually embraced some 19 Townships, an area of 684 square miles (Figure 1).

The lands selected by this first group of Ukrainians to settle in Manitoba were later described as marginal at best and mostly unfit for settlement. In retrospect it seems odd that this area of badly drained, clay, and gravelly soils was first settled by one of the best organized and best led groups of Ukrainian settlers ever to settle in the West. Led by Kyrylo Genik, these first settlers had been selected by Dr. Osyp Oleskiv, the Ukrainian professor of agriculture whose pamphlets *Pro Vilni Zemli* and *O Emigratsii* were largely responsible for triggering Ukrainian interest in Canada as a destination for emigrants. A year previously Oleskiv had visited Manitoba and toured the area south of Winnipeg as far as, and possibly beyond, Dominion City, on the eastern margin of the Red River valley. On the basis of this reconnaissance he advised settlers to select land south of Winnipeg, adjacent to the Mennonite reserves where cash-poor settlers could obtain employment (Kaye 1962). He perhaps made a common error in assuming that land quality remained constant throughout the region and that the quality of the soil that he observed in the Dominion City area would be much the same in the more heavily wooded area beyond the valley margins some twenty miles to the east. It may have been that he was aware that the nature of the land changed but considered it to be of little consequence since he intended his settlers to enter dairy farming and stock rearing, or perhaps he was misled by the Winnipeg land agent's description of the area as "chiefly rolling prairie interspersed

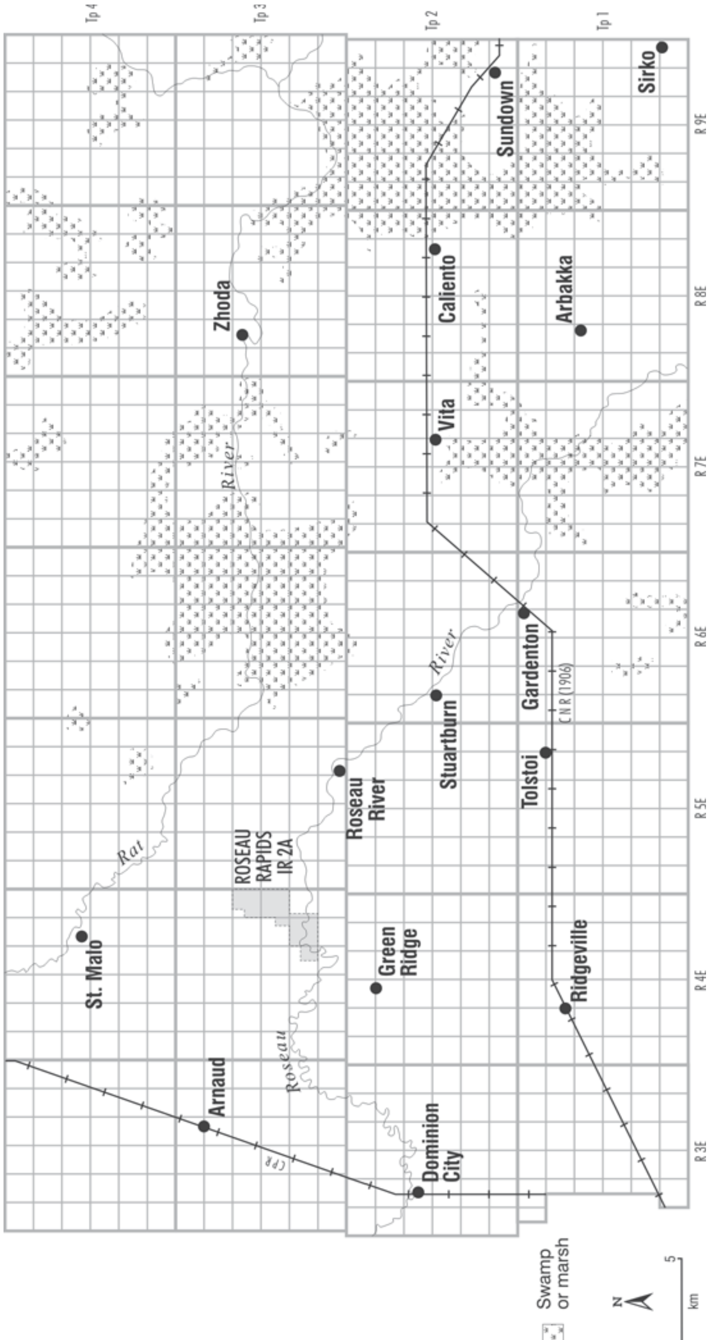

***Figure 1:** Area of southeastern Manitoba initially settled by Ukrainians.*

with fine groves of poplar timber, the soil ... a rich dark loam" (NAC Carstens 1896)

What later proved to be more realistic assessments were that the area was "... very rough and hard to clear and improve," and that it was "...of inferior character, and as such would be rejected by ordinary (i.e. Canadian) farmers...." (Canada, Sessional Papers 1896) The Commissioner of Immigration in Winnipeg, W.F. McCreary, had already learned that the Ukrainians evaluated land somewhat differently than settlers of other backgrounds and noted that "...they care but little whether the land is heavy soil or light gravel; but each man must have some wood on his place...." (NAC McCreary 1897). In his opinion the Township had some "very nice timber bluffs" and the land was of the type that Ukrainians elsewhere had settled eagerly (Canada Sessional Papers 1900). It has been argued elsewhere that these settlers not only evaluated the resource base from perspectives different from those of settlers from other backgrounds but that they were prepared to overlook a homestead's environmental shortcomings if they could attain a social advantage by settling adjacent to other family members or friends (Lehr 1985; 1996).

In order to gain further insight into the settlement process and the effect of the physical environment on the movement of the frontier of settlement, it was decided to map the extent of Ukrainian settlement, showing entries, abandonments, and patents, throughout the Stuartburn block from the inception of settlement in 1896 until the frontier had effectively closed in 1930. To do this effectively using conventional manual mapping techniques would be a daunting, extremely time consuming undertaking, so it was decided that GIS techniques would be employed and that as a first step a time series of maps showing the state of settlement at two year intervals would be produced.

Methodology

Maps are geographers' most important tool for displaying and analyzing spatial relationships. In this case they allow the process of settlement to be followed and the evolving pattern to be immediately evident. At the time that settlement was taking place neither the process nor the pattern would have been readily discernable by an observer on the ground. Maps, through their ability to convey to the observer information which never actually appears in the landscape, such as the ethnic origin, religion or age of a homesteader, can make the invisible visible. Through changes in scale they can extend our vision and so enable regional perspectives to be apprehended. Maps also have the capacity to extend our vision by displaying aggregate data, that is by displaying temporal relationships at another scale. Conventionally this has been done by compressing a period of time down to a point in time. For example, we can create a map of the Ukrainian settlement that took place between 1890 and 1900. Now, with computer technology, it has become practical to create animated sequences. For example, to study the progress of Ukrainian settlement the time scale can be changed so each year is represented by one second. Just as small distances between the symbols on the map represent larger distances on the ground we can use small units of time to represent longer time periods; a second might represent a day, a week, a month, or a year, or whatever time period best illustrates the process under examination (Vasiliev 1997).

For this study the progress of settlement at intervals of two years was mapped beginning in 1896. This was the year that Ukrainian settlers first entered the district and began to make official entries on to the land by paying an entry fee of $10.00. After they had fulfilled certain agricultural obligations, had built a house of specified dimensions and had resided on the homestead for a period of at least three years settlers were eligible to apply for the patent to their homestead. If this was granted they then owned the land outright, and so could mortgage, lease, rent or dispose of it as they saw fit. This administrative change in the status of the land was also mapped.

Records of homesteading attempts on over 1600 quarter sections in southeastern Manitoba were extracted from the records of homestead entry now held in the Provincial Archives of Manitoba. Each of these records, which contained up to 41 separate items of data, was then entered into a database. Only a very small number of these data fields were used in this preliminary analysis.

The first field in the database contains code numbers uniquely identifying each quarter section of land, other fields include the date of entry onto the land, the name of the settler, the settlers ethnic origin, the date the land was patented, the amount of land cleared and cultivated by year, and so forth.

The GIS software package IDRISI was used to generate the maps. First a raster image of the area was created where the cell values were the unique quarter section code numbers. The quarter section codes provide the essential link back to the database so other fields of data can be mapped. Coverages of the entry and patent years were made by having IDRISI replace the quarter section codes with the entry and patent years. These layers were then reclassified and overlaid on a raster image of the areas swampland to create coverages showing the state of settlement at the selected times. Vector overlays showing the location of rivers, the township grids, and the rail lines, when they came in, were added to create the final maps. The actual GIS operations were called from a macro file so it was only necessary to change the date on a few lines and rerun the macro file to create a new map.

Interpretation

The first maps showed some unexpectedly sharp and what appeared to be arbitrary limits to the extent of Ukrainian settlement. Some townships were not settled by Ukrainian or any other settlers according to available data. To ensure that no errors of omission had occurred in the recording and entry of data during the research phase of the study, the basic homestead entry information was checked against the information recorded in the Township General Registers. These data are less comprehensive than the Records of Homestead Entry but the Township General Registers do contain the name of all who attempted entry on to each quarter, the date of entry, and indicates if and when patent to the land was granted, or whether the entrant abandoned the claim. There is the further advantage that this record contains data on all lands including those that were never entered or patented or were not opened to homestead settlement.

These records indicated that the limits of the Ukrainian settlement were set by the United States boundary to the south, by physical limitations to the east, by 1880s Anglo- Canadian settlement to the west and by the presence of Metis Land Grants in Townships 3, 4 and 5 in Range 5E and the presence of Mennonite settlers, who entered in 1874-6, to the north in Township 6 Ranges 5 and 6E (see Figure 6). Other Townships that conspicuously lacked Ukrainian settlement and appear to be enclaves of vacant land in the midst of the Ukrainian settlement were entirely devoted to Metis Land Grants and so were never available for homestead settlement by non-Metis settlers. Other Townships were never opened to homestead settlement for other reasons. Townships 4 and 5 Range 7E, and Townships 4 and 5 Range 8E, were designated as "Swamp Lands" and remained vested in the Crown and thus were never opened to homestead settlement (PAM).

The time series of maps illustrates that the process of settlement was not the simple movement of an easily defined frontier. From the initial nucleus of settlement in Township 2 Range 6 E Ukrainian settlement expanded westwards until it encountered lands previously settled by non-Ukrainian peoples. To the south the international boundary limited settlement, although several families inadvertently wandered across the poorly marked border and settled on the most northerly tier of sections in Minnesota adjacent to their compatriots in Canada. These settlers were not recorded in this Canadian data and hence do not appear on the maps. Settlement expanded freely to the east, unfettered by political or administrative borders. The physical environment was the most significant factor controlling this eastward movement of the settlement frontier. The maps clearly demonstrate that swamps formed a physical barrier which caused the frontier to stabilize until most of the eligible vacant lands behind the frontier were taken, at which point settlement would leap-frog across the swamp and create a new nucleus which would expand both eastwards and westwards as settlers sought lands alongside their relatives and friends (Figures 2-6).

On occasion Ukrainian settlers would move into swampy areas. A common assumption has been that this was a course of action imposed upon them, one fostered in part by politically motivated claims carried at the time by the *Winnipeg Telegram*:

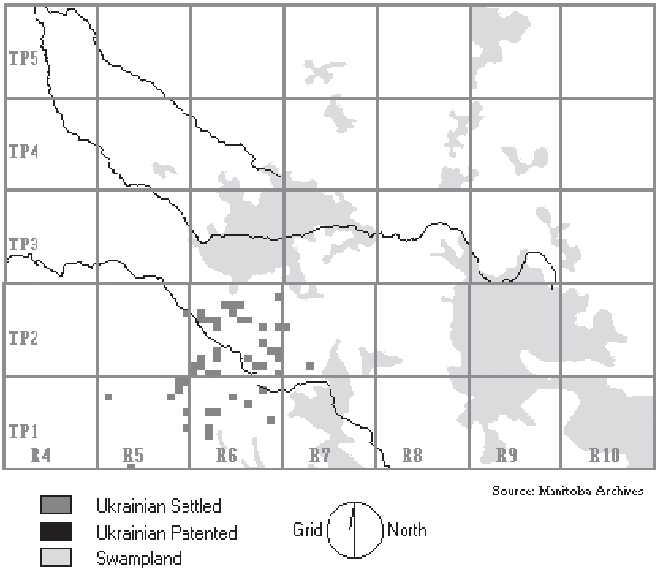

***Figure 2:** Ukrainian settlement in southeastern Manitoba prior to 1898.*

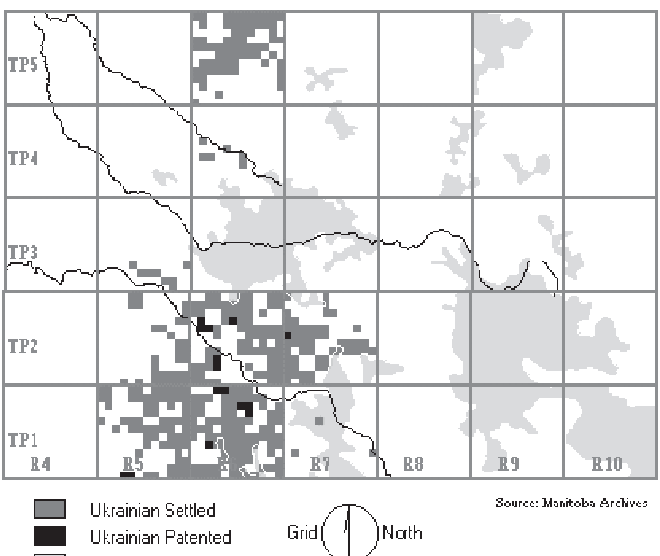

***Figure 3:** Ukrainian settlement in southeastern Manitoba prior to 1902.*

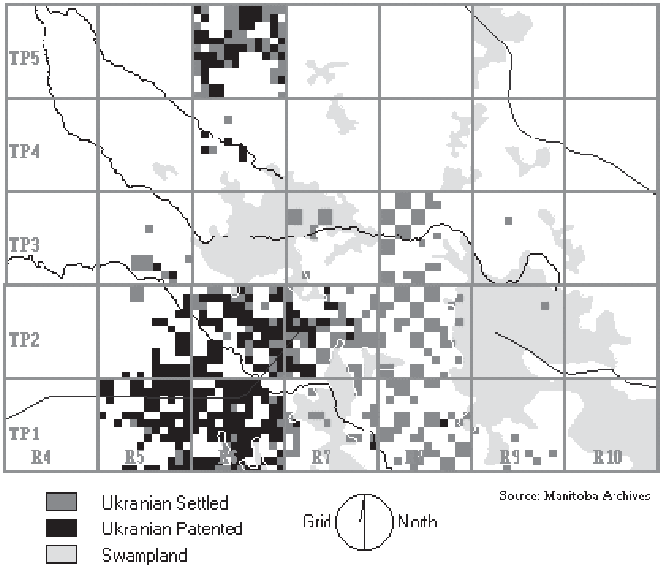

Figure 4: *Ukrainian settlement in southeastern Manitoba prior to 1906.*

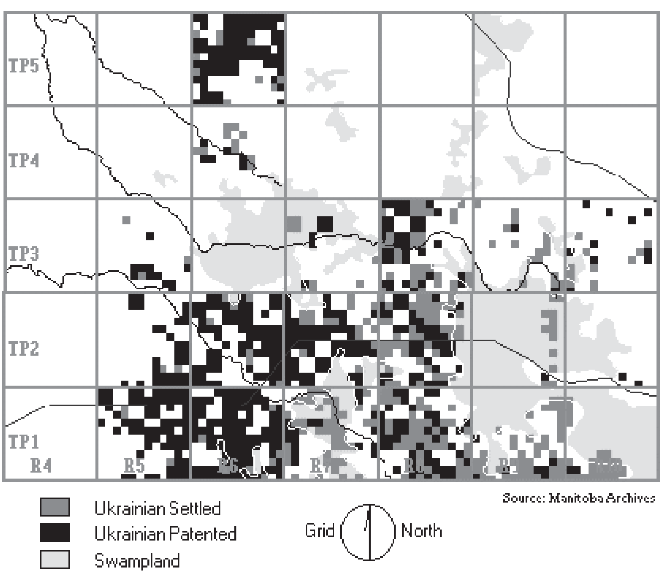

Figure 5: *Ukrainian settlement in southeastern Manitoba prior to 1916.*

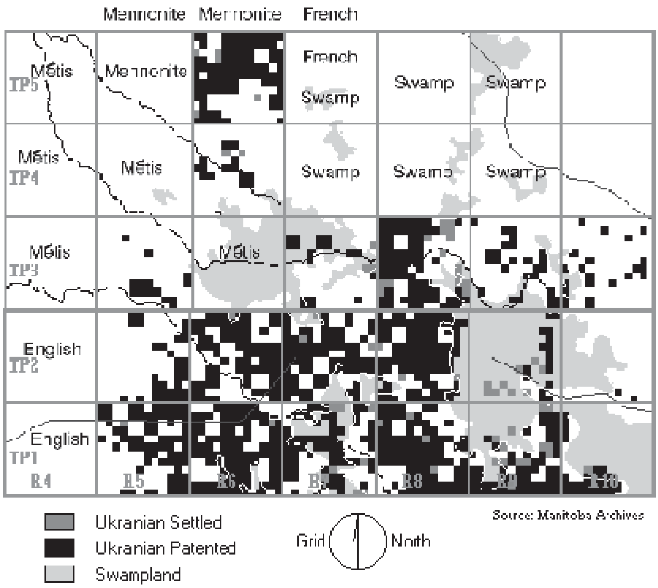

Figure 6: *Ukrainian settlement in southeastern Manitoba prior to 1928.*

> Frank Oliver [the Minister of the Interior] has placed these unfortunate Galicians on these lands and left them to bear as best they could the trials and sufferings incident to the attempted settlement of districts that could only be reached by walking through five or six miles of water. Women have shared with men these sufferings, deliberately imposed upon them by the Minister of the Interior (Winnipeg Telegram 1 April 1911)

The documentary record suggests otherwise and the process of settlement revealed by the maps also suggests that such claims were either politically motivated or were founded on ignorance of the situation in southeastern Manitoba. The lands entered before 1900 almost without exception lay outside of the swampland. In 1904, settlement was pushing the margins of the swamps in Township 1 Range 6 East, but only two settlers had entered for homesteads well within the swamp. It is possible, of course, that some Ukrainian settlers may have squatted in this area before it was officially opened for settlement and so would only appear on the record when they first made an official application for entry on to their prospective homesteads (Lehr 1988). Since only two settlers appear to have made entry for homesteads in this area by the end of 1904, it seems that there was no great pent-up demand by squatters waiting for the area to be opened for settlement. Indeed, there was no significant movement into this territory until 1910 when alternative locations in the same general area were becoming increasingly scarce. At this time settlers had to weigh environmental limitations against the social advantages that would accrue from settling alongside friends and kin. It is significant that the first two settlers to penetrate the swamp in Township 1 Range 6E formed the nucleus of a small group who subsequently settled around them in the swamplands.

Conclusion

When placed in the context of the documentary record and supplemented with other data gleaned from the records of homestead entry, municipal tax rolls and from pioneer reminiscences, map time series can greatly enhance our understanding of the settlement process. While it is possible to produce such a series of maps using conventional manual plotting of data the process would be labourious, time consuming and expensive. More significantly it would be relatively inflexible. Previous attempts to map the spread of Ukrainian settlement over a smaller area than that covered in the present study produced unsatisfactory results. To produce a single map showing the annual spread of settlement, while distinguishing between entries and patents, necessitated the employment of numerous hues in the legend. This created a map which was overly cluttered and as a result did not convey a clear impression of temporal trends.

Perhaps more significantly, when plotting data manually, the researcher is effectively denied the opportunity to see the state of settlement at a particular month within a specified year, or to select out a particular category such as the entries made or the patents granted in a specified month. The flexibility and low cost of producing maps of temporal data using GIS technology promises to establish it as an essential element in modern historical geography.

Acknowledgements

The authors would like to thank the Social Sciences and Humanities Research Council for the funding of the data collection on which this project is based and the University of Winnipeg for their financial support of the data entry process.

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WINNIPEG TELEGRAM, 1 April 1911.

Integrating disparate data sources in an agricultural GIS

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Introduction

The modern agricultural industry is in the midst of a technological revolution. GPS (Global Positioning System) receivers and integrated yield, moisture, and protein monitors will soon be standard options on new machinery. In addition, variable rate seeding and spraying systems are expected to be commonplace within a few years. In anticipation of the demand for geomatics technology and spatial information, enterprising rural entrepreneurs have initiated the growth of a rural-based agro-geomatics industry. These relatively small operations offer a variety of imagery (e.g. CIR aerial photography, B/W digital orthophotography, Landsat TM, and SPOT) distributed by section or quarter section, GPS receivers, and mapping, image analysis, and soil testing services.

The agricultural industry's adoption of technology has traditionally been quite typical in that it is driven by profitability. The relatively rapid incorporation of fertilizers and pesticides, for example, occurred as a result of the significant yield increases and profits that were realized. However, when such an economic advantage can not be demonstrated, due either to real or perceived technological limitations, the adoption rate may be comparatively low.

Technology has to be affordable, profitable, and easy to use. These critical barriers to the adoption of geomatics technology in the agricultural industry have yet to be conquered. GPS equipped yield moisture and protein monitors produce vast quantities of spatial information that are in themselves of little use until properly interpreted and incorporated into a farm management strategy. The integration and effective utilization of these new technologies presents a challenge that the ultimate benefactor, the farmer, is currently ill equipped to accommodate.

Objectives

This paper is the result of ongoing research conducted on behalf of the Manitoba Zero Tillage Research Association (MZTRA) addressing issues related to the development and implementation of an agricultural geographic information system in a rural Manitoba setting. The objective of this research is to develop and evaluate methodologies for integrating and effectively utilizing the variety of data currently available with consideration of those factors believed to impede the adoption of these technologies.

Vegetation indices derived from NOAA AVHRR, Landsat MSS, Landsat TM, and SPOT HRV red and near infrared bands have been used extensively for monitoring the presence and vigor of natural vegetation and cropland (Tucker, 1979; Tucker et al., 1984; Goward et al., 1985; Tucker et al., 1985; Philipson and Teng, 1988; Lloyd, 1990; Teng, 1990; Eidenshink, 1992; Richardson and Everitt, 1992; and Zhu and Evans, 1994). More recently, indices derived from high-resolution video systems have been similarly used (Mausel, 1993).

In most cases, vegetation indices are based on relatively course resolution imagery. For example, Doraiswamy and Cook (1995) attempted to assess spring wheat yield utilizing 1.1-Km AVHRR imagery. Of primary concern were issues associated with mixed pixels and interference with non-wheat areas; both a function of image resolution. However, with the exception of Tucker (1979), few CIR derived vegetation indices have been used for crop assessment or yield prediction. These comparatively high-resolution data may provide information regarding crop health and ultimate yield at a sufficient level of detail and early enough in the growing season to be incorporated into the current years farm management strategy. This paper evaluates and compares the relationship between wheat yield and the Normalized Difference

Vegetation Index (NDVI) derived from Landsat TM and CIR photography.

Study Area and Data Sources

The MZTRA Research Farm is a one-section facility located 18 km north of Brandon, Manitoba. Private corporations, Agriculture Canada, Manitoba Agriculture, Ducks Unlimited, and resident staff conduct research on behalf of association farmers. The farm is equipped with the latest technology, such as differential GPS receivers and yield and moisture monitors. Further, remote sensing data is routinely acquired to support ground experimentation.

Yield data was collected during the 1997 harvest at a rate of one sample per second. A John Deere 6620 combine was equipped with an AgLeader-2000 yield monitor, which had been calibrated to +/- 5%. An Omnistar 4000 Differential GPS receiver, accurate to 1m, provided georeferencing. Geo-referenced points and corresponding yield values were stored on a PCMCIA memory card and later imported as an ASCII text file.

Prairie Agri-Photo Ltd. is contracted by the MZTRA to acquire CIR aerial photography of the research farm each year. In 1997 photography was acquired on July 27th at a height of 7600 ft, using a 70mm aerial camera with an IR filter. This photo was scanned at 600 dpi resulting in a ground resolution of approximately 1-meter.

Landsat TM imagery acquired August 8th 1997 was provided by Agriculture Canada. The image was geo-referenced and NDVI values calculated prior to receipt of the data. The image was then subset to an area slightly larger than that of the research farm.

Methodology

Image Rectification and Preprocessing

In order to integrate these disparate data each had to be geo-referenced to a common projection. In addition, the scanned CIR photo had to be rectified to correct for distortion inherent to aerial photography. Ground control points were collected by mounting a

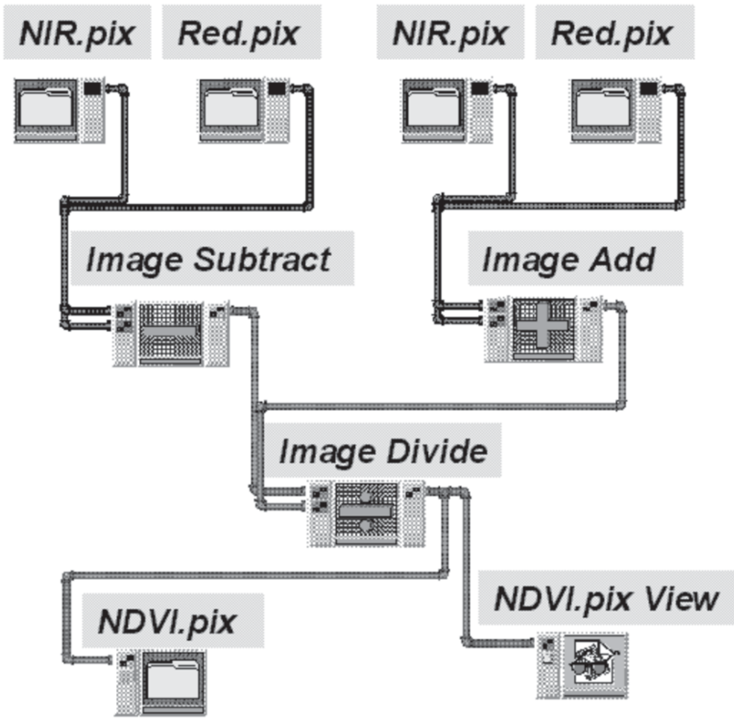

Figure 1: *Derivation of NDVI in PCI Visual Modeler.*

differentially corrected GPS receiver on an ATV and visiting a number of sites across the study area that were visible on the scanned photograph. These control points were then used to rectify the scanned photo using the PCI Image Works GCP-works function.

The Landsat TM and yield data were also imported into PCI ImageWorks. The spatial accuracy of the Landsat image was checked against the control points and as a result the entire image was shifted 7 meters to the east. The yield data was inspected for anomalous points (i.e. points not differentially corrected due to signal noise) which were edited from the file.

Calculation of the NDVI from CIR Photography

The NDVI is a simple ratio of reflected near infrared and red light that compensates for variations in illumination, surface slope,

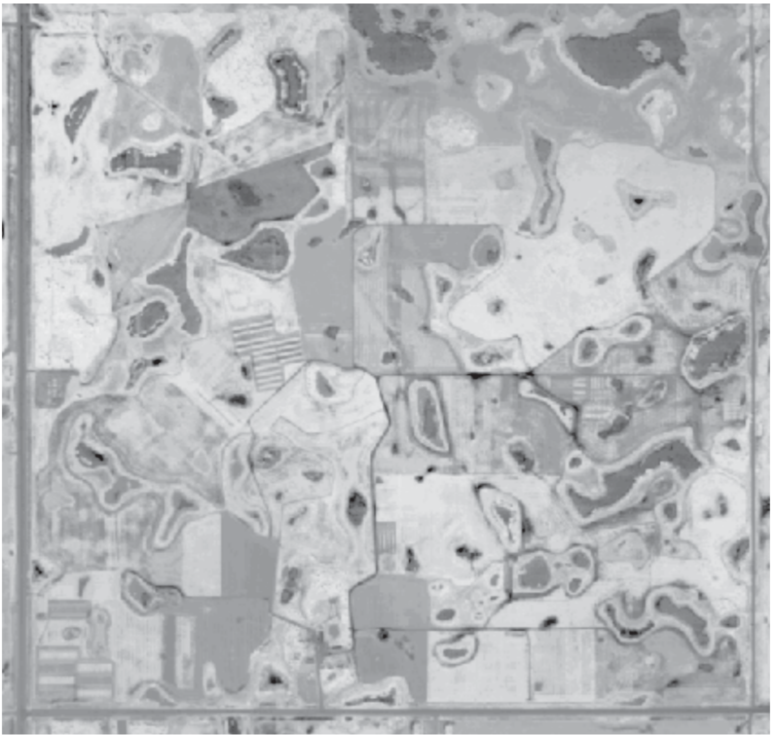

Figure 2: *NDVI image derived from scanned CIR photo.*

and viewing aspect. Values range from –1 to 1, with vegetation ranging from 0.1 to 0.6. Higher values are associated with lush, healthy vegetation; non-vegetated surfaces such as soil, rock, or water typically have negative NDVI values (Avery and Berlin, 1992).

NDVI = NIR-Red/NIR+Red

The scanned CIR photo was split into 3 bands; near infrared, red, and green. The infrared and red bands were saved as separate georeferenced files and the green band was discarded. The PCI Image Works Visual Modeler was used to create a short program (Figure 1) that executed the NDVI equation, creating a new, georeferenced NDVI raster image (Figure 2).

Comparison of Landsat TM and CIR NDVI Values

The Landsat and CIR derived NDVI images were then displayed in linked viewers so that visual comparisons of NDVI values could be made. In addition, two cross sections were created to evaluate difference and similarities between the Landsat TM and CIR NDVI values over different cover types and over the same cover type. The first cross section was approximately 1500 meters in length and covered a variety of features such as water, roads and several crops. The second was a diagonal profile approximately 250 meters in length across a single wheat field.

Visual analysis of these profiles suggested that the Landsat TM NDVI values were significantly influenced by feature boundaries resulting in mixed pixels along the edge of features that were not truly representative of either feature type. Since it was believed a comparison of Landsat TM and CIR derived NDVI values, which included these mixed pixels, would introduce significant error into the resulting correlation, a random sample of 50 "pure" Landsat TM and corresponding CIR NDVI values was selected. The Pearson product moment correlation was performed on these data to evaluate the strength of the correlation between Landsat TM and CIR NDVI values.

Comparison of CIR NDVI and Wheat Yield

An attempt was made to transform the yield data to raster format by interpolating a grid surface based on the original point coverage. However, the resulting raster image possessed a distinct linear orientation due to the irregular distance between successive sampling points as compared to adjacent combine swaths. In addition, in a few instances excessively high yield values occurred where the swath had rolled in front of the combine. Several spatial filters were applied in an attempt to smooth the data but ultimately this approach was abandoned.

Alternatively, a random sample of 100 yield points was selected from the wheat field and the corresponding CIR NDVI values were recorded. A simple linear regression analysis was performed to determine the correlation between these variables and how well

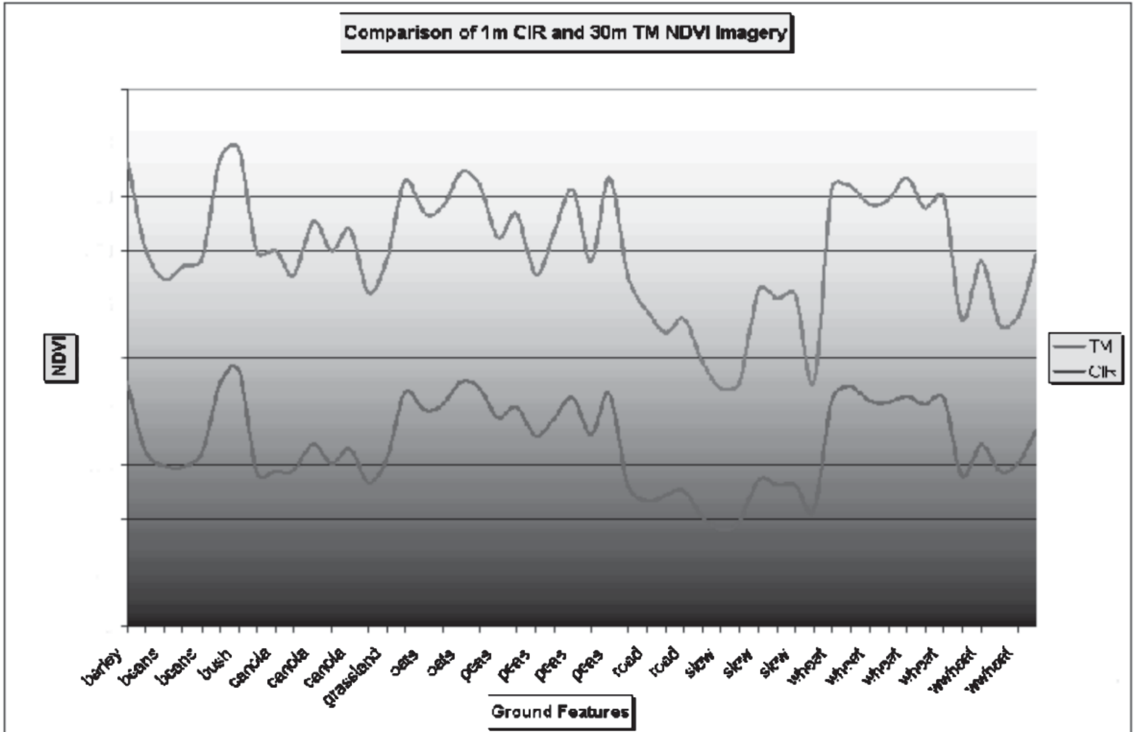

Figure 3: *Comparison of Landsat TM and CIR NDVI values by ground feature.*

mid-season CIR NDVI values are able to predict ultimate wheat yield.

Results

Figure 3 illustrates the strong relationship between Landsat TM and CIR NDVI values over a variety of landcover types. The Pearson product moment correlation coefficient over all landcover types was 0.68; however, when canola was removed from the sample the correlation increased to 0.95. It is believed that this variation was due a change in the spectral characteristics of canola between the acquisition date of the CIR photograph (July 27) and Landsat TM imagery (August 8). The strong relationship between these variables when mixed TM pixels are eliminated from the sample suggests that Landsat TM and CIR derived NDVI data are comparable even though the resolution of these data are significantly different

Figure 4 depicts the results of regression analysis. The correlation between mid-season NDVI and wheat yield was 0.79 and the coefficient of determination 063. This suggests that in our study area 63% of the variability in wheat yield can be predicted by mid season CIR derived NDVI values.

Conclusions

Given the significant correlation between Landsat TM and CIR derived NDVI values it seems reasonable to suggest that comparatively high resolution CIR photography may provide an affordable alternative to Landsat TM imagery for use in an agricultural GIS. The resolution of CIR photography reduces errors associated with mixed pixels and provides the level of detail required for analysis of this scale.

Regression analysis suggests that in this case there seems to be a significant relationship between mid-season CIR NDVI values and wheat yield, and while 63% of the variation in yield can be predicted by the NDVI, a large proportion of the variability is unaccounted for. Nonetheless, it would appear that it may be

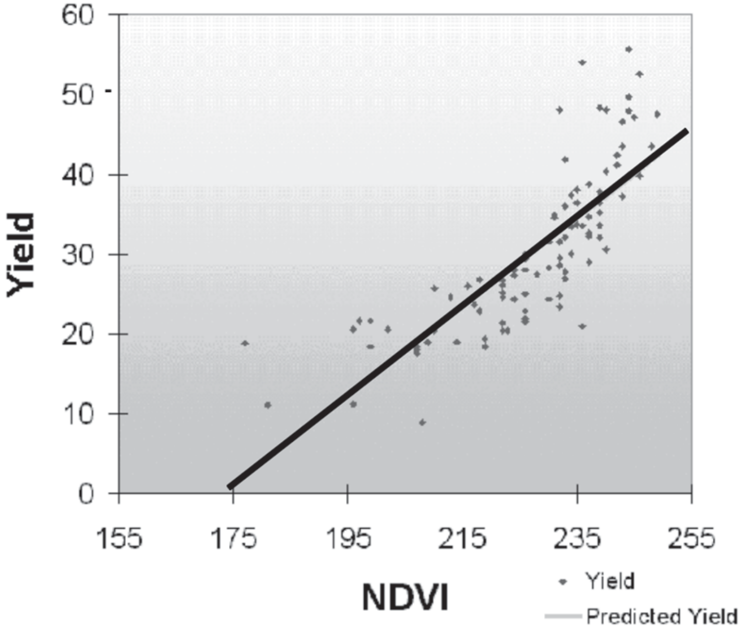

Figure 4: *Results of regression analysis.*

possible to predict wheat yield utilizing readily available and relative inexpensive data early enough in the season to allow this information to be integrated into that years farm management strategy.

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The Drought Severity Index and the recollection of drought by agriculturalists in the Palliser Triangle, southwestern Manitoba

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Abstract: Agricultural drought occurs when soil moisture levels fall below normal and crops experience moisture deficiency stress. This results in reduced crop yields for grain farmers and reduced hay production and poor pasture land conditions for cattle ranchers. Nine significant drought periods occurred within the Palliser Triangle area of south-western Manitoba between 1955 and 1988. These droughts were identified using the Palmer Drought Severity Index and characterised using Thornthwaite's Climatological Water Balance. The drought periods are ranked according to the lowest Palmer Drought Severity Index values and the total moisture deficit experienced during each drought. The particularly severe droughts in 1961, 1980 and 1984 had a considerable impact on rural household incomes within the study region. Generally the recollection of drought periods by the respondents to a questionnaire survey coincides with the drought ranking based on physical evidence. The well remembered severe droughts of 1961 and 1980 are ranked numbers three and one respectively. The low ranked 1988 drought however, was well remembered also, as it was the most recent drought event.

Introduction

Agricultural drought occurs when soil moisture levels fall below normal and crops experience moisture deficiency stress (Environment Canada 1989). This results in reduced crop yields for grain farmers and reduced hay production and poor pasture land conditions for cattle ranchers.

South-western Manitoba has experienced drought conditions on several occasions since 1950. The particularly severe droughts in 1961, 1980, and 1984 had a significant impact on the agriculture and rural household incomes within the region. Consequently, agriculturalists in this region can be expected to have considerable experience and related knowledge of drought and drought conditions in south-western Manitoba.

Objectives

This study intends to identify the drought periods that have occurred in south-western Manitoba over the past 30 years and to rank these droughts with respect to a duration-severity index. The study also will attempt to determine the ability of agriculturalists within the region to recall significant drought periods.

Study Area

The study area for this research covers 2238 km^2 and consists of Edward, Arthur, and Brenda municipalities in the extreme southwest corner of Manitoba (Figure 1). All the municipalities border on the United States and the municipality of Edward borders on the province of Saskatchewan.

Within the study area, Pierson has an Atmospheric Environment Services (A.E.S.) climatological data station and relevant calculations used in this paper are based on data collected at this site.

The three municipalities were selected as the study area because they are located on the eastern edge of the Palliser Triangle. The Palliser Triangle has been set aside by the Geological Survey of Canada as one of three special research regions for the study of global climatic change. The climatic record at Pierson, Manitoba shows evidence of several severe drought periods and provides 47 years of continuous climatic data for analysis. The Palliser Triangle is also an area in south-western Manitoba of marginal agriculture, containing both farming and ranching, thus making it ideal for studying the perception and recollection of agricultural drought.

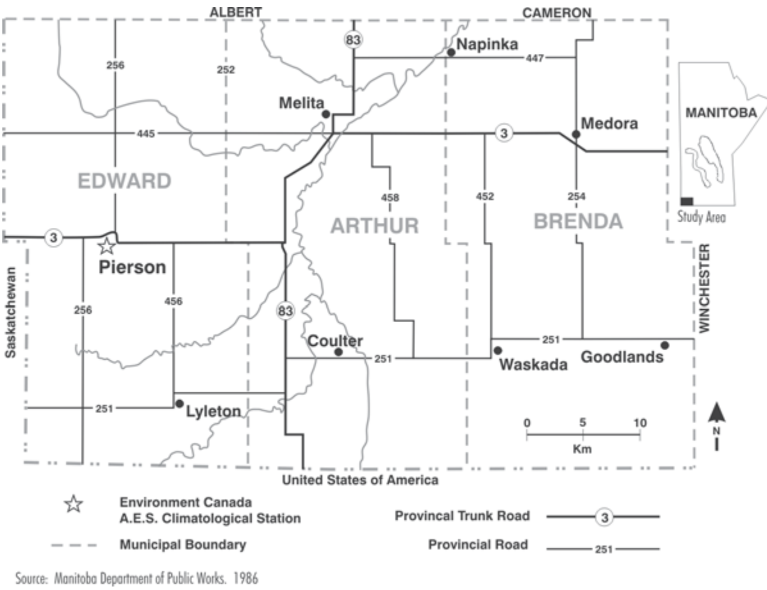

Figure 1: *Location of study area.*

Theoretical Considerations

The Palmer Drought Severity Index

W. Palmer (1965) based his study of drought on the relationships among actual water balance supply and demand parameters and their respective values that are 'climatically appropriate for existing conditions.' Precipitation (P) and plant available moisture held in the soil represent the supply variables, while evapotranspiration (ET) is considered to be the demand generated by the system. A hydrological accounting procedure, similar to Thornthwaite's Climatological Water Balance, was used to plot the distribution of water inputs, outputs, and soil storage amounts over time.

Palmer employs Thornthwaite's (1948) formula for calculating monthly potential evapotranspiration (PE):

$$\textit{Daily PE} = ADJ * 1.6\,(10\,T/I)^{A}$$

Unlike Thornthwaite's model however, Palmer's water balance parameters also include estimates of the potential for soil moisture loss (L), recharge (R), and runoff (RO).

Palmer's term "climatically appropriate for existing conditions (CAFEC)," is defined as the product of the ratio of the average of each water balance variable to the respective normal potential value, and the actual potential value. That is:

CAFEC ET = [Normal ET / Normal PE] x Actual PE

Climatically appropriate for existing conditions precipitation (CAFEC P) represents "the amount of precipitation that would have maintained the water resources of the area at a level appropriate for the established economic activity of the area" (Palmer 1965) and is calculated as a residual in water balance equation:

CAFEC P = CAFEC ET + CAFEC R + CAFEC RO - CAFEC L

Palmer argues that the differences between actual precipitation values and the CAFEC precipitation estimates ($D = P_i$ - CAFEC P_i) for each month (i) provide meaningful measures of the moisture departures from normal. Palmer's monthly moisture anomaly index (Z) is the product of the monthly moisture departure from normal (D) and the climatic characteristic (K). The Palmer Drought Severity Index is based on this monthly moisture anomaly index. That is:

PDSI for the month (i) equals $0.897\, PDSI_i - 1.0 + K_i D_i / 3$

The climatic characteristic (K) is derived from the average moisture departures during the driest spell of the particular period of interest. Thus, the K value is a weighting factor, representing averages for some undefined characteristics of the climate during dry periods (Palmer 1965). The average K value for southern Manitoba is 2.05.

Palmer developed a five point ordinal/nominal scale for describing the various stages of drought severity (Table 1). These values define the lower limit of each class boundary (Palmer 1965).

Table 1: *Stages of Drought Severity*

-0.5 =	incipient drought
-1.0 =	mild drought
-2.0 =	moderate drought
-3.0 =	severe drought
-4.0 =	extreme drought

Source: Palmer 1965

The Survey Instrument

The data required for studying farmers' recollection of drought were obtained through a questionnaire survey. The questionnaire addressed several aspects of farmers' perception and adjustment to the drought hazard and dealt with various dimensions of the rural inhabitants in south-western Manitoba. A specific section of the survey (four) focused on the recollection of drought periods and severity through 1955 - 1989.

Of the 485 rural inhabitants within the study area, 394 were farmers. A sample size of 164 potential respondents was determined using the Multi Stage Probability Sampling Procedure outlined by Dixon and Leach (1978). In total, 78 questionnaires were returned with four of them being returned incomplete. The final response rate was 45.1% (i.e. 74 out of a total of 164).

Results

The Droughts

Palmer Drought Severity Index (PDSI) values acquired from Environment Canada were used to determine the date and duration of the droughts, which occurred in the study area since 1955. Over the 33 year time frame, the monthly PDSI value indicates that the study area experienced nine significant droughts (Figure 2). PDSI

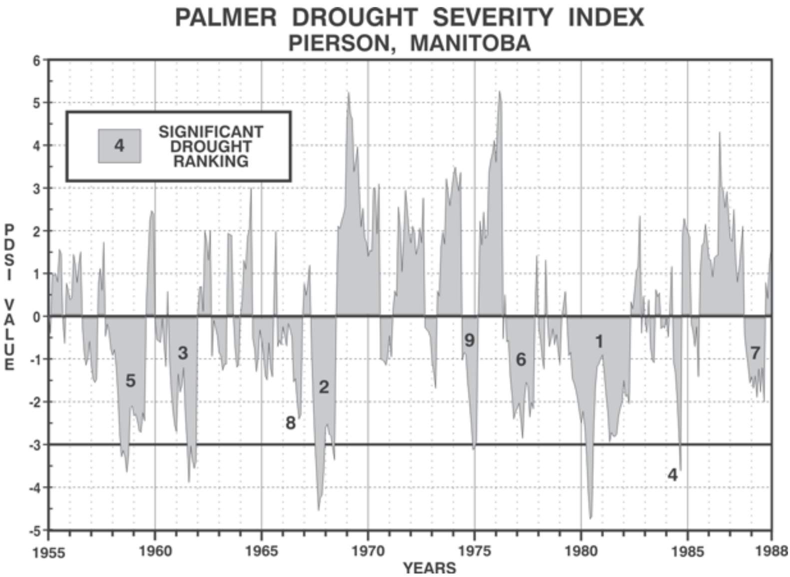

Figure 2: *Palmer drought severity index for Pierson, Manitoba.*

values of -2.0 (moderate drought) or less were considered significant in this study.

The first drought period began in September of 1957 and lasted until August 1959 for a duration of 23 months, and is here termed the 1958 Drought (Figure 2). There appears to have been sufficient moisture for crop growth during the four month antecedent period (May, June, July, and August of 1957) as PDSI values were greater than zero. Thus, the 1958 Drought began at the end of the 1957 growing season. During a period of one year, drought-like conditions continued to deteriorate to a minimum index value of -3.65 (Table 1), the most severe value recorded during the drought. This drought is classified as a "severe drought" on the Palmer scale (Palmer 1965). The summer of 1958 was especially dry with PDSI values of -2.77, -3.29, -3.14, and -3.29 being experienced during May, June, July, and August respectively. There was a four month period of moderate relief following September 1958 and by December of that year, the PDSI value had risen to -2.10. PDSI values began however, to decrease once again and by May 1959, had declined to -2.71, the recorded second minima in the 1958

Drought period (Table 1). By April 1959, drought conditions gradually ameliorated and the August PDSI achieved a positive value of 0.31, indicating the end to this 23 month drought period.

The 1961 Drought began in September 1960 and lasted until January 1962, for a duration of 16 months (Figure 2). PDSI values dropped sharply in the first few months of the drought to -2.71, which marked the first of three minima recorded during the drought duration (Table 1). The following five months recorded fluctuating PDSI values throughout a period of moderate drought relief. June 1961 marked the beginning of a second sharp decline in the PDSI to -3.88 by August 1961, a value that represented the most severe month during the 1961 Drought period (Table 1). Following this minimum there was a second very short (one month) period of drought relief, indicated by an increase in the PDSI value to -1.21. After this relief period, PDSI values declined to -3.56, the third minima of the drought (Table 1). Both periods of drought relief occurred during the non-growing seasons of 1960 and 1961. A PDSI value of -1.21 (May) was recorded at the beginning of the 1961 growing season and this PDSI value had decreased to -3.88 by August 1961. The 1961 Drought ended as suddenly as it started as evidenced by PDSI values of -3.38 in December 1961, followed by 0.14 in January 1962 (Figure 2).

There was a three year, ten month period between significant droughts during the early 1960s with the third drought beginning in October 1965. The conditions prior to the beginning of this drought are similar to those prior to the beginning of the 1961 Drought. There was a one year period were the PDSI values were less than 0 but greater than –2, signifying incipient and mild drought. This period was separated from the significant drought period by two months of relatively moist conditions (Figure 2).

Unlike the 1961 Drought, the 1966 Drought did not begin with a sudden decrease in PDSI values. The PDSI values fluctuated within the incipient drought stage for nine months before the conditions became moderate and only then did PDSI values slowly decrease from -0.31 to -1.46 over the growing season (Figure 2). It was not until September 1966 that the drought, having reached a PDSI value of -2.02 was recognised as a moderate drought. Four months later, the drought ended. October 1966 recorded the lowest PDSI value of -2.40 (Table 1). The 1966 Drought ended suddenly in January 1967, two months after the most severe minima. The 1966 Drought lasted a total of 15 months with twelve of these months experiencing PDSI values above -2.0. In terms of PDSI values and duration, this drought, ranked eighth (Table 1), was the second least severe of the nine droughts experienced within the study area over the 33 year period (Table 1).

A four month period, in which PDSI values were greater than zero, marked the end of the 1966 Drought. This four month period of moist conditions represents the antecedent moisture conditions for the 1967 Drought.

The 1967 Drought began in May 1967 when PDSI values were -0.73. By the end of the growing season (September) values had dropped to -4.54 (Figure 2). PDSI values remained below -4.0 for three months before a period of moderate relief began. According to the Palmer classification, the 1967 Drought was considered "extreme". In fact, the -4.54 value was the third lowest monthly index value recorded in the study area over the 33 year period of record (Table 1).

There was some alleviation in February 1968 when PDSI values of -2.53 were recorded (moderate drought). Conditions experienced during this period of minor relief however, were more severe than the drought conditions experienced during the entire 1966 Drought. PDSI values began to decline again to a minimum of -3.36 in June 1968, the last month of the drought. The 1967 Drought ended when June PDSI values of -3.36 rose sharply to 0.02 by July 1967.

The 1974 Drought (Figure 2) did not begin until five years and eleven months after the 1967 Drought ended. Of these 71 months, only 14 had PDSI values less than zero indicating that the moisture conditions during this period were well above normal.

The 1974 drought began in June 1974 and lasted for only nine months until March 1975. June 1974 recorded a PDSI value of -1.03 and from this mark the index increased to -0.85 and -0.89 for July and August respectively (Figure 2). It was not until after the growing season that PDSI values began to fall reaching the minima during the drought of -3.12 in December 1974 and -3.09 in January 1975 (Table 1). These index values indicate that the drought was classified as "severe" according to Palmer (1965). This drought however, generally began after the growing season of 1974 and ended before the growing season of 1975 thus, the 1974 Drought may also be classified as a winter drought. Since winter drought is considered to be less significant to the agriculturalists of the region, the 1974 Drought is ranked ninth in the Drought Severity Table (1). February 1975 was the final month of the drought recording PDSI values at -2.92, while the index value in March was a positive 0.06.

The sixth significant drought experienced in the study area over the 33 year period lasted for 16 months; from July 1976 to November 1977 (Table 1). The 1977 Drought (Figure 2) began after a period of moist conditions experienced in late 1975 and early 1976. May 1977 recorded a negative PDSI value but in June 1977 the PDSI value was again positive, delaying the start of the drought until July 1976.

PDSI values dropped over the first nine months of the drought and by April 1977 the drought severity index value was -2.86. There was a small period of relief during the winter of 1976-77 when index values rose up to -2.03 before decreasing to the lowest minima of -2.86 (Table 1). A second and larger period of relief occurred during the first half of the growing season when PDSI values of -1.55 were recorded in June 1977. The index values then began to decrease over the second half of the growing season to a minimum -2.36 in August 1977 (Table 1). The drought ended quite suddenly when the October PDSI value of -2.16 rose to 0.18 in November 1977.

The drought of 1980 (Figure 2) was the longest, and most severe drought experienced in the region over the 33 year period (Table 1). The drought began 18 months after the end of the 1977 Drought. During this 18 month duration, 13 months experienced PDSI values of less than zero. This indicates that the antecedent period for this drought was relatively dry with only short periods of precipitation.

Conditions slowly deteriorated over the first 13 months of the drought, achieving the lowest PDSI value of -4.74 in June 1980, which, according to Palmer, classifies the 1980 Drought as an "extreme" drought (Table 1). This value was also the lowest index value experienced over the study area during the 33 year record (Table 1). A six month period of moderate drought relief began immediately following this low point. This relief period occurred over the winter months of 1980-81 and PDSI values of greater than -1.0 were experienced in December 1980 and January 1981.

The 1980 Drought continued into 1981 recording PDSI values of -2.94 in May with the index values remaining below -2.70 for the remainder of the growing season. Another four month period of relief began in September 1981 and lasted until January 1982 (PDSI value of -1.51). The 1980 Drought ended in May of 1982 after 36 consecutive months of PDSI values less than zero.

There was only a two year period following the drought of 1980 until the next drought occurred in 1984. The 1984 Drought (Figure 2) lasted for five months making it the shortest drought to occur within the study region over the 33 year period (Table 1).

After a period of fluctuating moisture conditions following the 1980 Drought, the 1984 Drought began in May when the PDSI value reached -1.07. The PDSI values continued to decline rather sharply over the next five months to a value of -3.61 in September (Table 1). This classifies the drought of 1984 as “severe” on the Palmer scale. The 1984 Drought was a serious drought to the local farmers in that it was a summer drought occurring over the length of the growing season. The 1984 Drought ended quickly, with the minimum PDSI value of -3.61 occurring in September and an index value of 1.90 occurring in October.

The period between the 1984 and 1988 drought was a time where sufficient moisture was available for plant use leading to adequate crop yields for the farmers. The drought of 1988 (Figure 2) began in September 1987 following this long period of moist ground conditions and adequate precipitation.

The 1988 Drought differs from that of the 1984 Drought in that the drought conditions fluctuated monthly over the duration of the drought progressing to the lowest value rather than the sharp drop from the beginning of the drought which occurred in 1984 (Figure 2). In fact, it was not until August 1988, the final month of the drought, that the PDSI values actually achieved -2.0, a “moderate” drought on the Palmer (1965) scale. September 1988 recorded a PDSI value of 0.78 indicating the end of this 12 month drought.

Table 2: *Recent droughts in the Palliser Triangle, south-western Manitoba.*

DROUGHT I.D. YEAR	DROUGHT BEGINS	DROUGHT ENDS	DURATION (Months)	NUMBER of MINIMA	MINIMA INDEX VALUES	SUBJECTIVE RANKING
1958	09/1957	08/1958	23	2	-3.29 -3.65	5
1961	09/1960	01/1962	16	3	-2.71 -3.88 -3.56	3
1966	10/1965	01/1967	15	1	-2.40	8
1967	05/1967	06/1968	13	2	-4.54 -3.36	2
1974	06/1974	03/1975	9	1	-3.12	9
1977	07/1976	11/1977	16	2	-2.86 -2.36	6
1980	05/1979	05/1982	36	2	-4.74 -2.94	1
1984	05/1984	10/1984	5	1	-3.61	4
1988	08/1987	08/1988	12	1	-2.00	7

Ranking The Droughts

Table 2 illustrates the ranking of the droughts based on the minimum PDSI value during the growing season and the duration of the drought. Two droughts are classified as extreme, four droughts are considered severe and the remaining three droughts fall into Palmer's (1965) 'moderate drought' classification.

The 1980 drought was the longest and most severe drought recorded during the 33 year time frame and is ranked number 1. The thirteen month 1967 drought receives the second ranking based on the second lowest PDSI minima of -4.54. The severe drought of 1961, although slightly longer in duration, received the third ranking based on the third lowest PDSI value of -3.88. The relatively short (5 month) and severe (minimum PDSI = -3.61) 1984 drought received a higher ranking (4) than the 23 month 1958 drought due to the fact that the 1984 drought persisted through the five month growing season from May until September. The fifth ranked 1958 drought recorded only a slightly lower monthly index value of -3.65. The 1974 drought occurred during the winter “hibernal” season and although classified as “severe” received the ninth and lowest ranking.

The 1966, 1977, and 1988 droughts all registered minimum PDSI values less than -2.00 but greater than -3.00. The 1977 drought is ranked sixth based on a minimum monthly PDSI value of -2.86. The shorter (12 month) 1988 drought was ranked ahead of the 15 month duration 1966 drought on the basis that the 1966 minimum occurred during September and October, where as the 1988 drought achieved its minimum index value at the end of July.

Recollection of Droughts by Agriculturalists

The Palmer Drought Severity Index permits the drought researcher to precisely establish the beginning, duration and conclusion of a drought; farmers however, do not clearly delimit droughts (Taylor, Stewart and Downton 1988). For this reason the droughts identified in this study have been assigned the year designation associated with the lowest Palmer Drought Severity Index value.

Saarinen (1966) identified a characteristic pattern for drought recognition by the farmers on the Great Plains. Most farmers (more than 50 percent) remembered the most recent drought, regardless of severity, the most severe drought experienced, and the drought of primacy or first drought experienced. Taylor, Stewart and Downton (1988), substantiate Saarinen’s 1966 postulate. Taylor *et al.* (1988) point out however, that while many farmers remembered the most recent drought, unlike in the Saarinen study, this number was less than 50 percent of the respondents.

In this study the average age of respondents to the survey questionnaire was 46.3 years with 97.2% of them living within the study area for more than 20 years. The ethnic make up of the respondents is as follows: 68.6% British, 22.5% Belgian, 5.8% Scandinavian, and 1.9% French. Among the respondents, 64.8% have attained a secondary education while 35.1% have a post-secondary education. The majority of the farmers (62.1%) run mixed farming operations, 31.0% operate grain farms, and only 6.7% are employed in a cattle operation. The average farm size is

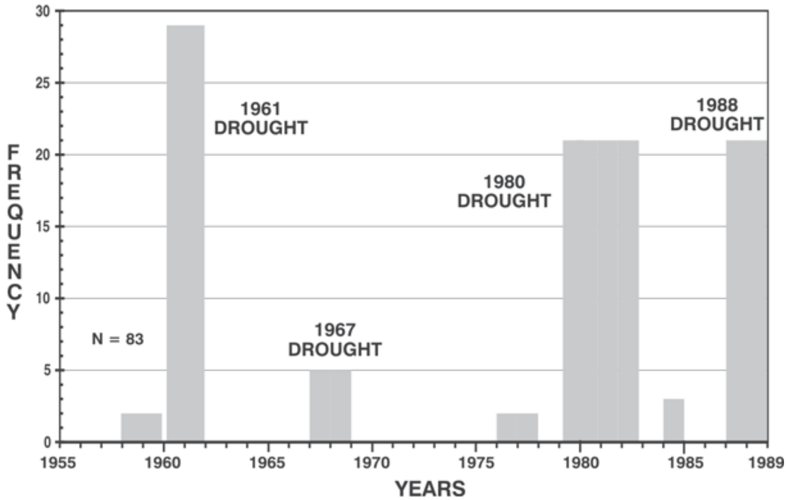

Figure 3: *Drought recollection by experienced agriculturalists.*

1402.5 acres with the majority of the respondents operating farms between 501 - 1500 acres.

The population of respondents to the questionnaire survey was divided into two groups. "Experienced" agriculturalists are operationally defined as farmers born or farming in the area before 1951. These farmers would be at least ten years old in 1961, would have experienced the severe drought of 1960 -1961 and could be expected to remember this severe drought. The "inexperienced" agriculturalists are operationally defined as farmers born or farming in the area after 1951 and are unlikely to remember the severe drought of 1960 - 1961.

The severe drought of 1960 -1961 was remembered by thirty respondents or 40.5 percent of the farmers responding to the questionnaire. Twenty-nine of these farmers are classified as "experienced" and only one farmer born after 1951 was able to recall this drought.

Figure 3 illustrates drought recollection by "experienced" farmers. Fifty-six percent (29 respondents) of the experienced farmers recalled the severe drought of 1961. For most of these older agriculturalists, the 1961 drought was the drought of primacy (Saarinen 1966). The 1980 Drought was well remembered by this

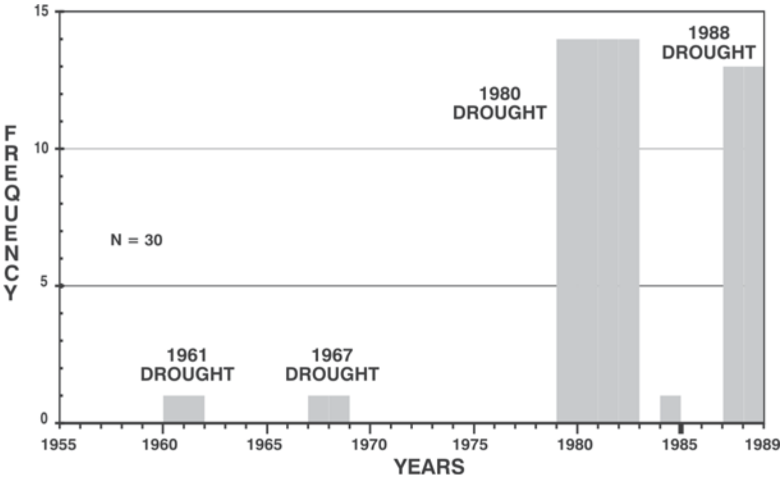

Figure 4: *Drought recollection agriculturalists born after 1951.*

group of agriculturalists because it was both the longest in duration and most extreme drought that occurred within the study area over the 33 year period (Figure 2, Table 1). Although the 1988 Drought was neither long, nor severe, the "experienced" farmers remembered this drought probably because it was the most recent drought event (Figure 2).

There are some anomalies present in the histogram (Figure 3). The 1967 Drought was more severe over the growing season than the 1961 Drought, yet only five respondents recognised this as being a drought year. Another example involves the short but very severe 1984 drought, which was recognised as a drought year by only three of the "experienced" agriculturalists.

Figure 4 illustrates drought recollection by the agriculturalists born after 1951. Clearly the 1980 drought is well remembered by the "inexperienced" farmers. Perhaps this was the drought of primacy, but this drought also was the drought of greatest duration and severity. The 1988 drought (most recent drought) was equally well remembered.

Figure 5 combines the two sub-populations of agriculturalists, farming or ranching, in the study area. Again, drought recollection in the Palliser Triangle region of south-western Manitoba may be

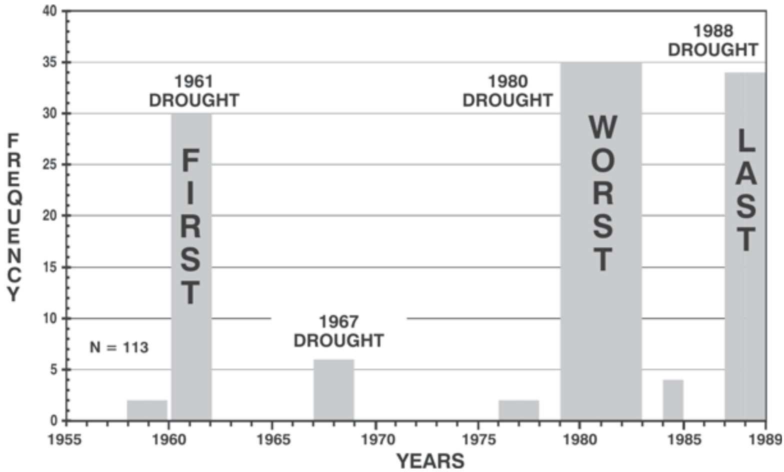

Figure 5: *Drought recollection by agriculturalists farming in southwestern Manitoba.*

patterned as a recollection of the first, worst and most recent droughts.

Conclusions

Nine significant drought periods occurred within the study area between 1955 and 1988 (Figure 2). These droughts where identified using the Drought Severity Index (Palmer, 1965) and ranked subjectively according to duration and the lowest monthly PDSI value experienced during each drought (Table 1).

Generally, the recollection of drought periods by the respondents to the questionnaire survey coincides with this ranking. For example, the well remembered droughts of 1961 and 1980 are ranked numbers three and one respectively.

Fifty-six percent of the older, more experienced, respondents remembered the 1961 drought probably because it was the first severe drought many of these farmers experienced. The 1980 drought was well remembered because it was both the longest and most extreme drought that occurred within the study area over the 33 year period. The 1980 drought was also the first severe drought experienced by 47 percent of the respondents farming after 1970.

The fifth and second ranked droughts (1958 and 1967 respectively) were probably less well remembered because they both occurred too long ago, and because neither was likely to be the first drought most respondents experienced while farming within the study area. Also, the severe 1984 drought was less well remembered because it was preceded by the extreme drought of 1980 and followed by a more recent drought in 1988. The low ranked 1988 Drought (number seven), although neither long, nor severe, is well remembered (46%) by the respondents because it was the most recent drought event. These results are similar to those of Taylor *et al*. (1988). The respondents to the questionnaire survey generally knew when the droughts occurred but had little understanding of the varying degrees of drought severity.

In conclusion, it is suggested that drought recollection, by experienced agriculturalists, is based on the principle of “First, Worst and Last” (Figure 5).

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The changing geography of the terminal elevator: a preliminary analysis

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Abstract: Prairie wheat cultivation has had a significant landscape impact outside the region, reflecting its location within Canada. This is particularly noticeable where terminal elevators have been constructed to ensure the efficient overseas export of grain. The construction of 'Western' terminals had its earliest impact upon the Thunder Bay cities of Port Arthur and Fort William. Later, however, Vancouver and Prince Rupert also became characterised by grain exporting. This paper details the rise of grain terminals in these centres, discusses the variable patterns of ownership of the structures, and explains the changes in the 'balance of terminal power' over the years.

Introduction and Background

The contemporary international wheat economy makes up one part of what Immanuel Wallerstein has called the modern world system, which model provides a framework that describes and accounts for the extensive development of capitalist agriculture[1]. Although it is meaningful to study the world as a system, it is also important to look at the constituent parts of the structure. For as Taylor has pointed out, "in order to properly understand the world economy we must know the places that constitute its whole",[2] and to understand these 'places' we must see their development over time and through space — for they are formed not by relative isolation and occasional diffusion, but by a constantly changing relationship with the rest of the world.

The Canadian grain trade contains many 'places' that need to be understood, ranging from the farmers' fields to the country elevator, to the city of Winnipeg, but one component of the system that deserves a new look is the part that physically connects Canada with the rest of the world - the terminal elevator system.[3]

The moving of the western grain crop "to the terminals" has been described as a "stupendous task" that "has no parallel in any part of the world".[4] It involves the use of a complex transportation system for a relatively limited portion of the year - the grain moving season. For the balance of the year many of the constituent parts of this system may be virtually idle. The bumper crop of 1928 illustrates the magnitude of this problem quite well: between 1st August 1928 and 4th January 1929, receipts at The Lakehead were 306,545,807 bushels, at Vancouver were 40,748,845, and at Prince Rupert were 2,154,592. The total movement involved a handling of 286,023 car loads of grain by the railways — and, of course, by the terminal elevators.

During the peak (September to December) movement time, 111,475 loads were moved east from Winnipeg by the CPR, at a 77 working day rate of 1,447 cars per day. (Made up into 24 trains with an average of 60 cars, with the record day [September 30th] moving 35 'average trains' - one every 41 minutes).[5] The magnitude of this task becomes more apparent when we remember that Winnipeg lies on the eastern edge of the grain belt, and is some 430 miles from the grain terminals of Lake Superior.

The development over time and over space of 'the terminals', on Lake Superior and of those on the West Coast, is the major topic of this paper. In both areas these exporting structures are a long distance from the lands upon which the grain is produced, as well as being far from the European markets upon which Canada depended at this time,[6] and these facts are critical to their character and their development. The years up to the early 1930s will be concentrated upon, as the major facilities were then in place, the major 'happenings' had 'happened', and the major trends were becoming clear—and the Depression had not arrived to make an analysis even more complex than it already is!

The Eastern Route

The Early Days

As with many facets of the grain trade, Great Lake transportation began with the USA, with a small cargo reaching Buffalo (a major lake-port, and where the first terminal elevator was built in 1841) from Grand Haven on Lake Michigan in 1836, and the first wheat being shipped from a Lake Superior port to the lower lakes in 1870.[7] The first Prairie wheat 'export' also found an outlet through the US (by rail, south from Winnipeg, and then east to Duluth from where it was lake-freighted to Ontario to be used as seed).[8] The first grain cargo from Western Canada to take an all-Canadian route was carried from the Head of the Lakes in the fall of 1883, following the completion of the CPR line. It was shipped by James Richardson and Sons — a company to loom large in the Prairie grain trade—in the steam barge 'Erin'. It was loaded partly in bags, because no facilities existed at that time for bulk grain handling.

Between 1883, when the CPR first connected Thunder Bay with Manitoba by rail, and 1920, Port Arthur and Fort William handled practically all of the grain exported from the West.[9] Winnipeg, however, managed with great effort to maintain its position at the centre of the grain trade, as the principal city of the Canadian West, and "the converging point of a great wheat funnel, the spout of which [led] to the water-front of Lake Superior".[10] Fort William, at the mouth of the Kaministiquia River dates back to La Verendrye, although its name only harks back to 1800 and the Northwest Company.[11] Port Arthur's Landing (as the town was first known), lies directly to the east of Fort William. It took its title from the Duke of Connaught whose men landed there on their journey westward to help repress the 1870 "rebellion" in Manitoba (Figure One).

The Early Terminals

The first western terminal elevator was completed in Port Arthur (which had deeper water) in 1884 (standing until 1923 when it was replaced), and the first shipment of wheat by an all-British route from Brandon to Glasgow soon followed; the second terminal was completed in Fort William during the winter of 1885. Two large warehouses were also completed around this time, one at each location. Significantly, the CPR owned all of these structures, in contrast to country elevators and warehouses that were rapidly being constructed on the Prairies at this time, by other private companies. Although it avoided investing precious capital in the smaller structures,[12] it was to the obvious advantage of the CPR to make sure that the grain could get to market in the cheapest, easiest, and fastest way. This meant the construction of terminals.

Although early records are incomplete, it is likely that the cost of these structures, as well as the demand they generated for new marketing skills, initially precluded the entry of smaller operators into this end of the grain trade. In 1884 the two CPR terminal elevators could store 520,000 bushels; the average country structure held around 34,000 bushels, but most operators originally opted for ‘flat warehouses’ that were even cheaper to construct, and averaged some 15,000 bushels in size. In addition, this section of the grain handling system was completely located in Manitoba, which was much more accessible in every way to the small businesspersons who were dominant in the early grain trade.[13]

Although Port Arthur and Fort William are side by side, and for decades have functioned as essentially one harbour development, with diversified types of improvement over an extensive area of river channels and lake frontage protected by breakwaters, their origins and early evolution show variations. Port Arthur had deeper water than Fort William, and grain vessels were at first reluctant to go ‘up-river’ for cargo. In fact the first ‘Fort William’ grain had to be reloaded into cars and taken to Port Arthur. It was soon demonstrated, however, that a sufficient depth of water existed, and in June of 1885 the S.S. Algoma was loaded and sailed from Fort William with little trouble.

Terminal Development

The capacity of the terminals at the Lakehead quickly increased as the cultivation of wheat was extended across the Prairies. In 1884 it had been 1,870,000 bushels in the four structures (Table One). By 1890, there were still only four buildings, one warehouse and three elevators, but they could hold 3.2 million bushels. The closure of the remaining warehouse soon after, temporarily lowered overall capacity, but by 1892 the two elevators then licensed held over 4 million bushels. One, the original CPR structure now known as the "King" elevator (after J.G. King who operated it) held 325,000 bushels at Port Arthur. The second, an enormous CPR structure at Fort William held the balance.

With minor fluctuations this was the pattern until after the turn of the century. For a few years T. Marks and Co. operated a small (150,000 bushel) warehouse at Port Arthur, but in 1902 there were only five Lakehead terminal elevators. The "King" structure at Port Arthur was still being operated, and the CPR had four at Fort William. Together over 7 million bushels could be stored. As noted earlier, prior to 1902 "all the terminal elevators at Fort William and Port Arthur had been owned and operated by the Canadian Pacific Railway. In that year, however, the Canadian Northern Railway built a terminal elevator and leased it to a commercial company.[14] A further change took place in 1904, when elevator companies to be operated in conjunction with their own line elevators established at country points erected the first terminal elevators. Later the Canadian Pacific Railway gradually withdrew from the elevator business and leased its properties to commercial companies."[15]

It is also worth noting that changes were constantly being made to these terminal structures in the form of repairs, renovations, and extensions, in order to accommodate the ever increasing size of the crop and of the lake vessels.[16] In 1902 a maximum length of 440 feet was established for the lake freighters, but in 1906 seven vessels in the 600-foot class took to the water. As a consequence the number of hatches varied, and thus elevator spouts and docks had to be adjusted to coordinate with the ships' loading facilities, so that turnaround time could be minimised.

A New Order

A major change in direction occurred in 1906 after Canada had "established a market that made it possible to hedge grain". Frank T. Heffelfinger and Frederick D. Wells, sons-in-law of Frank Peavey, the US elevator king, leased the huge Canadian Northern-owned grain terminal at Port Arthur, as well as signing a contract to build country elevators along CNor lines. Although not the first Americans to make their mark in the Canadian grain trade, the coming of the Peaveys showed that traders from south of the border had truly arrived in force, and the character of the grain trade would significantly change as a result. In 1906 18.5 million bushels could be stored at the Lakehead - ten times the capacity available two decades earlier. The year was also notable in that on May 26th 1906, the Ogilvie-owned elevator at Fort William slipped into the Kaministiquia River!! Not all change was positive.

More companies began to build terminals at the Lakehead as the first decade of the Twentieth Century unfolded. This development in the grain-handling system resulted from a number of causes. First, competition amongst large companies was increasing. Secondly there were more large companies - and particularly American companies - to compete. Third, grain handlings were increasing, and thus more terminals were needed.[17] Fourth, the advantages of vertical integration had become obvious, and the wealthier (who were generally the larger) traders hastened to take advantage of them. As the port and terminal facilities grew in size and number, the complexities of grain shipping increased, and in 1909 the Lake Shippers' Clearance Association was formed to act as a "clearing house" for grain, and to speed up the loading process.[18]

By 1911-12, when definitive and long-term records first appear, there were 15 terminals at the Lakehead, five at Port Arthur, and the balance at Fort William. This was an increase in terminal numbers of 66%, and in terminal capacity of 33% from 1906. At Port Arthur, there was one terminal elevator on the CPR, and four on Canadian Northern trackage. At Fort William, clearly the CPR's port of choice, there were nine terminals on lines owned by this company, and one on a Grand Trunk Pacific line (the Grand Trunk Pacific Elevator Co.). This latter terminal, owned jointly by the Railway and by American elevator operators[19], later became part of the Peavey group after the latter company bought out the interests of its compatriots.

Ownership patterns were very different from earlier days. Although the CPR still owned three of the structures on its own lines in Fort William, this railway serviced six private companies. Of these, one was run by Ogilvie Flour Mills, which was to have perhaps, the most completely vertically integrated pattern of ownership of any company in the Canadian grain trade.[20] Three of the others were owned by conglomerates, which were also heavily into country elevator ownership (the Empire, Western, and Consolidated Terminal Elevator companies).[21] Two seem to have been independents (Black and Muirhead, and Davidson and Smith). On CNor lines at Port Arthur, two terminals were owned by the Port Arthur Elevator Co. and two by other conglomerates, both of which (the Thunder Bay and National Elevator companies) appear to have had Peavey family connections.[22]

The Industry Adapts and Grows

In 1912, as regulations were being clarified, an important distinction was made between "Terminal Elevators" and "Hospital Elevators"[23], where the latter were used treating rejected or damaged grain with special machinery in order to make it saleable at a higher grade. Remarkably perhaps, but reflecting the lucrative nature of this end of the business, three of the existing terminals were immediately reclassified as "hospitals", and five new hospital elevators were built (all at Fort William) - including one by N.M. Paterson Co., a family owned and operated outfit that was to become a major long term player in Fort William, as well as the grain trade in general. Another significant change at this time was the transfer of two of the Fort William CPR elevators (thereafter operated as one unit) to the Grain Growers Grain Company - the farmer cooperative that had been set up to avoid the tentacles of the private trade, and which was to become the United Grain Growers in 1917.[24]

Over the years, the terminal elevator scene demonstrated both growth and change. Growth took place in individual elevators that had their capacity increased, and in terms of numbers. Thus by 1915 there were 25 elevators at the Lakehead, by 1920 there were 32, and by 1925 the number had risen to 36, although by 1930 there were 'only' 32. This number remained relatively static until the mid 1930s when the total once again began to drop, reaching 28 in 1940, 26 in 1951, and 11 in 1988.

Although the rise of the West Coast terminals may have had some affect on numbers, these totals can, in themselves, be misleading. For the 43 million bushel capacity of 1915 rose through 64 million in 1925, to nearly 95 million bushels in 1930, and although there was then little change for about three decades (it was 93 million in 1961), the total was over 106 million in 1964, before dropping to some 90 million a decade later. Currently the 11 terminals can hold about 2 million tonnes.

Ownership Patterns

Growth was to be expected though as Canadian wheat exports, as well as those of other grains handled by the terminals, continued to rise. Perhaps more interesting, however, were the changes in ownership that reflected the development of the trade from an unregulated free-for-all to a tightly controlled publicly influenced industry.

As we have seen, CPR ownership eventually gave way to the building of huge terminals by large conglomerates, made up mostly by groups of country elevator owners and grain traders. This reflected the development of the industry as a whole, and in many ways the changes at the Head of the Lakes continued to effect changes in the overall grain trade - with the 1912-13 entry of the Grain Growers Grain Company to Fort William being the first of many typical examples of this generalisation.

In 1917 another future trend was signaled when The Saskatchewan Cooperative Elevator Company added a Public Terminal Elevator in Port Arthur. (A change in definitions at this time had redrawn distinctions so that the Hospital elevators were essentially reclassified as Private Terminal Elevators, with the balance remaining as Public Terminal Elevators[25]). There followed many minor changes as terminals changed their category (e.g. Davidson and Smith became “private” in 1918, “public” again in 1919, and “private” again in 1921 before being sold in 1923), or were closed (e.g. Black’s in 1919).

There were also variations in ownership that reflected changes in the grain trade as a whole. As companies jockeyed for position with other operations, as general economic conditions changed, and as increased farmer-ownership of elevator operations became more likely, some companies tried to consolidate their place in the grain trade by expanding at the Lakehead. Thus in 1921 the Horn terminal went to Edmonton-based Gillespie Grain, the Muirhead-Bole structure was sold to the Brooks Elevator Co., and the Merchants Grain building became owned by the Saskatchewan company of R.B. McClean. The Gillespie, Brooks and McClean companies were major country elevator owners, all originally from the USA, which were trying to extend their influence "vertically", although the Brooks structure was sold again in 1922, as this company's plans changed once more. Other country elevator owners such as James Stewart, Mutual, Bawlf Grain, McCabe Bros., and Wiley Low were all more or less successful in following the same routeway.

In 1926 the Saskatchewan Pool appeared, initially taking over the Saskatchewan Coop assets, but also by taking control other structures (e.g. from the Grain Growers Export Company in 1928), and particularly by building new terminals (e.g. one at Port Arthur in 1928). The Manitoba Pool (as the Manitoba Coop.) also appeared at Port Arthur taking control of two elevators in 1928 that had been previously licensed to Canadian Coop Wheat Producers. The Grain Trade mergers and take-overs of the late 1920s were also, necessarily, reflected in changes at the Lakehead. Thus a number of terminals became part of Federal Grain in 1929 (from Canadian Consolidated, Northwestern, and Stewart).

The Head of the Lakes in 1930

If we look at 1930, a review of the terminals at the Lakehead gives a good picture of the overall grain trade at that time. There were 32 structures (a drop from the 1925 high-water mark of 36), 16 in both Fort William and Port Arthur, with a capacity of 94,597,210 bushels (up by nearly 50% from 1925). Most (28) were public or semi-public[26], reflecting the sharp decrease in Private elevators (from 27 out of 32) since 1929 - in part because of another redefinition of terminology which sharply changed the 'private' definition, and introduced the 'semi-public category' to which many of the previously 'private' elevators were shifted.

Many of the major grain companies that were to be found owning country elevators on the Prairies, also appeared at the Lakehead. Thus Federal Grain, Ogilvie Flour Mills, Canadian Consolidated, Paterson, Western, Searle, McCabe, National, Union, and Reliance had their own terminals. The remaining privately owned structures were mostly quite small. In addition the farmer owned coops (the UGG, Saskatchewan Pool, and Manitoba Pool, with the Alberta Pool being conspicuous by its absence - and its presence on the West Coast) were also located in Port Arthur. The Saskatchewan Pool had four structures, the Manitoba Pool two, and the UGG one. The Saskatchewan Pool also had a Terminal in Fort William.[27]

Over the next decades, ownership was further consolidated, and as noted earlier the total number of licensed structures declined - while size increased. Perhaps most noticeable was the continued complexity of the pattern which makes the clarification of the story difficult for later researchers. For instance, in 1933 Manitoba Pool Terminal #2 (in Port Arthur) was sold to Canadian Consolidated Grain. This elevator was previously had previously been a Manitoba Coop elevator before company reorganisation and a name change in 1929. Prior to this it had been a Canadian Coop operation, and before this it was Gillespie owned, this company having bought it from Horn in 1921, which company had built it more than a decade earlier. This elevator was sold back to Gillespie in 1934, which company returned it to Manitoba Pool (as #2 once again) in 1935. It seems to have been demolished in 1936. The reasons for many of these changes remain unclear, but this is not an isolated example.

The Pacific Route

Early Development

Although connected by rail with the Prairies since the early 1880s, the Pacific route for grain exports was not a very important one before the opening of the Panama Canal. The construction of the Panama Canal caused far-reaching changes in the flow of ocean traffic - one of which was the development of shipments of Canadian grain destined for consumption in Europe through the ocean ports of British Columbia. This route gave the farmers of Alberta and western Saskatchewan an alternative route for their exports, and this competitive factor helped to keep down eastern carriage rates.[28] The shipment of grain to the Orient also boosted Vancouver as an ocean grain terminal. By the late 1920s, one third of the grain from Vancouver was destined for the UK, and one third for the Orient, with the balance going to 'other countries'.

Initially grain was exported from Vancouver in 'parcel shipments' - 'bottom cargoes' in ships in liner service, and through this means the city managed to build up some momentum in the trade. This discouraged the early growth of grain terminals in for instance, New Westminster, which had no extensive liner traffic, although a small terminal was eventually built there in 1928. Victoria also built up a trade, and constructed a private company terminal in 1928, but its island location precluded extensive growth in this trade.

Prince Rupert, however, relatively flourished as it was chosen as the western terminal of the Grand Trunk Pacific Railway, with the Dominion Government building a terminal there, subsequently leased to the Alberta Wheat Pool, in 1925. This proved particularly useful to the Pool when pressures on shipments through Vancouver - such as grain 'blockades'[29] -threatened its contracts. Although 500 miles from Vancouver by the inside passage, the export trade route of Prince Rupert via Panama is only 280 miles longer than that of Vancouver - a small percentage of the total distance to Europe. Its more northerly location is somewhat offset by a better connection to the ocean, and a shorter distance to the Orient. In addition, although nearly 200 miles further from the wheatlands, CN traditionally maintained freight rate parity between Vancouver and Prince Rupert. However, predictions by CN President Charles M. Hays that 100,000,000 bushels of wheat would move annually through Prince Rupert proved to be overly optimistic (the largest amount shipped up to 1930 being 7.6 million bushels, in 1927-28).

The Growth of the West Coast Trade

But the growth of the West Coast terminals did not come immediately after the opening of the Panama Canal in 1914. In addition to war-time problems, such as the scarcity of shipping, which delayed its true testing, a considerable investment in eastern movement had already been made, the technical conditions of eastward movement were well known, and the organisation of grain exports were centred around the eastern route. The railways also made more money out of the longer eastern haul, and there was, therefore, no real economic motive for them to develop a grain traffic to the Pacific. Lastly, there was some doubt that grain could safely be shipped, in bulk, using a tropical route, without seriously deteriorating while in transit. There was, thus, what MacGibbon termed a natural disinclination to change.[30] It was only in the early 1920s that Vancouver became definitely recognized to be an important outlet for grain.[31]

Responding to pressure from the City of Vancouver however, the Dominion Government had built a terminal elevator on the harbour front, with a capacity of 1,250,000 bushels that was completed in 1916. At this time there were 26 terminal buildings at the Lakehead, with a total capacity of over 45 million bushels. In 1917 the Panama Canal route was tested, and passed with flying colours, with only 160 bushels of a cargo of 100,000 bushels being damaged.

Despite this success, however, there was little increase in Pacific port usage. Just less than 600,000 bushels were shipped in 1920, for instance, mainly to the Orient. This sluggish development reflected both high ocean freight rates that favoured the shorter Atlantic route, as well as higher westward rail freight rates that favoured the Lakehead. In addition, a lack of inward cargoes and the competition of exporters in the Pacific ports of the United States for outward cargo space restricted the growth of the grain trade in this area.[32] After 1920, however, these disabilities began to fade, and by 1922 14.5 million bushels were shipped out of Vancouver with 11 million going to Europe. From this time trade from the West Coast steadily grew. For the crop-year 1925-26, total B.C. shipments were over 53 million bushels (nearly half to the UK). By 1928-29 the total was nearly 95 million bushels, with nearly one third of the total being billed to the United Kingdom. The ability to ship during the winter months when the Great Lakes were frozen was a particular boost to the West Coast. This was an impressive increase, but it must be noted that in the same year the Lake Shippers' Clearance Association shipped 376 million bushels.

Terminal Variations

Apart from differences in shipment-size at this time, there were other differences between the two regions of terminals. Although the terminals of Fort William and Port Arthur were principally assembly points where grain was put into a condition for export (cleaning, drying, mixing, etc.), Vancouver had the added function of being a gateway through which grain moves to foreign markets. It thus combines the functions traditionally divided between the Lakehead and Montreal. Although there was initially a pressure to have only publicly-owned terminals at Vancouver, this did not occur, and soon the public terminals had been leased to private companies, in addition to other structures that were built by the private concerns; as a consequence, in terms of elevator type, Vancouver most closely resembled the Lakehead, having mostly private terminals.

In other ways, however, the terminals of the Lakehead and Vancouver differ. As Vancouver is an ocean port and requires the use of the foreshore of the harbour for other purposes, the elevators are built further back, with the grain being carried to the ocean vessels by belt conveyors carried over galleries. In addition, as storage capacity is relatively limited in Vancouver, a different permit-delivery system had to be devised to maximise efficiency.

Conclusion

The development of the grain trade in Canada has been spectacular and exciting, and the growth of the terminal elevator system is characteristic of this progress. It had a lasting and positive influence, leading to some of the most distinctive cultural landscape elements in both areas studied. It transformed minor Lake Superior settlements into major cities, and helped Vancouver become (and remain) a world-class port. Many of the factors that led to the growth of the Canadian terminal elevator system originated in the United States, but when they diffused to Canada they took on a form that became characteristic of this region. Although our discussion terminates before the West Coast ports fully developed their grain exporting capacity, and a more complete story of the later changes deserves telling, it was already clear by the early 1930s that the Pacific route had introduced a significant new factor into the Canadian grain trade.

Endnotes

1.This line of thought is developed more fully in Peter J. Hugill and John C. Everitt 'Macro-landscapes: The cultural landscape revised by world-system theory' in S.T. Wong (Ed.) *Person, Place and Thing: Interpretive and Empirical Essays in Cultural Geography Geoscience and Man*, Vol. 31 (Baton Rouge: Department of Geography and Anthropology, Louisiana State University) 1992: 177-194.

2.Taylor, P.J. 'World-systems analysis and regional geography' *Professional Geographer,* Vol. 40, No. 3, 1988: 264.

3. Five Interior Terminals were built by the Dominion Government from 1914-1917, at Moose Jaw, Saskatoon, Calgary, Edmonton, and Lethbridge. One was also built at Churchill in 1930. These will not be considered in this paper.

4. MacGibbon, D.A. *The Canadian Grain Trade* (Toronto: MacMillan) 1932: 118.

5. MacGibbon, 1932: 118.

6. The world's largest market for wheat was England, whose food deficit continued to increase during the nineteenth century. By 1900 British farmers could supply domestic requirements for only two months out of every year (see J.C. Everitt 'The borderlands and the early Canadian grain trade' in R. Lecker (Ed.) *The Borderlands Anthology* (Montreal: ECW Press) 1991: 146-172.

7. MacGibbon, 1932: 238.

8. Naylor, R.T. 'The banks and finance capital' Volume 1 of *The History of Canadian Business*, 1867-1914 (Toronto: J. Lorimer) 1975: 15.

9. In addition, a relatively small amount of grain was shipped to Duluth, for instance via the Great Northern-owned Brandon Saskatchewan and Hudson's Bay Railway. In the fall of 1928 this amounted to less than 1,000 cars (MacGibbon, 1932: 120).

10. Buller, A.H.R. *Essays on Wheat, Including the Discovery and Introduction of Marquis Wheat, the Early History of Wheat-Growing in Manitoba, Wheat in Western Canada, the Origin of Red Bobs and Kitchener, and the Wild Wheat of Palestine* (New York: Macmillan) 1919: 49.

11. The modern city is located on an estuary of the Kaministiquia River that bifurcates twice within 2.5 miles of the mouth. The two subsidiary outlets are known as the Mission and the McKellar Rivers. Dredging through sand bars at the river mouth has long been necessary to open and extend the navigable channels.

12. Everitt, J.C. 'The line elevator in Saskatchewan' *Saskatchewan History*, Vol. XLIV, No. 2, Spring 1992: 41- 58.

13. Although some large eastern Canadian companies, such as Ogilvie Milling, showed an early interest in Manitoba wheat, most of the initial traders in Winnipeg operated at a small scale. (See W.T. Thompson and E.E. Boyer *The City of Winnipeg, The Capital of Manitoba, and the Commercial, Railway, and Financial Metropolis of the Northwest: Past and Present Development and Future Prospects* (Winnipeg: The Commercial Press) 1886; and A. Begg and W.R. Nursey *Ten Years in Winnipeg*. A narration of the principal events in the History of the City of Winnipeg from the Year A.D. 1870 to the year A.D. 1879 inclusive (Winnipeg: Times Printing and Publishing House) 1879.

14. The Warner-McWilliams consortium that owned the Canadian Elevator company.

15. *Wheat Studies of the Food Research Institute* (Stamford University) Vol. 1, No. 8, July 1925: 235.

16. These vessels also carried ore and coal cargoes in order to maximise their usefulness throughout the year, and were often American-owned. This dependence caused occasional crises for the Canadian wheat trade, and led in part to the growth of Canadian

shipping operations, such as those of the Paterson, Parrish and Heimbecker, and Richardson (Pioneer) companies.

17. Wheat acreage on the Prairies was to rise from 2,495,000 acres in 1901 to 25,586,000 acres in 1931. It was 24,629,000 acres in 1961 (Tyler, 1967: 97).

18. MacGibbon, 1932: 232-238.

19. The Warner-McWilliams consortium that owned the Atlas Elevator Company, which operated on Grand Trunk rail-lines. These corporate connections were common in the grain and railway industries (see D.W. Holdsworth and J.C. Everitt 'Bank branches and elevators: Expressions of big corporations in small prairie towns' *Prairie Forum*, Vol. 13, No.2, 1988: 173-190.

20. Everitt, J.C. 'The early development of the flour milling Industry on the Prairies' *The Journal of Historical Geography*, Vol. 19, No. 2, 1993: 101-121.

21. The Empire Elevator Co. was originally owned by the Northern, Dominion, Canadian, and Winnipeg Elevator syndicates. By 1905 it was so successful that the CPR was worried that its elevators were losing out, and the railway company was trying to take steps to restore its previous success. (Whyte to Shaughnessy 15-11-05 [CP 79651]).

22. The various holdings of the Peavey Group were consolidated into the National Grain Company Limited in 1940. (see J.C. Everitt 'The line elevator in Alberta (Part One)' *Alberta History*, Vol. 40, No. 4, Autumn 1992: 16-22.

23.*Terminal Elevator* included every elevator or warehouse that received or shipped grain, and was located at any point declared by the Governor in Council to be a terminal. "Hospital Elevator" included every elevator or warehouse that was used for cleaning or other special treatment of rejected or damaged grain and which was equipped with special machinery for that purpose. (1912-1913 List of Licensed Elevators and Warehouses in the Manitoba Grain Inspection Division (Ottawa: Department of Trade and Commerce).

24. Everitt, J.C. "A 'tragic muddle' and a 'cooperative success': an account of two elevator experiments in Manitoba, 1906-1928" *Manitoba History No. 18,* Autumn 1989: 12-24.

25. Under this new definition a "Private Terminal Elevator" included every elevator or warehouse that was used for cleaning or other special treatment of rejected or damaged grain and which was equipped with special machinery for that purpose. This was essentially the same wording as for the old "hospitals". In addition, however, a paragraph was added that stated "under regulations governing sample markets, all grain received into such elevators must be their own property. Nevertheless the owner, or owners of grain may contract for the handling or mixing of grain in such elevators." (1917-1918 List of Licensed Elevators and Warehouses in the Western Grain Inspection Division (Ottawa: Department of Trade and Commerce)).

26. A further revision of definitions created the 'semi-public' elevator. "Semi Public when used with respect to an elevator, means any elevator, not being a mill elevator or a public elevator, the manager whereof is expressly permitted by the terms of his license as such manager to bin as he sees fit any grain except wheat graded in any of the four grades first specified in Schedule One to this Act." The 'public elevator' definition was revised to read "Public when used with respect to an elevator means any elevator other than a mill elevator, a private elevator, or a semi-public elevator." The 'private elevator' definition then read "Private when used with respect to an elevator means an elevator used by the manager exclusively for the storage or handling of grain belonging to him alone, or, when the manager is a co-operative association of grain growers, or is a company controlled by one or more such associations, is used by such association exclusively for the storage or handling of grain belonging to it or produced by or received from some one or more of its members." (1930-1931 List of Licensed Elevators and Warehouses in the Western Grain Inspection Division (Ottawa: Department of Trade and Commerce)).

27. In addition to their country systems, by 1935 the three Pools owned or leased seven modern terminal elevators at the Head of

the Lakes, and four on the Pacific coast, with a combined capacity of over 36,000,000 bushels, or more than a third of the total terminal storage on the eastern and western fronts of the grain belt of Western Canada.

28. The exact location of the ‘grainshed’ between the West Coast and the Great Lakes varies with the cost of shipping. In the early 1930s, “a calculable difference in shipping costs of one- eighth of a cent per bushel.... [would] deflect shipments from the Atlantic to the Pacific Coast.” (MacGibbon, 1932: 273)

29. A grain ‘blockade’ occurs when there is more grain at a shipping point than can be moved by the transportation system.

30. MacGibbon, 1932: 267.

31. Macgibbon, 1932: Chapter X.

32. *Wheat Studies of the Food Research Institute* (Stamford University) Vol. 1, No. 8, July 1925: 258. Some tramp steamers did, though, travel the 35 days from the UK in ballast in order to pick up a cargo of wheat (MacGibbon, 1932: 272).

A comparison of rural community development strategies in Saskatchewan and North Dakota

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Abstract: As far back as the 1950s and 1960s, the attention of many governments in the developed world was drawn to the ongoing rural transformation processes and their associated problems. Consequently attempts were made to create development programmes and strategies in order to deal with rural decline in many developed countries such as Britain, France, Canada and the United States. This study was undertaken to analyze rural community development (RCD) programmes in two different political but similar geographic regions in North America: Saskatchewan in Canada and North Dakota in the United States. The goal of the study is to understand some of the underlying theories, philosophies, strategies, and agents of various RCD policies and programmes that have been implemented in these selected regions during the period 1960 to 1995. The purpose of the study is three-fold: first, to identify different development strategies; to understand the factors which are responsible for such differences; and finally, to examine the relative impact of various RCD approaches adopted in both study areas. Two major development strategies, which feature prominently in this study, include top-down and bottom-up development approaches.

Introduction

Whereas researchers, planners and governments in Canada and the United State have examined changes in the rural sector and devised various development strategies, few have compared and contrasted such approaches in order to gain greater insight into their applicability within various contexts. This study attempts to compare the differences and similarities, if any, that exist between two different political units, Saskatchewan (Canada) and North Dakota (United States), which are located in the same geographical region, the Great Plains of North America. This paper has been divided into five major sections. In the first section the purpose and objective of the research is presented, followed by the methodology of the research in section two. A chronological presentation of some of the major federal and provincial/state rural/ community, regional and economic development policies and programmes initiated in the two study areas, especially since the1960s to 1995, is provided in section three. Section four compares the information obtained from field research to identify features of divergence and convergence that exist between RCD programmes in the study areas. The final section presents some of the major findings of the research.

Purpose and Objectives of Research

This study compares the theoretical approaches and RCD strategies adopted by Saskatchewan and North Dakota during the period 1960 - 1995. Specifically, the research attempts to identify any difference in strategies, to distinguish those factors responsible for such differences and to assess the relative impact of variable approaches to rural development adopted in these two study areas.

The main objectives of this research project are:

-to identify the types of RCD strategies that have been used in each of the studied areas and to understand the theory and philosophies underlying the adoption of such strategies;

-to explore in detail some of the more important strategies presently followed in both places using case studies;

-to ascertain different kinds of problems associated with the implementation of such development strategies, and;

-to identify measures that have been taken or are being taking to solve some of these problems.

Methodology

Saskatchewan and North Dakota share almost the same geographical characteristics in terms of location (Great Plains Region), vegetation, climate, relief/topography, natural resources, small population size, and socio-economic characteristics (a significant rural and agricultural population). The differences that exist between these two areas may be seen in terms of their administration systems, prevailing development or planning policies, and constituent populations. Four case study areas were selected from these geopolitical regions.

Both secondary and primary data were collected for the study. The latter involved oral interviews and questionnaire survey. One of the main reasons for adopting these methods of data collection is to minimize the discrepancies that might have occurred if one method of data collection had been pursued. The methods complement each other.

A comparative analysis of data (differences and similarities) from both study areas was attempted. The rationale underlying this comparative analysis approach is to understand or identify the similarities and differences of theory and philosophies of RCD strategies, and dominant causal forces (political, economic, socio-cultural, etc.) that have influenced these strategies and have shaped the communities under investigation. In the absence of any generally accepted criteria for measuring performance of RCD programmes, this study utilized contextual data obtained through the questionnaire survey, oral interviews, annual reports of the various departments on the performance of the various development programmes, and field observations for the comparative analysis on the performance of the selected RCD programmes and study areas. The comparative analysis of this study was conducted under three major sub-headings:

(i) comparative analysis of the general background characteristics of the study areas,

(ii) comparative analysis of the implementation of RCD programme in the study areas within the last thirty-five years starting from 1960, and

(iii) comparative analysis of the performance of the various RCD programmes in the case study areas by considering the following factors:

achievement of the goals and objectives of the programme, programme life span, scale of operation, funding assistance, human resources and other technical assistance, political support, evidence of good leadership, evidence of local community participation, nature of programme and local resource base upon which rural development programmes are implemented. The level of performance of these factors was evident in the contextual data obtained from field investigation.

The second sub-heading is the main focus of this paper. The next section presents some of the major RCD programmes implemented in both study areas over the past thirty-five years.

Chronological Presentation of Major RCD Programmes in Saskatchewan and North Dakota

The introduction and implementation of development policies and programmes in both Saskatchewan and North Dakota actually started as far back as the Confederation era through the Great Depression to the 1960s when more purposeful attempts and efforts to undertake rural/community, regional and economic development programmes in Canada and the United States began. The 1960s were, therefore, chosen as the base year for the study. RCD planning activities in both study areas have been carried out under the federal and provincial/state levels. Itemized in Table 1 (a and b) are some of the major development programmes initiated by the federal governments in both Canada and the United States which have had an impact on the development of rural areas in Saskatchewan and North Dakota. Table 2 (a and b) contain some of the provincial/ state government regional and RCD programmes.

***Table 1**: Some Federal Government regional and RCD programmes.*

1(a): Saskatchewan

No.	Name of Programme	Time Period/Year	Strategy Adopted
		Before 1960	Top-Down*
1	Prairie Farm Rehabilitation Adm. (PFRA)	1930s	
		1960-1977	Top-Down
2	Winter Works Program	1959/60	
3	Agric. Rehab. & Dev. Act (ARDA)	1961	
4	Area Development Agency (ADA)	1962	
5	Fund for Rural Econ. Dev. (FRED)	1966	
6	Dept. Regional Econ. Expansion (DREE)	1969	
7	General Dev. Agreements (GDAs)	1973	
		1978-95	Top-Down
8	Department of Regional Industrial Expansion (DRIE)	1981/82	
9	Ministry of State for Economic & Regional Development (MSERD)	1981/82	
10	Economic and Regional Development Agreement (ERDA)	1984	
11	Industrial and Regional Development Program (IRDP)		
12	Dept. of Western Diversification (WD)	1989/90	
14	Partnership Agreement on Rural Development (PARD)	1993	Top-Down
15	Partnership Agreement on Water-Based Economic Development (PAWBED)	1993	& Bottom-Up* *

Compiled From: (i) Addo, E. (1992: 20-27); (ii) Dale, E. H. ed. (1988: 25-30); (iii) Gertler, M. *et.al*. (1992: 54); (vi) Hardy, N. in RDI (1990: 8-12); and (v) SED Annual Reports 1992-93; 1993-94.

***Top-Down Development Strategy or Development From Above**: This means development planning decisions are taken at the central or national level and filter through the political, administrative and economic hierarchy to local areas.

****Bottom-Up Development Strategy or Development From Below**: It is theoretically, the direct opposite of development from above. It contends that development planning, policies and decisions should be taken and implemented at the grassroots level by local people affected directly by the development decisions rather than at the central or national level.

1(b): North Dakota

No.	Name of Programme	Time Period/Year	Strategy Adopted
		Before 1960	Top-Down
1	Commission on Country Life (CCL)	1910	
2	NEW DEAL under US Department of Agriculture (USDA)	1930s	
3	Farmers Home Administration (FmHA)	1947	
4	Rural Electrification Administration (REA)	1949	
5	Rural Telephone Loan (RTL)	1949	
6	Rural Free Delivery (RFD)	1949	
7	RURAL DEVELOPMENT PROGRAM (RD): Embodies 1,3,4,5&6	1955	
8	ND Association of Rural Electric Cooperatives (NDAREC)		
9	ND Association of Telephone Cooperatives (NDATC)		
10	Small Business Administration (SBA)	1953	
11	Commodity Credit Corporation (CCC)		
		1960-1977	Top-Down
12	RURAL AREA DEVELOPMENT (RAD): New name for RD	1961	
13	Area Redevelopment Act/Administration (ARA)	1961	
14	Accelerated Public Work Act (APWA)	1961	
15	Public Work and Economic Development Act (PWEDA)	1965	
16	Economic Development Administration (EDA): Replaced ARA	1965	
	- Economic Development Districts (EDDs)	Late 1960s	
17	Housing and Community Development Act (HCDA)	1974	
18	Community Development Block Grants (CDBG)	1974	
19	Office of Intergovernmental Assistance (OIA):In-charge of CDBG		
		1978-1995	Top-Down
29	National Rural Development Partnership (NRDP)	1990	
	(i) National Rural Development Council (NRDC)		
	(ii) State Rural Development Councils (SRDCs): North Dakota Rural Development Council (NDRDC)	1990-1991	

21 Rural Economic and Community Development Services (RECDS/RECD): Embodies RD, FmHA, other Federal Programs 1994
(i) Rural Business-Cooperative Services (RBS)
(ii) Rural Housing Services (RHS)
(iii) Rural Utility Services (RUS)

Source: Compiled From Field Information, 1996

***Table 2**: Some Provincial/State Government regional and RCD programmes.*

2(a): Saskatchewan

No.	Name of Programme	Time Period/Year	Strategy Adopted
		1960-1977	**Bottom-Up**
1	Community Capital Fund		
2	Community Recreation Director's Grant		
3	Community Recreation Support Grant		
4	Construction of water Supply Projects		
5	Industrial Towns Assistance		
6	Municipal on-the-job Training		
7	Regional Parks Program		
8	Rural Transportation Program		
9	Saskatchewan Development Program		
10	Neighborhood Improvement Program		
11	Residential Rehabilitation Assistance Program		
12	Municipal Infrastructure Program		
13	Municipal Incentive Program		
14	Community Service Grant Program		
		1978-1995	Bottom-Up
15	Community Economic Development (CED)		
16	Infrastructure Development:		
a	(i) Enhancing the Physical Infrastructure - Rural natural Gas Distribution Program - Rural Industrialization (ii) Water Development and Management - Well Drilling Assistance Program - Large Scale Irrigation Projects		

	- Rafferty-Alameda Water Management Project		
b	Educational Infrastructure for Rural Areas		
	- Consolidation of Fragmented Schools-Coherent Network		
	- Saskatchewan Communication Network		
c	Information Infrastructure Development		
	- Rural Service Centre (Computer Network)		
17	Department of Rural Development (DRD)		
a	Community Economic Development Program (CED)		1982
b	Rural Development Corporations (RDCs)		1986
	(i) Agricultural Development & Diversification Boards (ADD)		“
	(ii) Rural Economic Development Grant		“
18	Small Business Loan Association	1989	
19	Partnership for Renewal (PR)	1989-90	
20	Partnership for Growth (PG)		
21	Saskatchewan Economic Development (SED)		
a	Decentralization Program		
b	Co-operative & Community Economic Development		
	- Regional Economic Development Authorities (REDAs)		1993
22	Canada-Saskatchewan PARD		Partnership -
23	Canada-Saskatchewan PAWBED		Agreement

Compiled From: (i) Addo, E. (1992: 20-27); (ii) Dale, E.H. ed. (1988: 25-30) (iii) Gertler,M *et. al.* (1992:54); (iv) Hardy, N. in RDI (1990: 8-12); and (v) SED Annual Reports 1992-93; 1993-94.

2(b) North Dakota

No.	**Name of Programme**	**Time Period/Year**	**Strategy Adopted**
		Before 1960	Bottom-Up
1	Bank of North Dakota (BND)	1919	
2	Economic Development Commision (EDC)	1957	
		1960-1977	Bottom-Up
3	Regional Development Councils (RDCs)	1969	
		1978-1995	Bottom-Up
4	North Dakota Spirit Program	1989	
5	North Dakota Vision 2000 Project:	1987-1990	
a	Rural Development Academy	1991	
b	Growing North Dakota Program	1991	
	i North Dakota Development Bank (NDDB)	1991	
	ii Department of Economic Development & Finance (ED&F)		1991
	(a) Funding Programs:		
	- Future Fund (FF)		

- Regional Rural Revolving Loan Fund (RRRLF)
- Technology Transfer Inc. (TTI)
- Mini and Incentive Grants

(b) Agency Services Programs:
- Community Economic Development (CED)
- International Trade
- Native American Business Assistance
- Women's Business Development
- Research

Source: Compiled From Field Information, 1996

Comparative Analysis of RCD Programmes in Study Areas

This section compares and contrasts the two study areas in terms of their development trends, strategies, goals, areas of focus, scale and underlying problems of policy and programme implementation.

Similarities

Prior to the 1970s, design and implementation of development policies and programmes in both Saskatchewan and North Dakota were carried out separately between federal and provincial/state governments, and between rural and urban communities. The current trend in operation is a convergence of development ideas and support from both levels of governments.

Interest in rural and economic development in both political regions was reactivated shortly after the recent recession period. The recent recovery processes exhibit similar characteristics in both regions. Assessments of prevailing rural and economic conditions were conducted by similar committees established by both provincial and state governments. These committees adopted a similar investigation approach whereby representatives from every sector of the economy, social groups, local communities (rural and urban), and private individuals were incorporated in the process. Based on the recommendations of these independent groups, broad long-term provincial/state development initiatives were established: the Partnership for Renewal/Growth in Saskatchewan and the Growing North Dakota programme in North Dakota. Likewise, the implementation of these programmes were placed under the supervision of newly organized and restructured provincial/state departments, SED in Saskatchewan and ED&F in North Dakota. These departments also share similar programme/project implementation approaches. While they serve as facilitators in rural and economic development, and provide financial and technical support for various local development programmes and projects, they allow local communities to initiate their own development programmes/projects through voluntary leadership and self-help approaches on either an individual community or regional partnership/co-operative basis. This strategy, a combination of bottom-up and top-down approaches with particular emphasis on grassroots participation, is the most important development in rural planning in both areas.

The late 1980s and the 1990s have witnessed a gradual convergence of the top-down and bottom-up strategies in both study areas. The partnership agreement programmes such as WD and PARD in Saskatchewan, and NRDC and NDRDC in North Dakota are evidence of this claim. Recent observations reveal that while none of these approaches can exist in isolation, communities cannot develop on their own, and so the current convergence of both approaches requires that:

> "[f]ederal and [provincial or] state governments set the legal and program contexts, regulate activities and possess the financial tools that must be accessed at other levels. Those who work at the community level need to network horizontally (to mobilize the community) and vertically (to engage in intergovernmental management) to make development successful" (Radin *et al*. 1996: 207).

While previous RCD policies and programmes in Saskatchewan and North Dakota focused attention on developing the traditional primary economic sector (particularly agriculture) and providing infrastructure, loans and grants assistance to local communities, current development policies and programmes place greater emphasis on job and wealth creation and strategies for community sustainability such as encouraging more value-added primary production activities; assisting business establishment, retention and expansion; funding infrastructure rehabilitation and development projects; and developing the tourism industry. Recently, emphasis has been placed on the use of computer and telecommunication technologies in the development process.

The ultimate goals for Saskatchewan and North Dakota include diversification of the rural economy, reversal of rural out-migration trends, and helping local people take charge of their own destinies by incorporating self-help, self-reliance and sustainable development into local communities.

Differences

The two political regions however, differ somewhat in their approaches to development. While Saskatchewan witnessed a gradual shift from federal domination in RCD activities to more decentralized locally controlled development programmes in the early 1970s (e.g., the GDAs programme in 1973), North Dakota continued to implement top-down development programmes until the 1990s (although bottom-up strategies were also developed early in the study period, egs., BND and the RDCs/SPRs). A recent investigation into the problems confronting rural North Dakota indicates that "federal dependence and lack of local control over economic conditions have resulted in a general feeling of frustration among a populace with a strong tradition of shaping their own destiny" (ED&F Handbook: 17). Ironically, most of the state's public economic development policies and programmes, until the 1990s, have been geared toward development of public institutions: each of the major cities in North Dakota (Bismarck-Mandan, Fargo and Grand Forks) hosts state institutions such as state prisons, state hospitals and state universities. These institutions have received the bulk of the state government's economic development funds.

Saskatchewan and North Dakota also differ in the nature and implementation of their bottom-up regional development programmes. Whereas North Dakota adopted the regional planning development approach in the first phase of the study period (i.e., in 1969), Saskatchewan did so in the second phase (i.e., in 1986 with the RDCs). The boundaries of the regional entities in North Dakota (State Planning Regions) are relatively permanent in nature, but those in Saskatchewan (RDCs and the REDAs) are more flexible. The variations in the nature of these regional boundaries make comparison of size very difficult. The planning regions in North Dakota expand over the entire state but in Saskatchewan, they are yet to be extended to the northern section of the province.

The major rationale for pursuing the regional approach in both study areas is to eliminate unhealthy competition, duplication, and overlapping of development programmes and limited resources, but a critical look at the implementation of development programmes in North Dakota's regional entities reveals some deviation from these reasons. At the grassroots level, development programmes/projects in North Dakota are mostly initiated and implemented on an individual rural community basis within a region. In Saskatchewan, local programmes/projects are largely undertaken on a regional basis involving two or more communities.

Similarities and Differences of Achievements

The involvement of federal governments in the development of Saskatchewan and North Dakota has been relatively successful, particularly in the area of initiating development policies and programmes which in most cases have excluded the involvement of local community members, and providing financial and technical support for policy planning and implementation. Comparatively, the availability and accessibility of financial assistance for RCD has continued to be relatively higher in North Dakota than in Saskatchewan. Currently, rural communities, organizations and regional entities who are interested in rural and economic development in North Dakota can obtain development funding from the two major state funding departments, NDDB/BND and ED&F financial agencies and also from several federal departments in the state such as OIA (CDBG) and RECDS. Their counterparts in rural Saskatchewan are limited to provincial development funds from SED and other federal-provincial agreement programmes such as PARD.

It can be argued that a greater number of funding agencies does not necessarily translate into greater funding for successful rural and economic development. In spite of its relatively numerous financial agencies, North Dakota has continued to experience higher rural out-migration than Saskatchewan. In both areas, the governments' technical support in the form of development personnel yielded limited results because these officials had little knowledge of prevailing local conditions.

In spite of the forgoing achievements, rural and economic development in Saskatchewan and North Dakota declined during the mid-1970s to mid-1980s recession. During this period, federal governments in both study areas dissolved some of the existing development programmes such as ARDA and DREE in Saskatchewan, and EDA in North Dakota. They also decreased financial and technical support for some other programmes such as PRFA in Saskatchewan, and CDBG and FmHA in North Dakota. Both study areas suffered from a bureaucratic centralization of development programmes and resources, and a lack of adequate funding for local development activities (Poole 1996; Radin *et al.*, 1996; Dale 1988; Gertler 1972).

The decentralization and federal-provincial partnership agreements approach for RCD have enhanced the development effort in Saskatchewan while North Dakota has just recently adopted this approach under the GND and NDRDC initiatives. Dale (1988) argues that while government assistance to rural communities in Saskatchewan is commendable, they are no more than stop-gap measures because they do not get to the core or root of the problems confronting these places.

Only recently have people argued that "new" RCD policies and programmes have to introduce more fresh ideas and generate positive results in local communities. Prior to the 1990s, while the names of policies and programmes changed, their underlying purpose, goals, objectives and development strategies remained the same. For example, in Saskatchewan, the federal DREE programme was changed to DRIE and later to ERDA, and the provincial SED took over from SEDT. In North Dakota, the federal FSA programme was renamed FHA and later, FmHA, while the state EDC programme also became ED&F.

Almost all federal and provincial/state RCD programmes were established and controlled from urban centres, significantly hindering the ability to recognize the nature of rural problems. For example, the head offices of federal and provincial/state RCD programmes such as PFRA, PARD, and REDAs in Saskatchewan and RECDS, CDBG and BUILD in North Dakota are located in the urban centres of Regina and Bismarck respectively.

The problems and needs of rural communities are very dynamic in nature and, as a result, should be approached from a more dynamic perspective. The on-going Partnership for Renewal/ Growth (Saskatchewan) initiative and the Growing North Dakota (North Dakota) programme exhibit such dynamism in tackling rural problems. The activities of these broad provincial/state programmes are not limited to selected communities or geared toward solving selected rural and urban problems but they attempt to deal with development problems in a more cohesive manner. Yet the programmes are hindered by a lack of personnel. As of July 1996, there were five rural and economic development officers involved in the implementation of the state-wide BUILD programme in North Dakota, while in Saskatchewan they numbered fifteen for the implementation of the REDA initiative. Nevertheless, if their implementation on a long-term basis is not jeopardized and if they receive the required support from all the parties involved in the development process, they may produce more positive results in the future.

This section indicated that while both areas share similar development trends, goals and strategies, they differ in many respects. The next section summarizes the major findings of the research.

Summary of Major Findings of Research

There were several major findings as a result of this research, including a gradual convergence of the top-down and bottom-up development strategies. Long-term implementation of provincial/ state-wide rural and economic development policies and programmes has become the norm over short-term, selective-problem area development programmes. Preference is given to regional cooperation in rural and economic development rather than single community development, particularly in Saskatchewan. There has been a broadening of the RCD horizon beyond the traditional farm gate to include economic development activities such as value-added production and job creation through small-scale business and industrial set-ups, tourism, and environmental sustainability. Finally, there is a trend towards protecting major socio-cultural life styles of rural communities.

Conclusion

This study demonstrated how federal, provincial/state, regional and local governments have played diverse roles in RCD in Saskatchewan and North Dakota. The dominant players in the past have been the respective federal governments who initiated and implemented several top-down development policies and programmes. Nevertheless, government approaches to rural/ community, economic and regional development in the last few years have shifted from the rigid, hierarchical, top-down approach to a more flexible, decentralized, bottom-up grassroots approach. Future development programmes should aim at striking a balance between rural and urban communities rather than addressing the development issues of these communities in isolation. Development programmes should be geared towards strengthening and interweaving local institutions, infrastructure, economic, socio-cultural, religious and political components of the local system. While the similarities and differences of this study have not considered political changes and their impact on RCD, academics, particularly social scientists, are called upon to take up this challenge. Finally, academics should strive to develop a generally accepted method or procedure for conducting comparative social science research of rural areas.

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Waldsea Lake revisited: another look at the recent history of one of western Canada's best-studied meromictic lakes

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Abstract: Waldsea Lake is a small (~ 5 km^2), meromictic lake located in central Saskatchewan about 100 km east of Saskatoon. It is also one of the most intensely studied saline lacustrine environments in western Canada. Past sedimentological, geochemical, and paleolimnological research efforts have been fruitful because of the high salinity, meromictic nature of the water column, and the fact that the basin is topographically and hydrologically closed, factors which lead to exceptional preservation of fine lamination coupled with a diverse endogenic and authigenic mineral suite. Previous investigators, although recognizing a complex Holocene history of the lake, concluded that the past few thousand years in the basin to have been relatively uneventful. This is surprising considering the magnitude of the environmental changes that have taken place in the region over the past millennium. The objective of this current research project is to apply new high resolution paleolimnological techniques in an effort to decipher the chemical and hydrologic fluctuations that have occurred in Waldsea over the past several thousand years and to understand the driving mechanisms of these fluctuations.

Introduction

Waldsea Lake occupies a small, topographically closed basin in south-central Saskatchewan. With nearly thirty papers, technical reports and theses published on the lake, it has received considerable attention from the scientific community over the past three decades, and is one of Canada's best-studied perennial saline lakes. The basin is also the site of a popular regional park, with associated cottages and recreational areas developed at the south end of the lake. Much of the past and current scientific interest in Waldsea Lake stems from three factors. Firstly, it is a meromictic lake: the upper, relatively fresh, low density water mass does not regularly (seasonally) mix with the lower, hypersaline, high density water. Indeed, Waldsea Lake is one of only four meromictic lakes in the entire northern Great Plains region of western Canada (Last 1989), an area comprising some 400,000 km^2. The elevated solute concentrations coupled with low O_2 levels and the accumulation of high amounts of H_2S in the monimolimnion, produce a toxic environment for most benthic organisms. Lack of bioturbation as well as wind-generated wave energy permits excellent preservation of sedimentary structures in the offshore areas of the lake.

Secondly, the saline to hypersaline nature of the water in Waldsea Lake results in the occurrence of a wide variety of interesting and significant endogenic and authigenic minerals. For example, the presence of non-detrital dolomite in the sediments of Waldsea provides critical geochemical and environmental information about how this economically-important mineral forms in low temperature, near-surface sedimentary settings (Last 1990). Thus, the lake offers a large scale natural laboratory where earth scientists can better understand the genesis and diagenesis of carbonate, sulfate, and sulfide minerals.

Finally, because of its location at the boundary between two major ecosytems, the prairies to the south and the boreal forest to the north, the stratigraphic sequence preserved in Waldsea Lake offers considerable potential for interpreting past changes in regional climate. Similarly, due to its closed topographic and hydrologic nature, the lake sediments in the basin are particularly sensitive recorders of even minor hydrologic fluctuations and environmental changes. Thus, Waldsea Lake is able to provide a wealth of paleoenvironmental information for this ecologically pivotal area of western Canada.

Our objectives in this paper are to provide a brief overview of past geolimnological and paleoenvironmental work that has been done on Waldsea Lake and to highlight the stratigraphic fluctuations that have occurred in several selected paleolimnological parameters, endogenic mineralogy and detailed carbonate petrography, during the past several thousand years. The mineralogical and petrographic results presented here are part of a larger on-going effort to better understand and resolve the most recent (past 2000 years) history and paleolimnology of Waldsea Lake through the use of multiple proxies, including stable isotope and trace element geochemistry, organic Rock-Eval geochemistry, palynology, and ostracode biostratigraphy.

Materials and Methods

The sediment cores used in this study were acquired with a modified Livingstone piston corer. All cores were collected during the winter using the ice cover as a stable coring platform. Cores were extruded while on the ice, allowed to freeze, and transported to the University of Manitoba where they were kept frozen until logging and analyses. Subsamples were collected at variable intervals (from 1 mm to 2 cm) throughout the cores as determined by the bedding features and amount of material required for analysis. All mineralogical analyses were done by standard X-ray diffraction techniques and all crystal size data were collected using a laser-optical analyzer (Galai CIS-1). Details of these lithostratigraphic analytical and sampling procedures can be found in Hardy and Tucker (1988), Klug and Alexander (1974), Last (1996), Marquart (1986), Schultz (1964), Goldsmith and Graf (1958), Aharonson et al. (1986), Dean (1974), and Allen (1981). Image analysis and quantification of the aragonite crystal shapes were done using the shape analysis subroutine of the Galai CIS-1 PSA equipment (Galai Production Ltd. 1989) Chronostratigraphy of the recovered sequences was provided by ^{14}C dating as presented in Schweyen (1984), Last and Schweyen (1985), and Last (1991). Sediment trap methodology is presented in Håkanson et al. (1989), Håkanson and Jansson (1983), and Last (1993; 1994). Thermodynamic saturation interpretations follow the concepts presented in Wasson (1984), Shang and Last (1997), and Shang (1999). Sample preparation and mounting techniques used for scanning electron

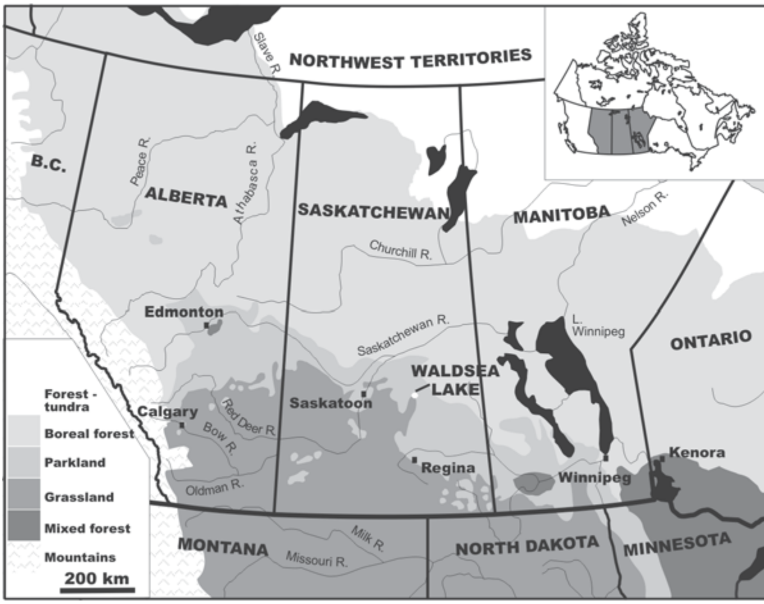

Figure 1: *Map of western Canada showing the location of Waldsea Lake. Also shown are the major vegetation/ecozones of western Canada: Forest-Tundra, Boreal Forest, Parkland, Grassland, Mixed Forest, and Mountains.*

microscopy follow the procedures outlined in Goldstein et al. (1984) and Trewin (1988).

Setting and Modern Geolimnology of Waldsea Lake

Because Waldsea Lake is so well studied, we will only briefly review the modern setting and sedimentary processes here. Details of the geolimnology, hydrology, and neolimnology of this basin can be found in Hammer (1978; 1986), Hammer et al. (1978), Lawrence et al. (1978), Parker et al. (1983), Schweyen and Last (1983), Swanson and Hammer (1983), Schweyen (1984), Last and Schweyen (1985), Last and Slezak (1986; 1988), and Last (1991).

Waldsea Lake is located about 100 km east of Saskatoon, Saskatchewan (Figure 1), in an area of flat to gently undulating topography. The basin is underlain by about 70 m of till and glaciofluvial/lacustrine sediments (Meneley 1967; 1964) which sit on Mesozoic sandstone and shale bedrock. Except for the regional park at the south end of the lake, the land surrounding the basin is intensively cultivated. The park and recreational complex contain several campgrounds, day-use picnic areas, and about 75 seasonal-use cottages. The lake is located within the aspen parkland vegetation zone, transitional between the shortgrass prairie to the south and west and the boreal forest zone to the north. The town of Humboldt, located 10 km south of the lake, receives about 36 cm of precipitation per year, however, nearly three times this amount can be lost from the open water of the lake during the ice-free season (CNC/IHD 1978). Mean temperatures for January and July are -18^{o}C and 19^{o}C, respectively.

Waldsea Lake has a surface area of about 5 km^2 (Table 1) and a simple cone-shaped morphology (Figure 2). The lake's maximum depth of 14.8 m occurs in approximately the center of the basin. Mean depth is just over 8 m.. Several small to intermittent streams drain a catchment of approximately 50 km^2. In normal years the lake's hydrologic budget is dominated by groundwater inflow and loss by evaporation. The basin is topographically closed with a spill point about 6 m above the present-day level. The hydrologic budget of the lake also indicates the lake is hydrologically closed. Water enters the lake mainly via groundwater inflow (plus streams, direct precipitation and sheetflow) but only leaves by evaporation (Schweyen 1984).

Waldsea Lake water is saline to hypersaline, with an average salinity of the mixolimnion of about 25 ppt TDS and 70 ppt TDS for the monimolimnion (Table 1). A phototropic bacterial plate, composed of the sulfur bacteria *Chlorobium*, exists immediately below the chemocline at about 8 m depth. Both the upper and lower water masses are strongly dominated by sodium, magnesium, and sulfate ions. The surface water is alkaline (pH 8.6-9.3) and, although the monimolimnion has a slightly lower pH, the entire water column is saturated or supersaturated with respect to various carbonate minerals at all times of the year (Figure 3). Because of the high Mg/Ca molar ratio of the brines, aragonite is the stable calcium carbonate phase being precipitated in the lake today. The

Table 1. *Morphometric and hydrochemical characteristics of Waldsea Lake.*

Morphometry

Surface Area	4.65 km^2
Drainage Basin Area	47.2 km^2
Drainage Area/Lake Area	10.2
Shoreline Length	10.7 km
Shoreline Development	1.3
Maxiumum Depth	14.8 m
Mean Depth	8.1 m
Relative Depth	0.63%
Volume	0.04 km^3
Volume Development	1.7
Volume in Mixolimnion	87%
Volume in Monimolimnion	13%
Total Salt	700 x 10^6kg

Hydrochemistry

	Mixolimnion	**Monimolimnion**
	(Average concentration: mg L^{-1})	
Ca^{2+}	320	441
Mg^{2+}	3939	5616
Na^+	4414	6988
K^+	156	273
HCO_3^-	231	427
SO_4^{2-}	12,488	30,067
Cl^-	4471	8863
TDS (ppt)	25.4	67.2
Ionic Strength	0.61	1.03
pH (pE)	8.7 (3.4)	7.8 (-5.3)
H_2S	0	590

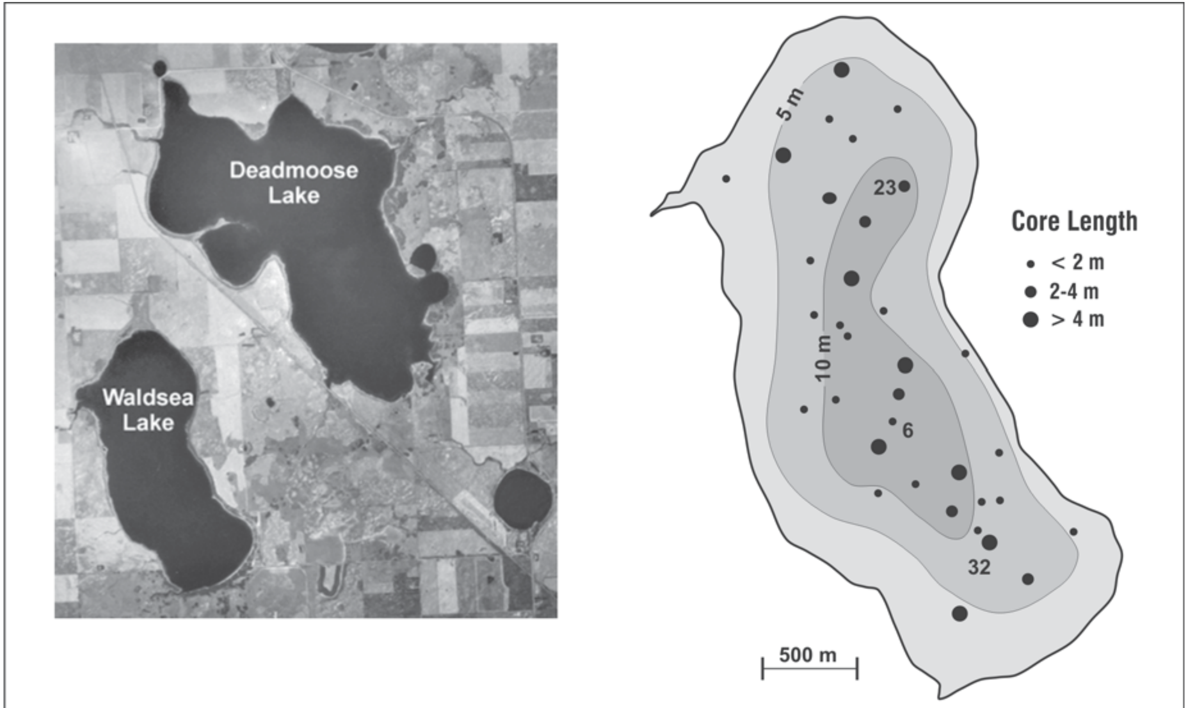

Figure 2: *Airphoto showing Waldsea and Deadmoose Lakes and the bathymetry of the Waldsea basin. Also shown on the bathymetric map are the locations of the 35 core sites in the basin. The numbers 6, 23, and 32 refer to the cores discussed in the text.*

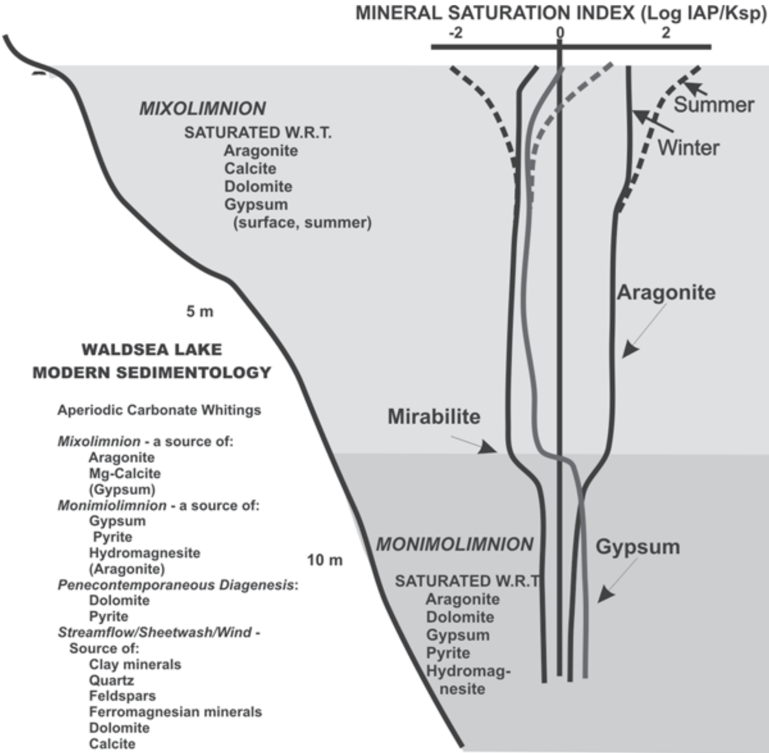

Figure 3: *Schematic summary of the modern chemical sedimentology of Waldsea Lake. The variations with depth in the water of the mineral saturation indices for aragonite, gypsum and mirabilite were calculated using WATEQ-F (Rollins 1989) and the long-term (1982-1997) mean water compositions.*

monimolimnion is also perennially saturated with respect to gypsum, as is the upper meter of the mixolimnion during winter. During the winter season, the surface water can also approach saturation with respect to various hydrated sodium and magnesium sulfates.

The modern bottom sediments exhibit a simple facies pattern (see Figure 5 in Last and Slezak 1986): a narrow (50-100 m wide) band of poorly sorted, coarse siliciclastics at the shoreline and in the near-shore areas grades basin-ward into fine-grained, organic-rich, calcareous sediments in the offshore direction. The modern offshore sediments are composed of sub-equal proportions of carbonate minerals and clay minerals (each approximately 30% of the inorganic component), with pyrite (20%), gypsum (10%), quartz (5%), and feldspar minerals (5%). The dominant carbonate mineral is aragonite, but small amounts of magnesian calcite, normal calcite, dolomite, and protodolomite also occur. In addition to these inorganic constituents, the modern offshore sediments comprise about 30% organic matter.

The details of the modern sedimentology and mineral genesis/ diagenesis in Waldsea Lake are exceedingly complex because of the presence of two water masses, each having different salinities, chemical compositions, temperature and organic regimes, and mineral saturation characteristics (Figure 3). In general, the modern sedimentology is controlled mainly by the interaction of the following factors:

(i) evaporative concentration and organic productivity of the mixolimnion which create highly supersaturated conditions and precipitation of endogenic carbonate minerals;
(ii) seasonal freeze-out concentration of the upper part of the mixolimnion which leads to inorganic precipitation of soluble sulfates;
(iii) dissolution and re-precipitation of both carbonates and sulfates in the water of the monimolimnion;
(iv) microbial sulfate reduction at the chemocline as well as within the monimolimnion which gives rise to elevated H_2S levels, penecontemporaneous dolomite formation, and sulfide mineral genesis, and;
(v) detrital influx by wind, sheetflow and streamflow.

A Synopsis of the Holocene History of Waldsea Lake

The Waldsea Lake basin probably originated about 10,000 years ago as a remnant of glacial Lake Fulda (Schweyen 1984) although, to date, our coring has yet to retrieve any lacustrine sediment older than about 6000 years. The stratigraphy of the mid- to late Holocene sediment fill is known from over 80 m of core taken from 35 sites in the basin (Figure 2). In contrast to the relatively simple modern sediment facies relationships, the subsurface facies are considerably more complex. While the entire offshore sedimentary sequence recovered consists of well laminated, fine-grained, organic-rich, calcareous muds similar to the modern deposits, there are significant variations in mineralogical composition, sedimentary structures, organic matter type and content, and isotopic and pore water geochemistry. Each of these parameters provide clues to help interpret the past depositional environments and long-term geochemical evolution of the basin brines. These stratigraphic data and interpretations, summarized in Figure 4, have been presented and discussed in Schweyen and Last (1983), Schweyen (1984), Last and Schweyen (1985), Last and Slezak (1986), Teller and Last (1990), and Last and Vance (1997).

The oldest (mid-Holocene) offshore deposits are laminated to massive, chemically-precipitated sediments (gypsum, mirabilite, magnesite, hydromagnesite, and protodolomite) mixed with relatively coarse grained siliclastics. The presence of numerous exposure horizons, desiccation zones, cemented beds, and pedogenic units within this lowermost sequence has not only curtailed our ability to recover older Holocene sediment, but has also made establishment of absolute chronology difficult. These laminated to massive mixed salts and siliciclastics represent deposition in a shallow, saline, clastic-dominated playa environment where water levels fluctuated from several meters depth to dry conditions. The presence of laterally equivalent peloidal carbonates, tufa and biolaminated sequences indicates this shallow, sulfate-dominated hypersaline brine pool was surrounded by carbonate springs and algal covered mudflats.

Beginning about 4500 years ago, deeper water conditions prevailed in the basin and the complex array of chemically precipitated and biolaminated playa/mudflat sediments at the base of the recovered section grade sharply upward into organic-rich, aragonitic muds. These finely laminated sediments were deposited in a relatively deep, meromictic lake as the hydrologic budget of the basin became increasingly more positive. The monimolimnion of this lake was considerably more saline than that of the modern lake, however, the upper water mass may have been similar to today’s salinity and composition. The fine, irregularly-spaced aragonite laminae probably were generated by fallout sedimentation from repeated, single, basin-wide whiting events, in which massive

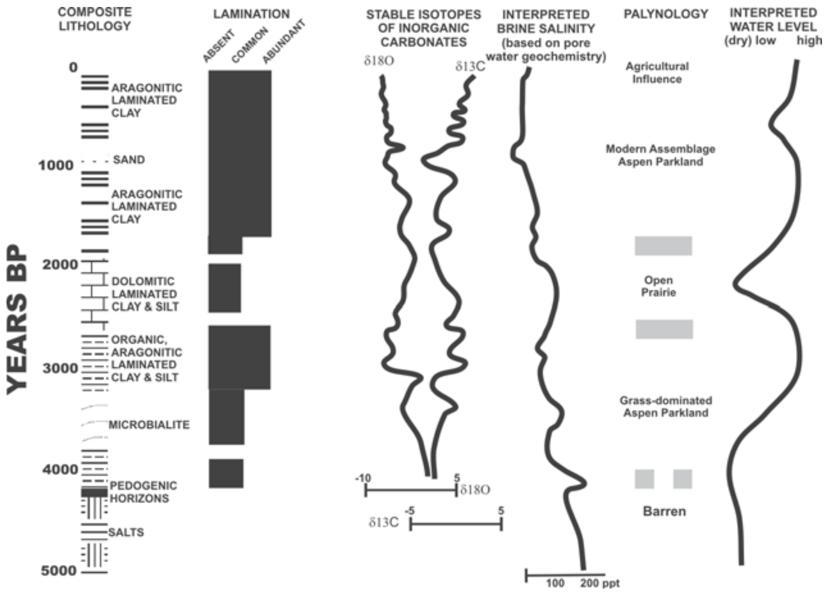

Figure 4: *Composite mid- to late Holocene stratigraphic sequence from Waldsea Lake showing changes in lithostratigraphy, lamination, stable isotopic composition of endogenic carbonate minerals, brine salinity (interpreted from pore water geochemistry), regional vegetation (interpreted from pollen remains), and water levels. These data and interpretations have been compiled from Schweyen and Last (1983), Schweyen (1984), Last and Schweyen (1985), Last and Slezak (1986), Last (1991), and Last and Vance (1997).*

inorganic calcium carbonate precipitation occurred in the mixolimnion. These aperiodic, short-term (several days to several weeks) events were most likely stimulated by irregular influxes of dilute calcium-bicarbonate-rich surface water which, upon mixing with the highly alkaline and Mg-rich saline and hypersaline brines, caused elevated levels of supersaturation, rapid nucleation, and precipitation. These deep-water, meromictic conditions have evidently persisted in Waldsea Lake for much of the past 4500 years except for a short excursion back to mudflat/playa conditions between 2800 and 2000 yr B.P.

Aragonite Laminae Petrography

Detailed petrography of the aragonite in the deep-water laminated sequence of Waldsea Lake offers considerable new insight into the paleolimnology of the basin. Although the entire recovered stratigraphic sequence from Waldsea Lake is finely laminated, our comments and observations here apply just to the sediments deposited during the past ~2000 years (approximately the upper 2 m of sediment).

The aragonite laminae range in thickness from about 0.2 mm to just under 2 mm. Overall, the laminae are widely spaced (two to three laminae per centimeter) but much closer spacing does occur (Figure 5). Upper and lower contacts are invariably sharp and horizontal. The laminae are usually white (Munsell: 5YR 8/1) to pale yellow (2.5Y 8/4) with occasional red (2.5YR 5/8) to pink (5YR 7/4) colours. The pink and red colours rapidly fade upon exposure of the core, and are presumably associated with deposition of organic material from the red to purple coloured bacterial plate at the chemocline or staining by pigments. Individual laminae and sets of laminae can be readily correlated from core to core thus confirming that these rapid precipitation events are basinal in extent. There is no apparent periodicity in the frequency or thickness variation of the laminations within the upper 2 m of section, although the detailed image analysis and statistical evaluation necessary to properly identify a non-random occurrence (cf., Zolitschka 1996; Pike and Anderson 1996) have not yet been completed.

Individual laminae are composed entirely of extremely well-sorted, euhedral, micron-sized $CaCO_3$ crystals. There is an almost complete absence of biological and other non-carbonate grains, suggesting that the layers represent rapid inorganic precipitation and accumulation without dilution by non-carbonate endogenic minerals, siliciclastics, or organic debris. These aragonite crystals show considerable variation in both size and morphology. Individual $CaCO_3$ crystals range in shape from acicular to ellipsoidal, but are usually uniform in any single layer (Figure 6). Most of the laminae have fine, needle-like crystals that are typical of the aragonite formed in many other perennial saline lakes in the northern Great Plains region (e.g., Valero-Garcés and Kelts 1995; Sack 1993; Van

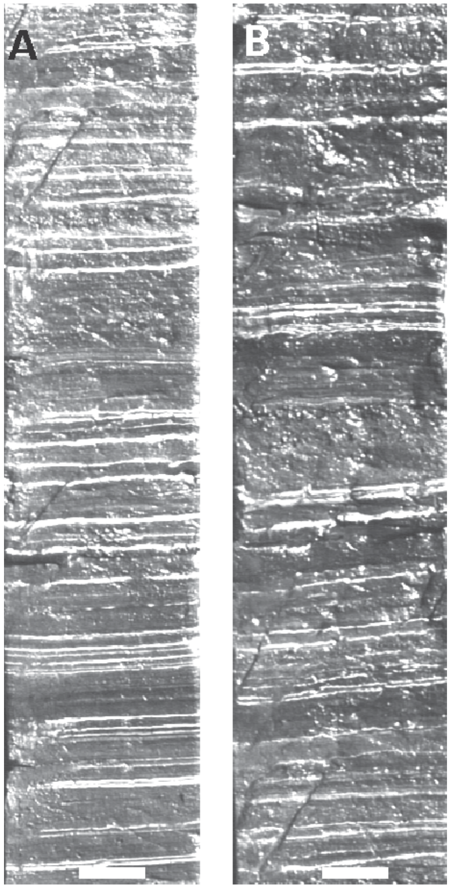

Figure 5: *Photographs of representative sections of cores from Waldsea Lake showing aragonite lamination. Scale bar is 1 cm. Photograph A is from core 32; photograph B is from core 6.*

Stempvoort *et al.* 1993; Slezak 1989). The aragonite in some of the laminae, however, has a distinctive wheat grain or rice grain morphology. This ellipsoidal aragonite has been noted in other deep water saline lakes in Canada and Australia, as well as from the Black Sea, and is indicative of newly-formed $CaCO_3$ crystals settling through a relatively deep, stagnant, somewhat understaturated water

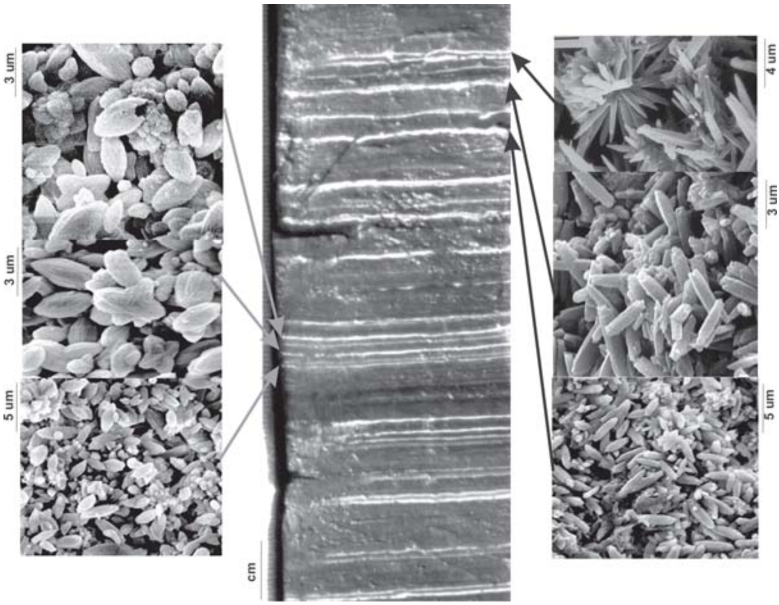

Figure 6: *Variations in aragonite crystal shapes in selected laminae from a Waldsea Lake core. Examples shown on the left illustrate laminae composed mainly of ellipsoidal (rice-grained) crystals; examples on the right show laminae in which the aragonite is mainly of acicular morphology.*

column (Sack and Last 1994; Last and De Deckker 1990; Stoffers and Müller 1978; Hsü 1978).

Conditions in Waldsea Lake today are such that ellipsoidal aragonite does not form and the modern bottom sediments contain only acicular $CaCO_3$. This is because both the mixolimnion, where the aragonite is forming, and the monimolimnion are very close to saturation with respect to aragonite. Geochemical modeling (Schweyen 1984) indicates however, that shallowing of the chemocline by about 4 m would produce understaturated conditions in the lower water mass and, in turn, create conditions favorable for the generation of rice-grain aragonite crystals. Thus, laminae with ellipsoidal aragonite crystals indicate the presence of a stratified water column in which the chemocline was considerably shallower than that of the modern lake, or, alternatively, the

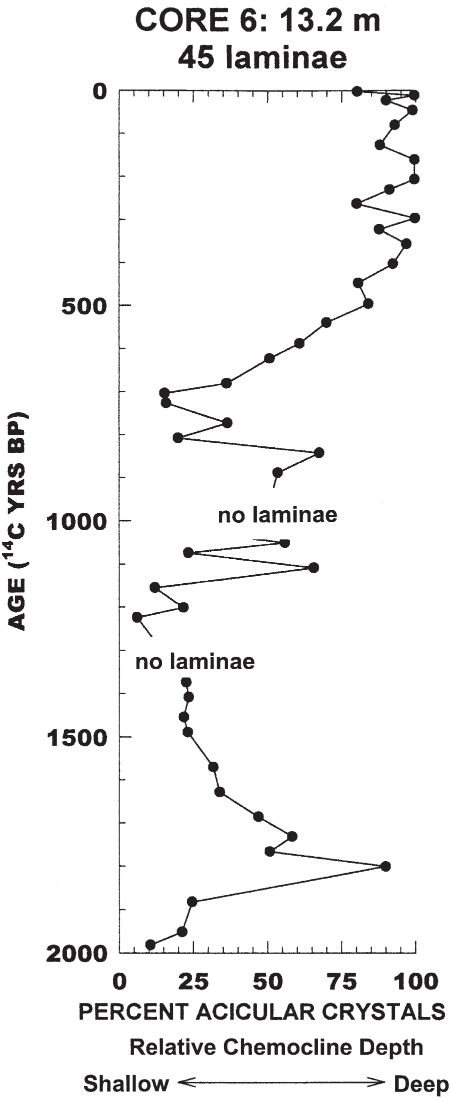

Figure 7: *Stratigraphy variation in the percent of acicular crystals in individual aragonite laminae from core 6. As discussed in the text, laminae with relatively low proportions of acicular crystals suggest relatively shallow chemocline depths and slightly undersaturated monimolimnion conditions whereas laminae with high proportions of acicular crystals indicate relatively greater chemocline depths and near-saturated conditions in the bottom water.*

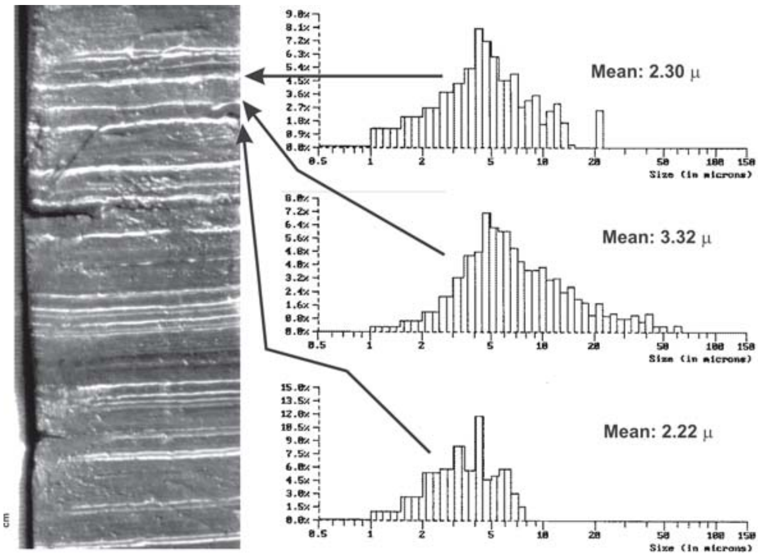

Figure 8: *Examples of variations in mean aragonite crystal size in laminae from core 6. Size spectra are shown as histograms of the relative abundance of the crystals in each size category. Note the logarithmic scale of the size axes.*

monimolimnion was less saturated (more undersaturated) with respect to $CaCO_3$.

As shown in Figure 7, the proportion of euhedral acicular aragonite crystals relative to other shapes in laminae from one of the cores near the basin center increased dramatically at about 500 years B.P. This suggests that the depth to the chemocline increased significantly in the lake about that time possibly due to the influx of more freshwater via precipitation and steam runoff, increased wind mixing of the mixolimnion, or an increase in the degree of saturation with respect to $CaCO_3$ of the monimolimnion.

The crystals in individual laminae are extremely well sorted (average $s < 1.0$ mm) and have a mean size ranging from less than 2 mm to more than 26 mm (Figure 8). There is a general trend toward increasing crystal size upward in the cores. Although many geochemical and environmental factors combine to determine the size of precipitated inorganic crystals, one of the most important is the length of time the crystal resides in the supersaturated solution.

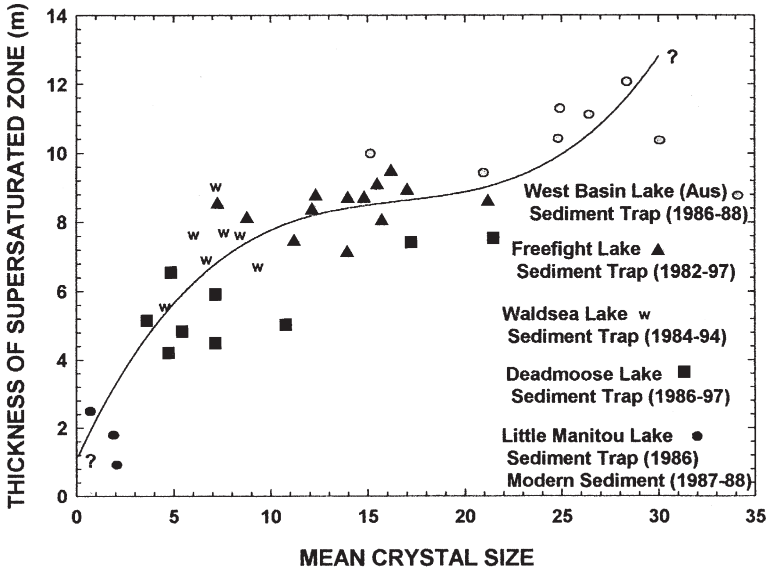

Figure 9: *Relationship between endogenic crystal size and the depth ("thickness") of the supersaturated water column in modern sediments from five aragonite precipitating saline and hypersaline lakes.*

Thus, the stratigraphic variation in aragonite crystal size in the laminae is a reflection of the depth of the supersaturated water column. In the modern lake, this is essentially the depth of the mixolimnion (or the depth to the chemocline). Using aragonite crystals collected in sediment traps from modern Waldsea Lake and other aragonite-precipitating basins (Figure 9), it is possible to calibrate the stratigraphic variation in crystal size in terms of approximate depth to the paleochemocline (or, more correctly, the vertical extent of the supersaturated water column). Other factors, such as the degree of supersaturation and the amount of crystal size modification that may take place during settling through an understaturated monimolimnion may affect these estimates, but this crystal size parameter should offer a reliable means of estimating past chemocline depths.

Figure 10 shows the fluctuation in interpreted chemocline depth of Waldsea Lake over the past 2000 years based on the mean crystal

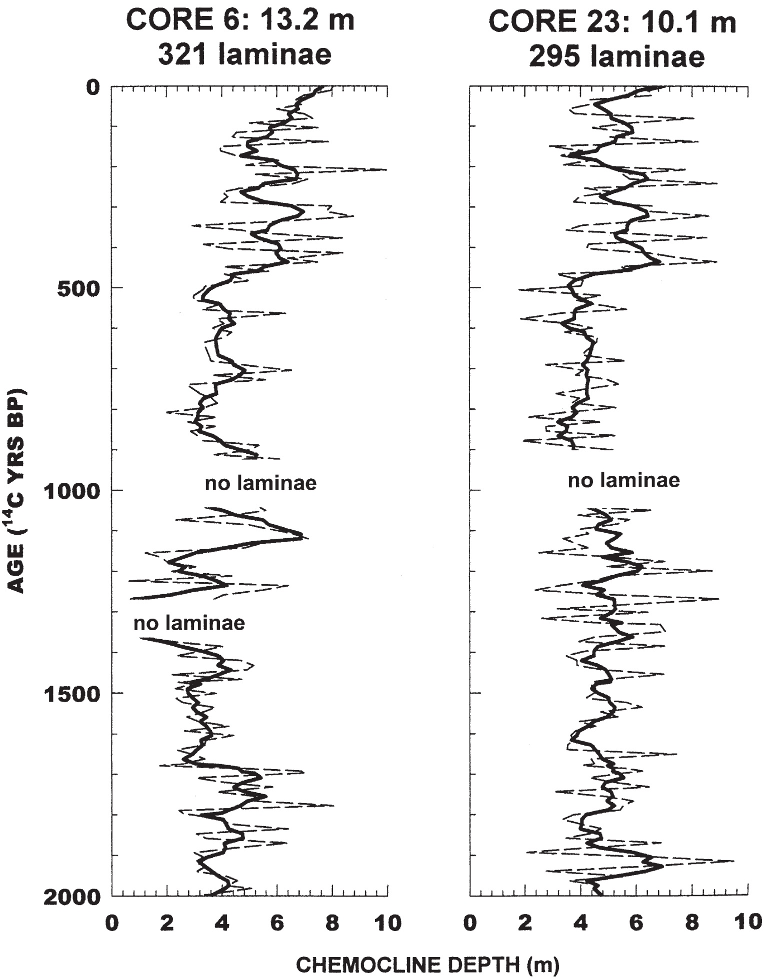

Figure 10: *Stratigraphy variation in interpreted chemocline depth based on detailed aragonite crystal size spectra collected from laminae of two cores from Waldsea Lake. The dark continuous line is a 3 sample running average.*

size of aragonite crystals in two cores in the basin. Core 6, the same core on which the detailed aragonite shape analysis was done, is located near the deepest part of the basin (Figure 2). Core 23 is located about a kilometer north of core 6 in ~10 m water depth. Although the fluctuations do not match precisely, there is good general correspondence between the two cores. Both cores show a significant increase in interpreted chemocline depth during the most recent 500 year period and generally shallower chemocline depths between about 500 and 1700 years B.P. This corresponds well with the changes in water column conditions interpreted from the aragonite crystal shape analyses.

Detailed Carbonate and Evaporite Mineralogy

Although the stratigraphic sequence recovered from Waldsea Lake is dominated by aragonite, pyrite, and clay minerals, a wide variety of other endogenic, authigenic, and allogenic minerals have been identified in the cores (Table 2). As pointed out above, the paragenesis of specific mineral phases and suites of minerals identified in Waldsea Lake is exceedingly complex. In a saline meromictic water body that is dominated by groundwater influx such as Waldsea Lake, the distinction between true endogenic sediments (material generated from within the water column) and authigenic components (minerals originating either by diagenetic alteration of previously deposited material or minerals precipitated from solution within the pore space of the sediments) becomes obscure. Nonetheless, a basic tenet of chemical sedimentology is that in a hydrologically closed system undergoing evaporative concentration, the assemblage of non-detrital minerals must have the same bulk ionic composition as the original water (Hardie 1984). As discussed elsewhere (Wasson *et al*. 1984; Torgersen *et al*. 1986; Teller and Last 1990; Last 1994), there are many assumptions and limitations that must be accepted in the application of this straightforward principle to paleolimnology. Waldsea Lake, a topographically and hydrologically closed basin having a relatively small catchment and a long, continuous record of chemical sedimentation from saline and hypersaline brines, is however, ideally suited for paleochemical reconstructions from such types of thermodynamic and mass balance calculations.

Fundamental to our understanding of past chemical conditions in the basin is the fact that regardless of *how* a particular mineral formed (i.e., whether it is endogenic or authigenic), its *presence*

Table 2: *Endogenic and authigenic minerals in Waldsea Lake sediment.*

ALUM	$Al_2(SO_4)(OH)_4\ 7H_2O$
ARAGONITE	$CaCO_3$
BLOEDITE	$Na_2Mg(SO_4)_2\ 4H_2O$
BOUSSINGAULTITE	$(NH_4)2Mg(SO_4)_2\ 6H_2O$
BURKEITE	$Na_6(CO_3)(SO_4)_2$
D'ANSITE	$Na_{21}Mg(SO_4)10Cl_3$
DESPULJOSITE	$Ca_3Mn(SO_4)_2(OH)_6\ 3H_2O$
DOLOMITE	$CaMg(CO_3)_2$
DYPINGITE	$Mg_5(CO_3)_4(OH)_4\ 5H_2O$
EPSOMITE	$MgSO_4\ 7H_2O$
FOGGITE	$CaAl(PO_4)(OH)\ H_2O$
GAYLUSSITE	$Na_2Ca(CO_3)_2\ 5H_2O$
GLAUBERITE	$Na_2Ca(SO_4)_2$
GYPSUM	$CaSO_4\ 2H_2O$
HALITE	$NaCl$
HANNEBACHITE	$2CaSO_3\ H_2O$
HANKSITE	$KNa_{22}(SO_4)_9(CO_3)_2Cl$
HEXAHYDRITE	$MgSO_4\ 6H_2O$
HYDROHALITE	$NaCl\ 2H_2O$
HYDROMAGNESITE	$Mg_5(CO_3)_4(OH)_3\ 4H_2O$
MAGNESITE	$MgCO_3$
METALUMINITE	$Al_2(SO_4)_6(OH)_4\ 5H_2O$
MIRABILITE	$Na_2SO_4\ 10H_2O$
MOHRITE	$(NH_4)_2Fe(SO_4)_2\ 6H_2O$
NORTHUPITE	$Na_3Mg(CO_3)_2Cl$
PROTODOLOMITE	$CaMg(CO_3)_2$
PYRITE	FeS_2
RHOMBOCLASE	$Fe(SO_4)_2\ 4H_2O$
SYNGENITE	$K_2Ca(SO_4)_2\ H_2O$
THENARDITE	Na_2SO_4

(rather than abundance) implies that the formative brine was saturated (or supersaturated) with respect to that mineral. In other words, the product of the chemical activities of the ions of which the mineral is composed must have exceeded the solubility product for that mineral. For example, a sample with an endogenic mineral assemblage composed entirely of gypsum implies that the lake or pore water had a minimum equimolar concentration of Ca^{2+} and SO_4^{2-} of 5.0×10^{-3}, or a minimum salinity of ~2 ppt TDS, whereas the formative brine responsible for a sample with both mirabilite and gypsum had a minimum salinity of about ~40 ppt and concentrations of 5.2×10^{-3}m Ca^{2+}, 6.3×10^{-1}m Na^{+},and 3.1×10^{-1} m SO_4^{2-}. This conceptually simple approach becomes more complex as the ionic strength of the solution increases because the salts become increasingly dependent on the co-solutes in the water.

Figure 11 shows the variations in relative thermodynamic activity for the major cations and anions in the formative brines over the past 2500 years interpreted from core 32. Clearly, Waldsea Lake brine compositions have fluctuated significantly over the past several millennia. Similar to the results of the aragonite petrography discussed above, it is evident a major change occurred at about 500 years BP in which the chemistry of the water became strongly depleted in calcium and relatively enriched in magnesium. Likewise, a similar Mg-enrichment/Ca-depletion phase occurred for several centuries immediately before 1500 BP which corresponds well with a relatively deeper chemocline interpreted from the aragonite petrography of core 6.

Conclusion

Waldsea Lake is one of western Canada’s best-studied perennial saline lakes. Because of its location at the boundary between prairie and forest ecosystems the stratigraphic record preserved in this basin holds considerable promise as an important archive of paleoenvironmental information. Although previous investigations have highlighted a complex mid-Holocene history of the basin and a somewhat more complacent recent history, our investigations of the carbonate petrography and detailed mineralogy

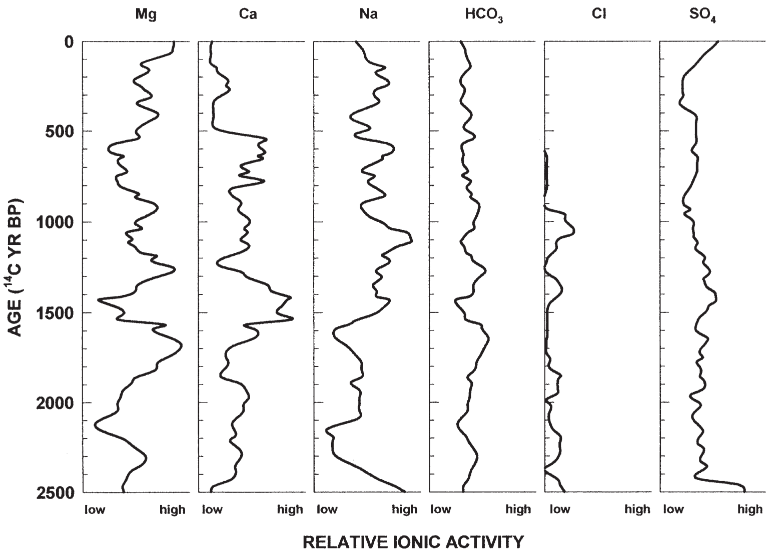

Figure 11: *Stratigraphic variation in relative chemical activities of major dissolved cations and anions of lake (or interstitial) brines in Waldsea Lake based on the endogenic/authigenic mineral suite. Relative activity values increase to the right.*

have shown that significant geolimnological fluctuations have also occurred within the past two millennia.

Although these types of brine chemistry water column reconstructions provide valuable insight into the past chemical and physical conditions in the lake, it must be emphasized that the Waldsea Lake depositional system is considerably more complex than a relatively simple non-meromictic salt lake or a shallow playa basin (cf., Shang and Last 1997; Last *et al.* 1999). Thus, the history of chemical change and water column variaton in this closed basin is difficult to interpret with respect to extrinsic environmental factors such as climate. These chemical changes may be indicative of changing watershed conditions (e.g., drainage basin size, vegetation cover), surface water hydrological fluctuations (e.g., lake size, depth, river inflow, diversion), or variations in groundwater contributions and composition, all of which may or may not be related to climate. Deciphering the interrelationships between lake hydrology, regional climate, and the chemistry of a brine is an arduous task even in a simple lacustrine system. Few lakes in the northern Great Plains offer an unambiguous record of climate change; Waldsea Lake is no exception. Nonetheless, examination and documentation of the interplay between the many intrinsic processes that are operating within the basin itself and the various extrinsic or external factors that help control the geochemical aspects of the lake is essential for a proper assessment of the lacustrine record.

Acknowledgements

This research was made possible through funding from the Geological Survey of Canada's Palliser Triangle Global Change Project, the Natural Sciences and Engineering Research Council of Canada, and University of Manitoba. Ms. Anne Ross and Mr. Grant Caresle provided valuable assistance in the laboratory.

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Cyclic water levels in Clear Lake, Riding Mountain National Park, Manitoba

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Abstract: Water levels in Clear Lake have ranged from an estimated mean daily high of 615.940 m in June 1994 to an historical mean daily low of 614.788 m (November 1961). The 115.2 cm range suggests significant variability in water levels over the 39-year period of record. The mean daily water level for the 1960-1998 period is calculated to be 615.275 metres above sea level. The standard deviation for the data is 0.195 m or 19.5 cm.

The 1960-1998 lake elevation records suggest that Clear Lake experiences cyclic high and low water levels. Cyclic water levels in the Clear Lake system are controlled by winter snow accumulation summer rainfall, evaporation losses, run-out discharge, the morphology of the outlet channel and beaver.

Normally, there is a ten-year period between extremely high and extremely low lake levels (e.g. low 1961-1962, high 1969-1971, low 1980-1844, and high 1993-1995). Low water stages are almost always associated with regional drought and appear in the lake stage record approximately every eleven years; 1962, 1973, 1984(?) and perhaps 1998. Extremely low water levels 1962, 1984 have a recurrence interval of approximately 20-25 years.

It appears that extremely high lake stages also occur every 20-25 years and persist over several seasons, approximately five to six years. These periods of extremely high water have been subdivided into three phases. The initial phase involves a two to three year period of high water, which is associated with wetter than normal conditions, and little or no runout down Clear Creek.

Normal or low water stages, which occur prior to the initial high water phase, expose the Clear Creek outlet sill to wave action and ice thrusting. During these times easterly winds build-up a beach crest or sand berm

across the outlet. These processes effectively raise the elevation of the outlet sill, inhibiting runout discharges and increasing the storage potential in the lake. Stream discharges equal to or less than 0.8 m^3 s^{-1} support beaver populations. A stair-step profile develops along the low gradient (< 0.002) outlet channel consisting of a series of beaver dams, impoundments and shallow, low flow connecting channels. Runout discharges from Clear Lake are small (< 0.2 m^3 s^{-1}) and may become sub-surface moving through the outlet berm.

The second (critical) phase in the "extremely high water" years begins when lake levels reach a critical threshold (approximately 615.600 m above sea level). Discharges are forced down Clear Creek, eroding the beach crest (berm) and scouring the channel. During this one to two year period, mean runout discharges generally increase as the channel cross-sectional area increases.

The final (draining) phase in the extremely high water years begins when the outlet channel has achieved maximum cross-sectional area. This phase usually lasts two to three years. Runout discharges peak at values ^{3} 2.0 m^3 s^{-1} and then fall to values < 1.0 m^3 s^{-1} as lake levels drop. Once runout discharges are < 0.8 m^3 s^{-1} the beaver return to the Clear Creek channel, initiate the development of the low gradient stair-step profile and further restrict outflow discharges.

Introduction

The Clear Lake watershed is centrally located on the Riding Mountain Uplands in southwestern Manitoba (Figure 1). The watershed drains an area of 142.18 km^2 of which over 65 percent is located in Riding Mountain National Park. Clear Lake represents approximately 20.7% of the watershed area (Figure 2). Park managers have recognised the need for data acquisition and scientific study regarding the Hydrologic Water Balance of Clear Lake and the associated watershed. This scientific knowledge is fundamental towards an understanding of the physical, chemical and biological processes, which occur in the watershed. Baseline data will ultimately provide a sound foundation for the development of both short term and long term park management plans for the preservation of the natural state in the Clear Lake watershed.

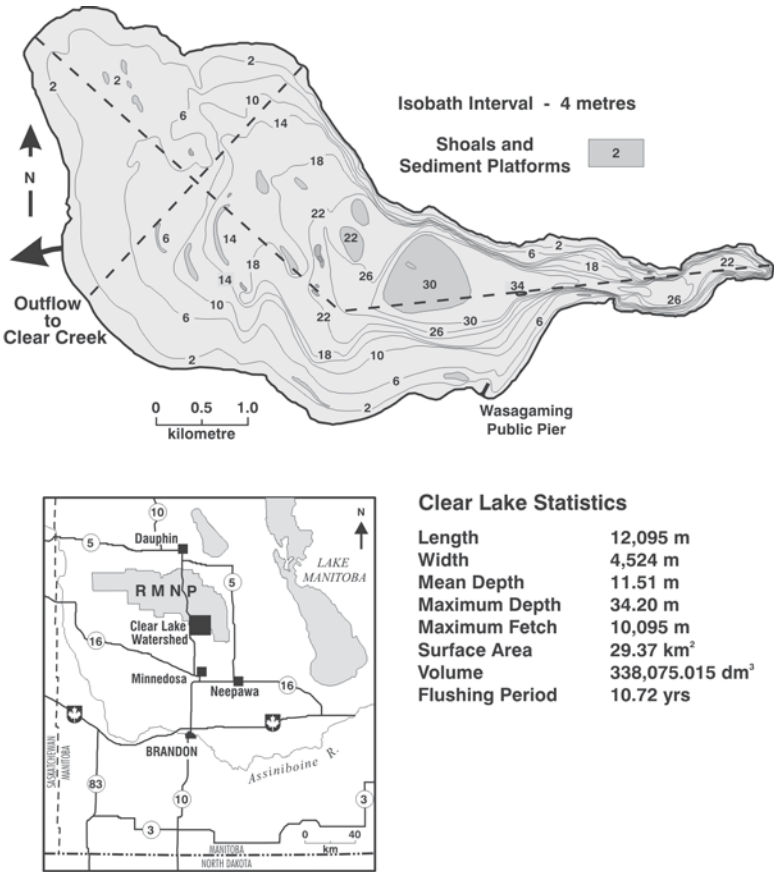

Figure 1: *Location of study area and Clear Lake bathymetry.*

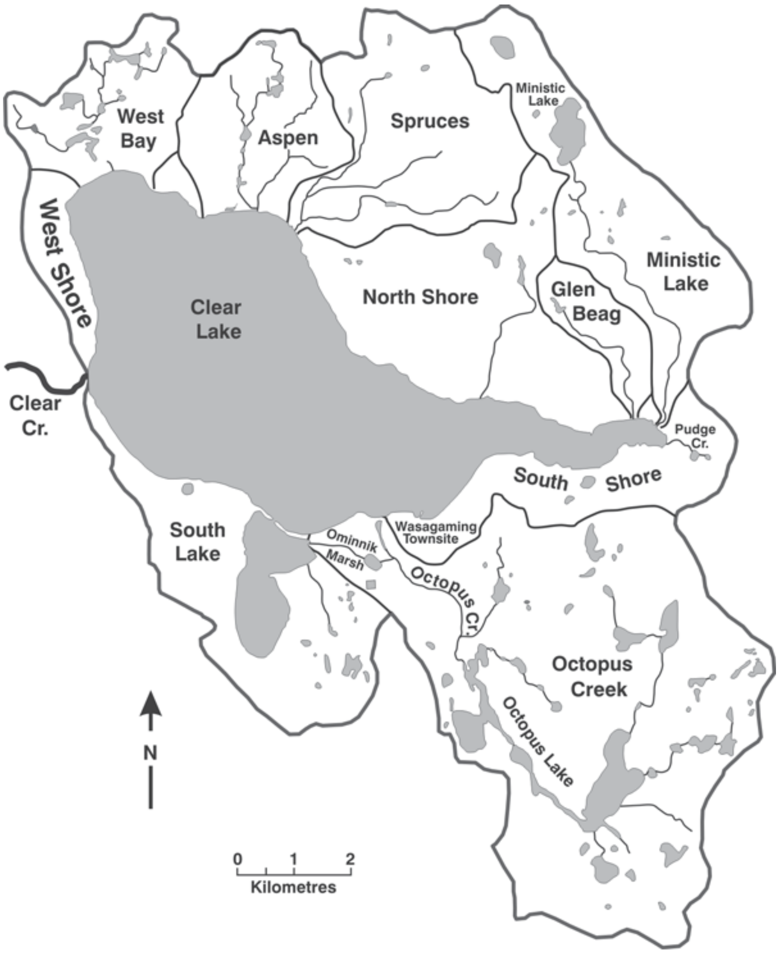

Figure 2: *Sub-basins of the Clear Lake watershed.*

The Components of the Clear Lake Drainage Network

Clear Lake is the most significant storage component in the Clear Lake drainage network (Figure 1). The lake covers an area of 29.37 km^2 (20.7% of the total watershed area) and has a maximum recorded depth of 34.2 m. Clear Lake has a west-east orientation; wider and shallower in the western portion and narrow and deep at the eastern end (Figure 1). The water body is approximately 12,095.0 m in length along a mid-lake line and approximately 4,524.0 m wide. The mean depth is calculated to be 11.51 m. It is estimated that Clear Lake holds approximately 338,075.015 m^3 of stored water.

Normally, Clear Lake is classified as oligotrophic, deep and deficient in plant nutrients (Bazillion and Braun 1992), and considered to be diamictic in that there is a spring and fall turnover. In the summer however, Clear Lake becomes thermally stratified and during these times the lake may be classified as holomictic or completely mixed (Bazillion and Braun 1992). The flushing period, defined as the time required to drain the storage volume of a water body through the outlet, is calculated to be 10.72 years. This number is based on a storage volume of 338,075,015.0 m^3 and a mean daily outlet discharge of 0.1 m^3 s^{-1}. It should be noted that recorded outlet discharges (measured between 1994 - 1998), range from 0.0 m^3 s^{-1} to 2.8 m^3 s^{-1}. The spring melt average discharge is estimated to be 1.0 m^3 s^{-1}. Prior to 1994 however, outlet discharges are believed to have been near 0.0 m^3 s^{-1} as the outlet channel was very shallow, narrow and overgrown with vegetation.

Prevailing winds during the open water period (May - October) are from the southeast (26.6% of the time) and northwest (23.7% of the time). During these periods the maximum fetch is approximately 7,666.0 m. Extreme winds are generally from the southwest (May - July and September) with a maximum fetch of 4,142.0 m. In August the extreme wind events are from the west. When these winds occur the maximum fetch is over 10,095.0 m and this physical combination can generate a small wind set-up in the narrow eastern end of Clear Lake.

Other significant water storage components comprising the Clear Lake drainage network include South Lake, Octopus Lake, and Ominnik Marsh to the south, and Ministic Lake in the northeast (Figure 2).

Surface runoff drains into Clear Lake by way of Octopus Creek, Pudge Creek, Bogey Creek (Ministic Lake Creek), Picnic Creek (Glen Beag Creek) and six intermittent streams located along the north shore of the lake (Figure 2). Three of the most prominent of these intermittent streams have been named Spruces Creek, Aspen Creek, and North Shore Creek for the purpose of identification during this study. Although there is little information at this time, groundwater is also believed to contribute to the storage volume of Clear Lake.

Clear Creek (Wasamin Creek), the outlet stream is located at the western end of Clear Lake (Figures 1 and 2). Water Survey of Canada has not gauged Clear Creek until recently, however, periodic observations suggest that the outlet stream can flow year round and that the mean discharge values are relatively small (0.0 $m^3 s^{-1}$ - 2.0 $m^3 s^{-1}$). Clear creek drains into the Little Saskatchewan River approximately six km upstream of Horod, Manitoba. Until very recently the stream channel was overgrown and the flow impeded by numerous beaver dams and associated storage ponds. It is suspected that groundwater discharge may represent a significant outflow from Clear Lake particularly when the outlet channel has a beaver dam stair-step profile and is overgrown.

Monitoring Programs

From 1960 to 1978 Water Survey of Canada (Environment Canada) monitored the open water lake levels in Clear Lake. A staff gauge, located on the Wasagaming Pier (Figure 1), was read manually and daily lake levels recorded. The lake level monitoring programme ended in October 1978. Monthly mean water level values are illustrated in Figure 3.

With the inception of the Clear Lake Basin Project (1994), Environment Canada, for Parks Canada, again monitored water levels on Clear Lake. The Environment Canada monitoring site, identified as 05MF019, is located on the east side of the Wasagaming Pier (Figure 1). From 1994-1997, a Stevens (A-71)

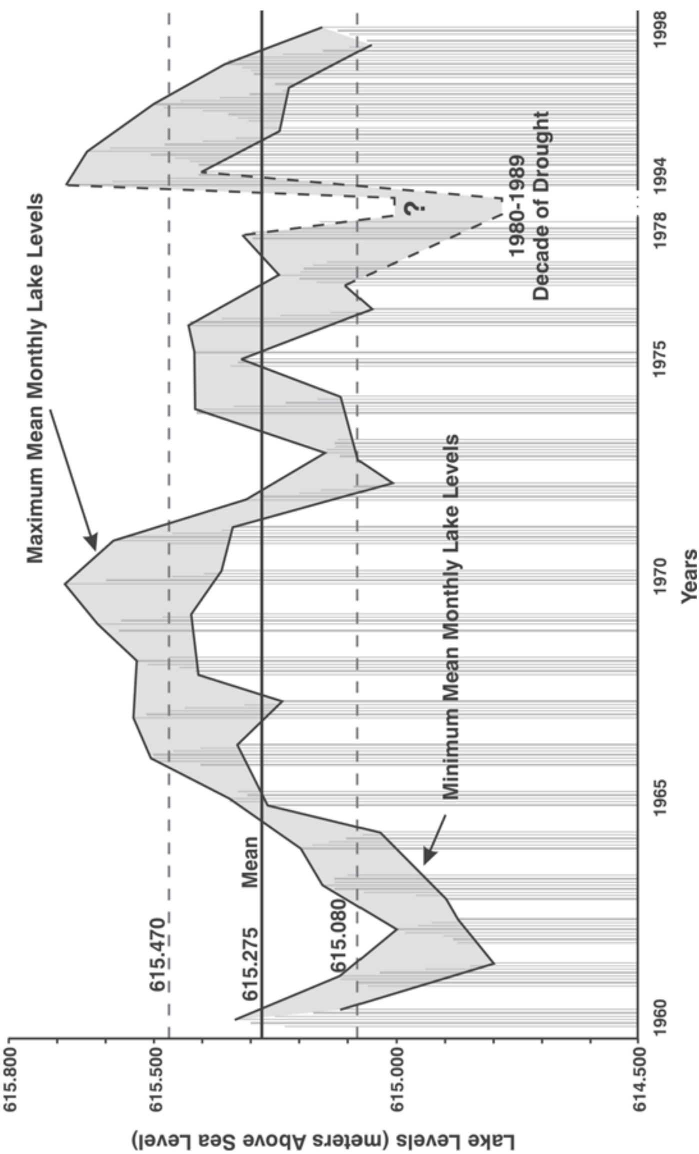

Figure 3: *Lake levels (1960-1978), (1994-1998) Clear Lake.*

Stage Recorder charted the instantaneous fluctuations in lake level and Environment Canada provided calculations of the mean daily lake level. A staff gauge, read by Park officials was also used. On March 24 1997, the stage recorder was automated, converting to an Accubar Pressure Transducer. Water levels, averaged every two minutes, are sent to a VADAS Environment Data Acquisition System, housed in the pump house located on Wasagaming Drive. Environment Canada calculates the mean daily water levels. The Stevens Stage Recorder was removed in spring, 1998. Monthly mean water level values are illustrated in Figure 3.

1960-1978 Lake Levels

The 1960-1978 lake level data set is variable and occasionally incomplete. Water level monitoring on Clear Lake normally occurred during the six-month open water period, May to October inclusively. For three years (1961-1963) however, the monitoring began two months earlier than normal on the first of March. In 1966, 1973 and 1977 water level monitoring began one month earlier than normal on the first of April. These earlier than normal startup times are probably indicative of earlier than normal ice cover break-up dates. Normal break-up occurs in mid May. In 1977 lake level monitoring continued into November, suggesting a late freeze-up. Normal freeze-up occurs in mid November. Some 1960-1977 monthly data are missing: October 1965, June 1969 and May and September 1975. All the 1978 monthly data is missing from the Environment Canada data set.

From a summer peak water level of 615.367 m in July 1960, water levels in Clear Lake declined to the historical mean daily low on November 13, 1961 (614.788 m). The period 1960-1962 is recognized as a time of severe regional drought in southwestern Manitoba (McGinn and Tolton 1989). The Palmer Drought Severity Index (PDSI) (Palmer 1965), a recognized measure of drought, achieved a value of -3.37 in August 1961 (Punak 1990).

The PDSI evaluates moisture conditions at a site in terms of the normal conditions. Normal moisture conditions are assigned a PDSI value of zero. Wetter than normal index values range from

1.0 to 7.0 where a value of 1.0 represents mildly wet conditions and 5.0 is considered extremely wet (Palmer 1965). Drought conditions range from -1.0 to -7.0. A PDSI value of -3.0 is indicative of severe drought (Bryant 1993).

Total accumulated rainfall for the water year (October 1960 - September 1961) was approximately 329.8 mm, about 126.2 mm below normal (Punak 1990). Calculated Potential Evapotranspiration (PE) for the same period was estimated to be 584.6 mm, 31.6 mm above normal. Potential Evaporation, a function of temperature and solar radiation, is an estimate of water demand and is considered to be a measure of evaporative power. The combination of below normal precipitation and higher than normal PE for two water years (October 1959 - September 1961) resulted in declining water levels in Clear Lake and the lowest historical monthly water level (614.798 m) observed (November 1961).

From the 1961 historical low lake level, mean annual water levels rose in Clear Lake throughout the mid sixties (Figure 3). During the 1968-1969 water years (October 1967 - September 1969) the Clear Lake watershed was wetter than normal. Precipitation totals recorded at the Wasagaming climate station exceeded 994.2 mm and the potential for evapotranspiration was lower than normal. PDSI values were positive 23 out of the 24 months (Punak 1990) and for five months in 1969 the PDSI values exceeded 2.0 (moderately wet). Consequently, water levels continued to rise. The highest historical mean daily lake level of 615.723 m and the associated highest historical mean monthly lake level (615.684 m) were observed in June 1970.

Following the historical high water level (June 1970), lake levels decreased as the drought of 1973 approached. A mean monthly value of 614.992 was recorded in November 1972 and lake levels remained below average throughout the 1973 water year (Figure 3). Water levels rose significantly in the spring 1974 and remained near normal throughout the remainder of the decade (Figure 3). The Environment Canada lake level monitoring programme ended in October 1978. The mean daily water level for the 1960-1978 period is calculated to be 615.254 m. The standard deviation for the data is 0.203 m or 20.3 cm.

1994-1998 Lake Levels

Water level monitoring in Clear Lake was re-established on August 1, 1994. The data set is continuous and complete from August 1,1994 to the present and the monthly mean water level values are illustrated in Figure 3.

Mean monthly lake levels from 1994 to 1996 were consistently above the 1960-1978 mean annual lake level of 615.254 m and maximum lake levels for the same period were consistently greater than one standard deviation above the over all mean lake level of 615.274 m above sea level (Figure 3). Consequently, lake stages during these years have been classified as “extremely high water” stages similar to the 1966-1971 years.

Mean annual water levels in Clear Lake have dropped an average of 9.0 cm each year since the peak water levels recorded in August 1994. Mean annual lake levels dropped 9.5 cm in 1995, 6.6 cm in 1996, 11.3 cm in 1997, and an additional 8.8 cm by May 31, 1998. The recorded total decrease in mean annual lake levels from 1994-1998 is 36.2 cm. This value is probably an underestimate since the 1994 spring freshet stages (May and June lake stages) are not included in the calculation of the 1994 mean annual water level.

The mean daily water level for the 1960-1977 and 1994-1998 period has been revised upward by 2.1 cm to 615.275 m. The variance in the data set has decreased slightly and the standard deviation for the data is 0.195 or 19.5 cm). A regression-correlation analysis of the monthly mean lake levels suggests that the August mean lake level of any given year approximates the mean annual lake level for that same year. The correlation coefficient was 0.9816, with $r^2 = 0.9636$ at the 99% confidence level.

Maximum daily water levels in Clear Lake have dropped from an historical high of 615.755 m above sea level, recorded on August 1 1994, to the present (Figure 4). It is assumed that a higher peak lake stage occurred in late May or early June 1994. August mean lake stages are normally 25% - 35% lower than the proceeding spring peak stage. On this basis the peak daily lake level for 1994 could have been approximately 615.940 m, a stage 21.7 cm above the record high observed on June 1, 1970.

The maximum daily lake level for 1995 was recorded on May 19 at 615.658 meters above sea level. This stage was 9.7 cm lower than the August 1, 1994 peak and 12.7 cm (0.127 m) higher than the 1996 maximum daily lake stage of 615.531 m, observed on June 6, 1996. The 1997 peak daily lake level occurred on May 23, 24 and June 2 (615.370 meters above sea level) and this stage was 16.1 cm lower than the 1996 peak. Lake stages recorded on May 28, 1998 indicate an additional decline in peak lake levels to 615.198 m (17.2 cm lower than the June 1997 peak). Maximum annual daily lake levels have dropped 55.7 cm since August 1 1994.

Low water stages parallel the high water trend. The 1994 minimum recorded lake level was observed on November 26 (615.394 m), a stage 11.9 cm above the overall mean annual lake level. By November 15 1995 minimum lake stages had fallen 0.161 m to 615.233 m. Low water stages remained the same in 1996 at 615.232 m (November 11) and declined in 1997 to 615.044 m (November 15), a value 18.8 cm lower than the 1995 and 1996 low water stage. Minimum annual daily lake levels have dropped 34.9 cm since November 26, 1994.

Classification of Lake Stages for Clear Lake, Manitoba

Water levels in Clear Lake have ranged from an estimated historical mean daily high of 615.940 m above sea level in June 1994 to an historical mean daily low of 614.788 m (November 1961). The 115.2 cm range suggests significant variability in water levels over the 39-year period of record. The mean daily water level for the 1960-1977 and 1994-1998 period is calculated to be 615.275 metres above sea level. The standard deviation for the data is 0.195 m or 19.5 cm.

Extremely high water may be defined as a persistent period (two successive months) in which the lake level exceeds the overall mean annual stage by values greater than one standard deviation. Figure 3 illustrates the plot of the annual maximum mean monthly lake stages for Clear Lake from 1960 to1998. This is a discontinuous plot since 15 years (1979-1993) are missing. Most of the 1979-1989 decade is recognized as drought years (McGinn and Cherneski 1992). Consequently, extremely high water is unlikely. The 1990-1991 water years (October 1989 - September 1991) probably represent a period of rising lake levels and the 1992-93 water years (October 1991 - September 1993) a period of "extremely high water" (Rousseau 1998a). Nine years have been identified as "extremely high water" years, 1966-1971 and 1994-1996, inclusively. In each of these years at least two successive mean monthly lake stages are above 615.470 m.

Unusually high water lake stages are defined as a year when the mean monthly lake levels are above the overall mean annual lake stage, and no more than one individual mean monthly value is greater than one standard deviation above the mean. That is all but one of the mean monthly lake stages fall between 615.470 m and 615.274 m. One year, 1975 has been identified as an "unusually high water" year.

Extremely low water lake stages are defined as a two-month period in which lake levels are at least one standard deviation below the overall mean annual lake level. Figure 3 illustrates the annual minimum mean monthly lake stages for Clear Lake from 1960 to 1998. One period of "extremely low water" is identified, the 1961-1964 drought period, which is centred on the very severe drought in 1961-1962.

Unusually low water lake stages are defined as a year when the mean monthly lake levels are below the overall mean annual lake stage, and no more than one individual mean monthly value is greater than one standard deviation below the mean. That is all but one of the mean monthly lake stages fall between 615.080 m and 615.274 m. Two drought years, 1973 and 1977, are associated with unusually low water stages in the Clear Lake watershed.

The historical lake elevation records 1960-1977 and 1994-1998 (Figure 3) suggest that Clear Lake experiences both an annual water level cycle and cyclic high and low lake levels over time. Cyclic water levels in the Clear Lake system are controlled by winter snow accumulation summer rainfall, evaporation losses, runout discharge, the morphology of the outlet channel and beaver.

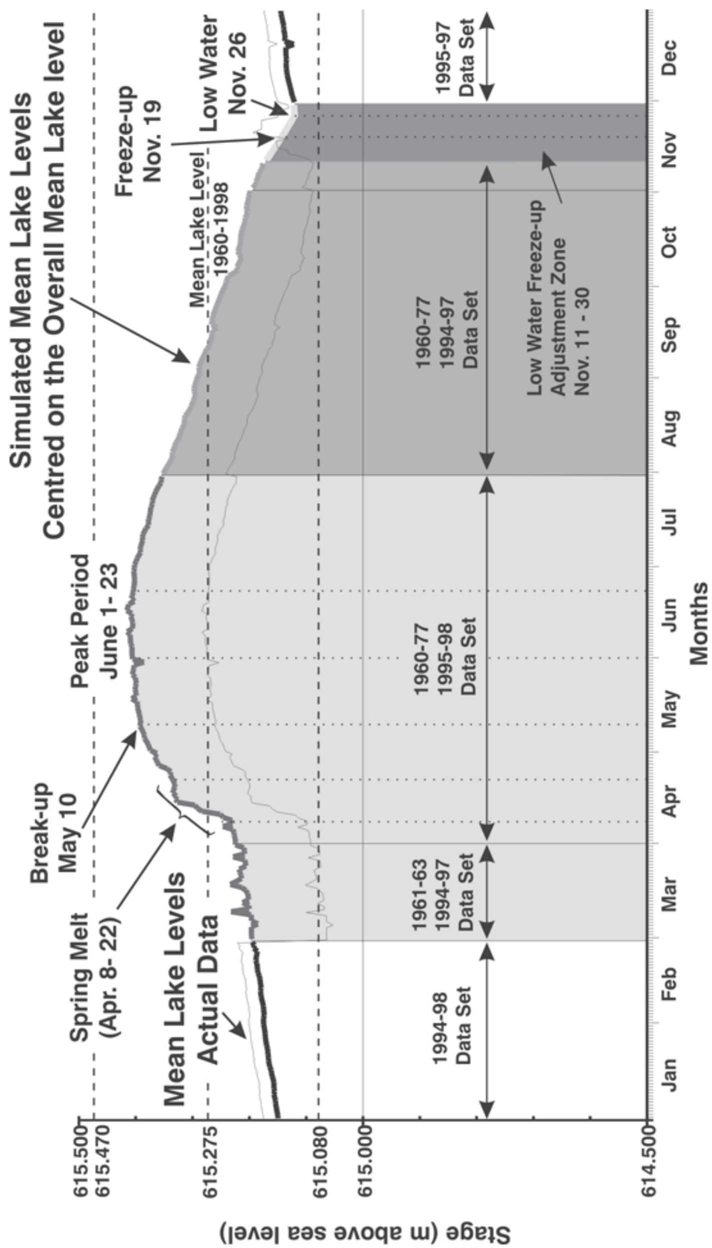

Figure 4: *Simulated lake levels annual cycle, Clear Lake.*

The Annual Cycle

Figure 4 illustrates a simulated normal annual cycle based on the 1960-1977 and the 1994-1998 data set. The discontinuity in the data set leads to several problems in generating an average lake level cycle and is reflected in the calculations of a "Mean Lake Levels Actual Data" plot (Figure 4). January, February and December plots are significantly displaced (a positive displacement) from the March to October plot. Daily mean lake levels calculated for these winter months are based on three or four measurements observed in 1994-1998. Consequently, one daily value recorded during these "extremely high water" years can significantly influence the daily means. By contrast, the April - October daily mean lake level plot is based on 17 to 21 years of data. Since the time frame represents "high" and "low water" years, this segment of the plot is considered to represent the normal annual trend in lake levels. March values are derived from the "low water"1961-1963 period and the "high water" 1994-1996 data. The year 1994 may be associated with the highest lake levels ever recorded and the introduction of these extreme data (August 1994-December 1994) to the calculation of mean lake levels is reflected in a significant positive displacement in the "Mean Lake Levels Actual Data" plot. Likewise, the inclusion of recent November data (a precipitation anomaly in 1997) had a similar impact on the actual data plot (Figure 4).

The simulated plot (Figure 4) is derived by assuming that the March to October plot of mean daily lake levels represents a template of the normal lake level cycle for an average water year. January and February calculations were adjusted (reduced) to the March 1 base. Similarly, the August and early November positive displacements were forced into the continuous plot. The November precipitation anomaly was ignored. The December 31 mean daily lake level was equated to the January 1 value, and December mean daily lake levels were extrapolated backward through late November to the low water date (November 26). Finally, an adjustment linkage joined the extrapolated November data to the composite January - early November graph.

The composite plot of mean daily lake levels was adjusted to the normal mean daily lake level (615.275 m). This was accomplished by placing both the peak lake level and the low water stage equidistant from the long-term mean lake level (Figure 4). Additional information illustrated on Figure 4 includes lake freeze-up and break-up dates, the normal spring melt period, and the time of peak and low water stages.

The annual spring runoff recharges water volumes held in Clear Lake and lake levels rise an average of 18.1 cm. Lake stages normally peak in June, approximately six weeks after the spring melt. During July and August and throughout autumn, lake stages normally decrease due to evaporation loss and runout. The lowest annual lake levels are usually recorded in November. Recent data (1994-1998) support this argument and suggest that lake levels are lowest in late November (a week after freeze up) and begin to rise slightly under the winter ice cover. However, following regional dry periods in the long-term cycle (1960-1962, 1966-1967, 1972-1973, and 1976-1977) low lake stages persist throughout the winter and into early spring. A later than normal spring freshet recharges lake levels and drought-breaking rains can maintain lake stages at levels higher than the early open water months. Consequently, in these years March lake levels are often the lowest in the annual cycle.

The Long Term Wet/Dry Cycle

The historical record 1960-1998 (Figure 3) suggests that there is a ten-year period normally occurring between extremely high and extremely low lake levels (e.g. 1961-1962, 1969-1971, 1980-1844, and 1993-1995). The period 1980-1989 is acknowledged to be a decade of high temperatures and drought (McGinn and Cherneski 1992). During this decade it is reasonable to assume that water levels in Clear Lake remained at or below normal and that an extremely low water lake stage probably occurred in the early 1980’s (1980-1984).

Low water stages, either “extremely low water” or “unusually low water” appear in the lake stage record approximately every eleven years; 1962, 1973, 1984(?) and perhaps 1998. Low water stages in the Clear Lake watershed are almost always associated with regional drought. The only exception occurred during the 1967 regional drought when lake stages were extremely high. Extremely low water levels in Clear Lake have a recurrence interval of approximately 20-25 years. These are always associated with local severe drought.

It appears that extremely high lake stages occur every 20-25 years and persist over several seasons, approximately five to six years. These periods of extremely high water may be subdivided into three phases. The initial phase (Figure 5) involves a two to three year period of extremely high water, which is associated with wetter than normal conditions, and little or no runout down Clear Creek.

Normal or low water stages, which occur prior to the initial high water phase, expose the Clear Creek outlet sill to wave action and ice thrusting. During these times north easterly winds build-up a beach crest or sand berm across the outlet. These processes effectively raise the elevation of the outlet sill, inhibiting runout discharges and increasing the storage potential in the lake. Stream discharges equal to or less than 0.8 $m^3 s^{-1}$ support beaver populations (Rousseau 1998b). As beaver move into the outlet stream, a stair-step profile develops along the outlet channel. This low gradient channel (< 0.002) consists of a series of dams, impoundments and shallow, low flow connecting channels. Runout discharges from Clear Lake are small (< 0.2 $m^3 s^{-1}$) and may become sub-surface moving through the outlet berm. In the autumn of 1993 the Clear Creek outlet channel had a short (30 m) reach, was overgrown with willow and sedges and had dimensions of less than a metre wide and only five cm deep. The channel split into several distributaries and drained into a beaver enhanced wetland. At this time lake levels were well above average and classified as “extremely high water.”

The second phase in the “extremely high water” (Figure 5) years begin when lake levels reach a critical threshold (approximately 615.600 m above sea level). Discharges are forced down Clear Creek, eroding the beach crest (sand berm). Observations during the 1993-1996 “extremely high water” period

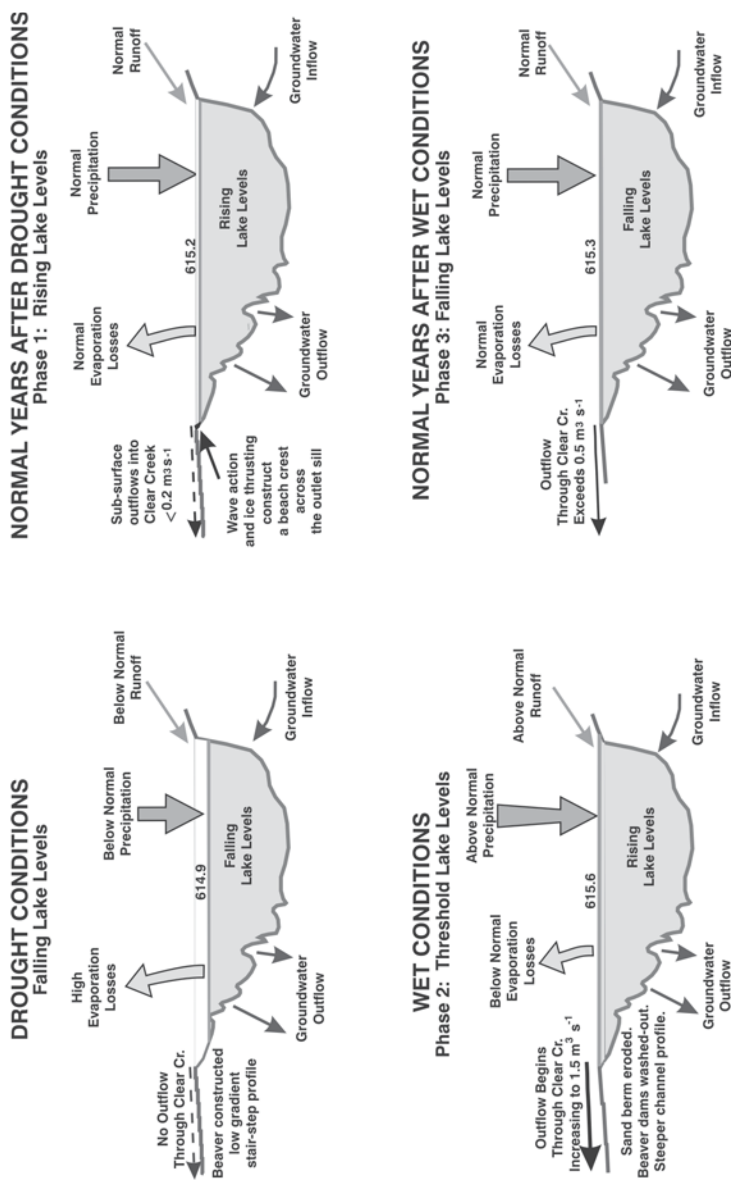

Figure 5: *Cyclic water levels in Clear Lake.*

indicate that two seasons of scour are required to lower the outlet sill and clean out the channel. During this period, mean runout discharges generally increase.

The final (draining) phase in the extremely high water years (Figure 5) begins when the outlet channel has achieved maximum cross-sectional area. This phase usually lasts two to three years. Runout discharges peak at values ^{3} 2.0 $m^3 s^{-1}$ and then fall to values < 1.0 $m^3 s^{-1}$ as lake levels drop. When runout discharges are < 0.8 $m^3 s^{-1}$ the beaver return to the Clear Creek channel, initiate the development of the low gradient stair-step profile and further restrict outflow discharges. Once the beaver become established in the outlet channel, a second threshold lake level (approximately 615.0 m) is required to initiate outlet discharges in excess of 1.2 $m^3 s^{-1}$.

Summary and Conclusions

Water levels in Clear Lake have ranged from an estimated mean daily high of 615.940 m in June 1994 to an historical mean daily low of 614.788 m (November 1961). The 115.2 cm range suggests significant variability in water levels over the 39-year period of record. The mean daily water level for the 1960-1998 period is calculated to be 615.275 metres above sea level. The standard deviation for the data is 0.195 m or 19.5 cm.

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The 1960 -1998 lake elevation records suggest that Clear Lake experiences cyclic high and low water levels. Normally, there is a ten-year period between extremely high and extremely low lake levels (e.g. low 1961-1962, high 1969-1971, low 1980-1844, and high 1993-1995). Low water stages are almost always associated with regional drought and appear in the lake stage record approximately every eleven years; 1962, 1973, 1984(?) and perhaps

1998. Extremely low water levels 1962, 1984 have a recurrence interval of approximately 20-25 years.

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Normal or low water stages, which occur prior to the initial high water phase, expose the Clear Creek outlet sill to wave action and ice thrusting. During these times easterly winds build-up a beach crest or sand berm across the outlet. These processes effectively raise the elevation of the outlet sill, inhibiting runout discharges and increasing the storage potential in the lake. Stream discharges equal to or less than 0.8 $m^3 s^{-1}$ support beaver populations. A stair-step profile develops along the low gradient (< 0.002) outlet channel consisting of a series of beaver dams, impoundments and shallow, low flow connecting channels. Runout discharges from Clear Lake are small (< 0.2 $m^3 s^{-1}$) and may become sub-surface moving through the outlet berm.

The second (critical) phase in the “extremely high water” years begins when lake levels reach a critical threshold (approximately 615.600 m above sea level). Discharges are forced down Clear Creek, eroding the beach crest (berm) and scouring the channel. During this one to two year period, mean runout discharges generally increase as the channel cross-sectional area increases.

The final (draining) phase in the extremely high water years begins when the outlet channel has achieved maximum cross-sectional area. This phase usually lasts two to three years. Runout discharges peak at values ^{3} 2.0 $m^3 s^{-1}$ and then fall to values < 1.0 $m^3 s^{-1}$ as lake levels drop. Once runout discharges are < 0.8 $m^3 s^{-1}$ the beaver return to the Clear Creek channel, initiate the development of the low gradient stair-step profile and further restrict outflow discharges.

Cyclic water levels in the Clear Lake system are controlled by the lake water balance (winter snow accumulation, summer rainfall, evaporation losses, runout discharge), the morphology of the outlet channel and beaver.

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Regionalization of water infrastructure in Canada: a comparative study of conflict resolution approaches

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Abstract: The principal objective of this study is to determine the means by which communities involved in cooperative water or wastewater projects resolve initial conflicts that occur during the negotiation process. Of particular interest are primary negotiations focusing on issues of fear of urban sprawl or the perception of loss of control. The study, employing a case study (Greater Vancouver, York and Halifax) approach, is of value to analysts and policy makers seeking guidelines for negotiating water and wastewater agreements. The case studies would serve as examples for guiding future inter-community projects. The findings of the study have revealed that regionalization of service and infrastructure presents a number of advantages including the sharing of capital costs, assurance of minimum service standards, a higher degree of coordination, long- and short-term operational savings, accountability and an increased ability to meet drinking water standards. Conversely, the disadvantages are less responsive administration of services, potentially higher costs in some components and the acceptance by smaller communities that the central city is of regional concern. The study further suggests that changes in leadership, provision of technical information and the imposition of deadlines assist in dealing with perceptions of gain or loss that may be encountered in the negotiation process. This research also demonstrates that water and sewage services are interconnected to sprawl, consolidation may be a deterrent to sprawl, and that a central city's refusal to extend water and wastewater treatment services may not prevent sprawl. Effective collaboration involves equitable mitigation of costs and distribution of benefits among participating communities, through a focus on long-range planning and a search for common ground.

Introduction

Geographers, along with planners and practitioners, have long been concerned with the conflict between "place-specific" interests and their unique properties and the benefits from economics of scale through amalgamation of economic space. Such challenges often stem from urban sprawl, annexation of fringe communities, and loss of control in conjunction with cooperative water and wastewater infrastructure agreements. Understanding the processes of negotiation, compromise and conflict-resolution used by communities that have pursued inter-jurisdictional water or wastewater agreements is of utmost importance to the policy makers.

The significance of this study lies in determining issues that impact water and wastewater system negotiations and implementations which would assist the planning process in comparable future situations, and analysing different agreements and negotiation processes that provide cases of methods of resolving inter-community issues.

Conceptual Issues Concerning Inter-Municipal Water and Sewage System Cooperation

A conceptual model of water systems conflicts and their resolutions is presented in Figure 1 to reflect the generalized issues and interconnections of the components in the systems. From an economic perspective, cooperative infrastructure development is an alternative for municipalities to bring greater efficiencies and cost effectiveness to large capital projects. From municipality and community perspectives however, the perception of loss of control, fear of urban sprawl and the threat of competition are the principal concerns. These elements are thus also barriers to inter-jurisdictional cooperation (Figure 1).

Fear of loss of power to make and/or control decisions is a serious impediment to multi-community collaboration. These fears specifically make it difficult for two communities to develop a cooperative agreement if the proposed collaboration is perceived

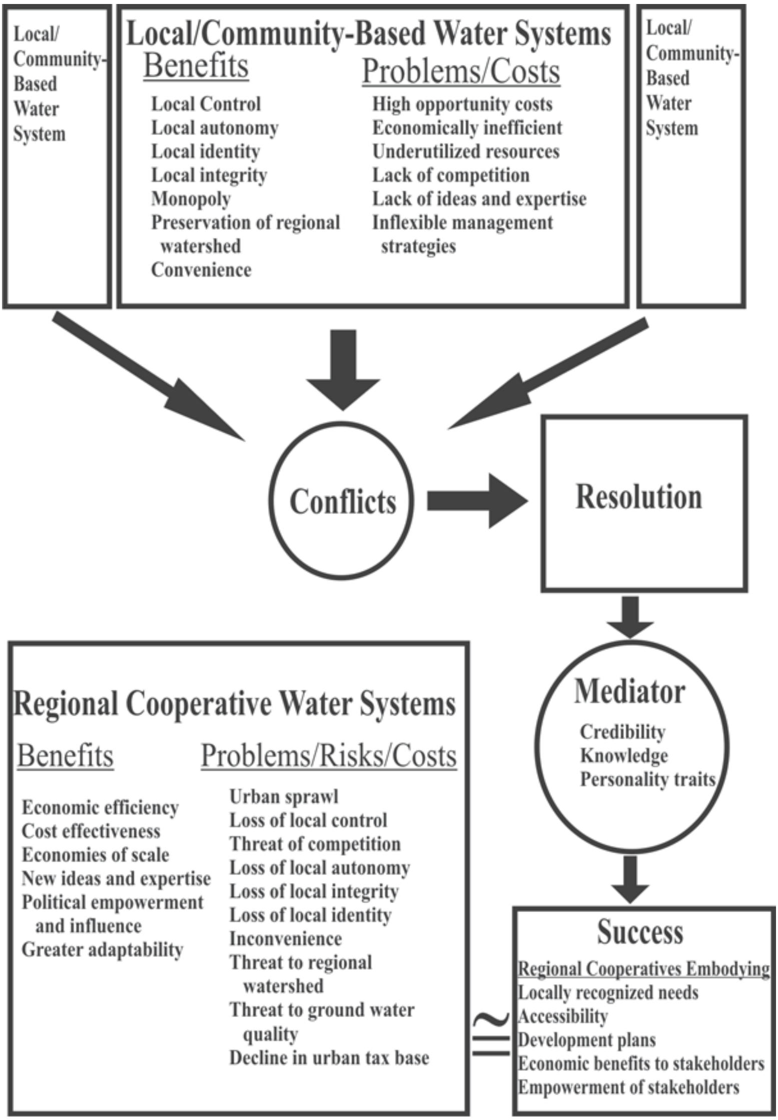

Figure 1: *A conceptual model of water systems conflicts and resolutions.*

as a potential cause of "loss of control, autonomy, community integrity, personal identity and/or convenience" (Hobbs 1992: 283-284). The perception that cooperation will result in greater loss than gain is demonstrated through resistance, lack of cooperation and lack of support. An example is the lack of cooperation between the City of Kingston and the Township of Ernestown, Ontario who assessed the options either to construct a new water system or to purchase surplus water from an existing conventional plant in Kingston. The perception of the Township was that the construction of a local water system would permit them to maintain local control over growth issues, service provision, and other community issues associated with local identity. Also, the City of Kingston delayed sending up-to-date technical information required for the Township of Ernestown's feasibility study. Such delay was attributed to the City of Kingston's fear that by providing the necessary plant information, they would miss an opportunity to wholesale water to the Township and to influence the community in other ways.

Conversely, collaboration may be viewed as a gain with little loss if the proposed ground for collaboration serves a "locally recognized need" (Hobbs 1992: 284). In North Dakota, U.S.A., for instance, five water systems have originated through the grass-root efforts in addressing the problem of good quality water in the majority of the district. The planning process, rather than stressing potential loss of control, focussed on the required initiatives and steps required to complete the project: defining the area, forming committees, defining the need, obtaining approval and funding from the state, securing public interest resources, and developing a detailed plan. Shaffer and Tweeten (cited in Korsching 1992) have summarized the costs of multi-community collaboration as: loss of local identity and control; high opportunity costs; lack of vision, goal and focus; and maintenance of collaborative efforts (Figure 1). They included the following items as benefits: synergism; economies of scale; new ideas and expertise; political empowerment and influence; and adaptability to emerging conditions and crises (reduced risk).

Disagreement about gains and losses also can contribute to the involvement of new participants or can recruit new leadership critical to a new direction required for multi-community solutions.

"Multi-community collaboration implies the creation of new action communities; networks of people organized to accomplish certain purposes on behalf of a community that have not existed before," Hobbs (1992: 286) notes. He adds that it also means a sense of purpose and participation that leads to identification of problems and organized activity to address them. The appointment of a mediator with sufficient credibility, knowledge and personality traits also can be critical to resolving issues of fear of loss of control (Figure 1). The ability of the mediator to keep the process continuing and to obtain agreement on difficult issues is especially important (DeHoop 1997).

Fear of urban sprawl may lead to the absolute refusal by a central city to extend water and sewage services to surrounding suburbs. The consequence, in some instances, has been a decentralized and fragmented infrastructure system, and a central-city with a significant over-capacity of water. Uncertainty on the effects of urban sprawl also can become a major impediment to negotiating multi-community service and infrastructure projects because of its close relationship with infrastructure or development. General principles related to sprawl reveal that the extension of water and sewage services can be a direct determinant of growth (City of Salisbury Task Force 1998). Urban sprawl tends to increase the costs of providing other public services to a widely scattered population. Further, excess capacities may promote sprawling development, with costs for new services exceeding generated growth of local revenues. Sprawl, combined with excess tax burdens, has been known to trigger out-migration which leads to long-term reduction in property tax bases and further increases burden on the remaining residents (Wade Miller Associates 1987 cited in Landau *et al*. 1990).

Reid (1996) adds that other issues concerning urban sprawl center around the impacts of sprawl including environmental damage, such as ground water contamination and the threat posed to the regional watersheds, the decline in the urban communities' tax base and the inter-municipality competition for assessments which may reduce the region's ability to retain and expand the assessment base (Reid 1996). Conversely, DeHoop (1997) observed that consolidation can be perceived as a deterrent of sprawl. The notion is that collaboration is a vehicle to enhance the "marketing" image of the central city allowing the region to compete more effectively, to provide more power and influence with higher levels of institutions, to offer a forum for directing urban growth through consistent and comprehensive land use policies, and to facilitate the creation of more compact and sustainable communities.

Regionalization of Water Infrastructure and Conflict Resolution

Several criteria were employed in the selection of the three case studies that relate to the cooperative infrastructure agreements analysed in this paper. They included: (i) urban-rural water cooperative systems established by communities of high growth areas (Region of York, Greater Vancouver Water District), and cases in which water or wastewater services have been extended to bedroom communities (Halifax Regional Water Commission); (ii) recent (occurred in the past 10 years) water and sewage negotiations involving two or more partners. The selected case studies vary according to the degree of structural changes required for inter-jurisdictional water or sewage cooperation. For instance, the Greater Vancouver Water District is a federation of 16 member and two non-member municipalities; three communities – Noth Vancouver City, Langley Township and Langley City – have become members of the Water District in the 1980s and 1990s. The York Region Inter-Regional Water and Wastewater Agreements involve the sharing of infrastructure maintenance and capital costs. The three agreements with Peel, Durham and Toronto, originally formed in the 1970s, have been renegotiated in 1996 and 1997. The Halifax Regional Water Commission is a consolidation of the region's four former municipal water utilities; a regional water system was formed following the amalgamation of Halifax and its surrounding communities in 1995.

The Greater Vancouver Water District (GVWD)

The Greater Vancouver Water District (GVWD) was originally formed in 1924 through the Greater Vancouver Water District Act. The Act, which sets out the basic reporting arrangements, structure and context for the regional system, establishes the District as a legal corporate entity responsible for providing water services to the region. It also gave the GVWD the power to acquire water rights and to acquire and supply water (GVRD 1997).

The GVWD is a federation of municipalities that is owned by the taxpayers of the region and is governed by a Regional Board (Morris 1998). The Water District is also governed by and affected by the policies and strategies of the Greater Vancouver Regional District (GVRD), which was established in 1996 to provide overall regional management of the region. Vancouver was the original member of the GVWD. Most member communities joined the system prior to 1950; more recent partners have included North Vancouver which joined in 1984, the Langley Township in 1990, and Langley City in 1991. In some selective cases, a portion or all of the costs of adding the communities to the system were borne by the GVWD system as a whole. The GVWD Act permits member municipalities to supply water to another municipality but not the connecting infrastructure. The municipality's opportunity to supply water to neighboring municipalities is subject to the approval of the GVWD's Board (Office of the Legislative Council 1996).

The GVWD draws water from three watersheds: Seymour Lake, Capilano Lake, and Coquitlam Lake. The system's output is approximately 1,055 megalitres/day and has a peak output of two billion litres/day during the summer months. Its maximum watershed hydraulic capacity is 4,500 megalitres/day. The GVWD sells water as a standardized wholesale rate to its members and two non-members, who collectively have a population of 1.8 million. Members retail the water to their community and third-party recipients with whom they have agreements.

Urban Sprawl and Autonomy Issues and Strategies

In recent years Surrey and the Township of Langley have expressed dissatisfaction with the water system because of the limits on urban growth that the GVWD has imposed. They have revealed their interest in breaking away from GVWD's water system because of disagreements on growth management strategies. The City of Surrey however, is entirely dependent on the GVWD water supply; it has only a limited local water supply available from farm-based wells. Langley Township is experiencing annual population growth of three percent. Prior to joining GVWD in 1987, the Township was on a rural well system that often experienced contamination. The authority also believed that the public felt safer when water was supplied regionally. Continuity of water supply initially was a concern of the Township as it is located at the end of the pipeline. This was resolved through the expansion of the GVWD system, which involved interconnection of the watershed and the addition of river crossings. The benefits of joining the GVWD were lower sewage cost, fairer rates for residential customers, and a mechanism for metering industrial and commercial users (Mongracz 1998).

The most recent agreements on water supply have been volume-based, in contrast to the provision of unlimited supply, and have evolved because of the need to share the water supply with a larger number of partners (Morris 1998). In the case of rapidly growing areas, the GVWD has established an agreement (effective until 2011) that obligates it to provide specific volumes. The agreement with Langley Township stipulates that Langley Township cannot provide water services to Third Party participants prior to 2011. Langley Township has experienced in increase in their tax and water rates, but joining the system was a necessary step owing to the unreliability of their well system.

Both the GVWD and the GVRD have followed two main strategies for dealing with potential urban sprawl: (i) the Livable Region Strategic Plan, and (ii) the Regional Water Supply Plan. The Livable Region Strategic Plan focus on four fundamental guidelines for regional growth: (i) protection of green zone; (ii) building complete communities; (iii) achieving a compact metropolitan region; and (iv) increase mobility and transportation choice. The Regional Water Supply Plan provides a framework for meeting the region's water needs until 2041. Factors considered in developing the plan include the municipalities' demand projections, assessments of water supply sources, and projections of infrastructure requirements for repair and construction of water mains, pump stations, and peak storage reservoirs.

The GVWD has not attempted to amalgamate any of its partners. The issue of annexation and amalgamation are not concerns to member municipalities; this is because the GVWD water supply is controlled by the federation and a corporate entity rather than by the City of Vancouver (Morris 1998; Mongracz 1998). Some municipalities have concerns about loss of autonomy but there is no strong element to feel threatened as all issues are openly discussed and voted upon through the federation's operation.

In sum, the key factors that have contributed to the GVWD's success include: the implementation of a public education program; the flexibility of the Livable Region Strategic Plan; its corporate structure which reduces fears of potential annexation; the creation of downtown centers to reduce urban sprawl, and; the ability of the GVWD to provide water more efficiently than members can provide individually. Difficulties of the GVWD include the municipalilties' tendency to view issues from the local perspectives, the need to upgrade the system's water quality, the geographical extent of the system, and the need to justify the costs to the region as a whole.

The Region of York

The Region of York, which was formed in 1971, consists of nine municipalities; it is one of the fastest growing of the five regions in Greater Toronto Area. York's population has increased from 166,060 in 1971 to approximately 635,000 in 1997, and is projected to reach 1.1 million by the year 2021 (Regional Municipality of York 1998). The Region of York lacks direct access to Lake Ontario, and Lake Simcoe provides some of York's water and wastewater needs via the King water treatment plant and the Georgina-Keswick wastewater treatment plant. The majority of its water and wastewater needs are met through three inter-regional agreements with Durham, Peel and Toronto (McGreggor 1998). These agreements, originated in the 1970s, were re-negotiated recently to reflect York's increased population, the transfer of provincial power to the local level, and the region's long-term water and wastewater needs. During the re-negotiation process, the issues concerning the threat of industrial competition, the fear of urban sprawl, the fairness of rates, and the need for partner equality have re-emerged.

The Region of York's preferred solution for a long-term water supply and wastewater treatment plan was developed following a public participation process. The selection criteria were based on the region's statement of goals to secure water supplies to continue the region's future growth, rate stability and cost minimization, finance future infrastructure and protect the environment. Additional criteria included independence, reliability, sources of supply and economic benefits to the region. The York Region/ Consumers Utilities Partnership formulated the preferred solution for water supplies to the region. It recommended a four-step phased strategy: (i) finalize the Metro agreement; (ii) implement a water-use efficiency program which would provide immediate cost savings for the region as well as defer capital expenditure; (iii) construction of a new water treatment facility at Lake Simcoe; and (iv) establishment of water supply facility to draw water from Lake Ontario via Durham (West).

The Interregional Water and Wastewater Agreements

York and Durham's original interregional wastewater agreement was developed in the late 1970s and early 1980s. In the early 1990s, due to York's specific need for additional capacity, a new 80 million gallon/day plant was built; in 1997 the plant was expanded to have a 160 million gallon/day capacity and a new wastewater agreement was finalized between York and Durham. In regard to capital cost, the regions agreed that the portions of the wastewater distribution system located within their own region would be financed individually, and that the capital and maintenance cost of the main sewage trunk and the pumping stations would be shared (Murray 1998).

The principal variations between the new agreement and the original agreement are the commitment of the municipalities to specific flow levels, specificity with regard to payment is defined, and York is recognized as a faster growing region. The two regions agreed that they would be responsible for the cost of maintaining the collection system within their own region, and would pay according to the flows, which are metered at the boundary. Built into the text of the agreement is that re-distribution will be permitted at a later date. The regions also agreed to permit an outside party to audit the meter on a regular basis and to have an open-book mechanism for deciding on capital costs.

Urban sprawl, loss of control or annexation, were not significant issues. The main reason is that prior to expansion of the wastewater plant, each region presented their official plans for development and the plant was built to meet anticipated demands. Growth was not a difficult issue because in both regions the residents informed the municipalities where they would like to live, not the other way around. The regions also found that because the agreement was interregional instead of inter-municipal, potential annexation was not a threat. Specifically, although individual municipalities still exist, political boundaries were not as pronounced because each regional government managed its own distribution and set rates for the region regardless of the size of the municipalities with their region (McGreggor 1998).

The York-Toronto Water Agreement was originally signed in 1974 with the assistance of the Province of Ontario. Within 20 years of the original agreement, however, the Region of York's water demands were at full-capacity and a re-negotiation process was undertaken to obtain additional water from Toronto. Some council members form the City of Toronto initially showed their reluctance to renew the agreement with York because of concern over the growth of York's urban boundaries. From the perspective of the City of Toronto, the key requirements in the agreement included restricting York's peak daily demand, ensuring that the agreement provided a return on infrastructure investment and ensuring that Toronto was not subsidising water rates in York. From York's perspectives, their projected growth was caused by Toronto's concentration of commercial areas and the naturally-occurring need for the workers to live somewhere nearby in order to fill these jobs. Eventually, York agreed to pay a dollar penalty if they exceeded their peak daily allowance, a 'power factor' (a premium on their water rates to account for the additional power required to transmit the water from Toronto), and to share the capital costs of the connecting infrastructure.

The Peel Regional Council approved an interregional wastewater servicing agreement with the Region of York in September 1997. Under the servicing agreement, Peel provides wastewater services to Woodbridge (City of Vaughan, Region of York) and two future areas of development – an area located north of the existing community and a business area located between highway 27 and the Peel/York boundary. Servicing for York will begin in 2001 when the York/Humber pumping station will have reached full capacity.

The main benefits on this interregional partnership are: (i) both Peel and York save on infrastructure cost, obtain capital cost savings through shared infrastructure, obtain savings through the sharing of plant operation, maintenance and overhead cost while providing service to a larger customer base; (ii) Peel anticipates cost savings between $63.2 and $82.4 million over the next 30 years, and capital cost savings between $10.4 to $29.6 million; (iii) Peel will receive a return on assets of $14.8 million from York for capacity rights, along with an additional $38 million from York in contributions to the Infrastructure Reserve over the next 30 years; and (iv) York is able to service existing and future growth in Woodbridge and benefit from capital and operational cost savings as a result of connecting to Peel's system (Zamojc 1998).

Some council members of the Region of Peel were concerned that commercial interests might find the Region of York more attractive than Peel. These concerns however, were eased following a market assessment that advised Peel council members of the impact of renewing the water agreement. In particular, the report indicated that competition from York was not dependent upon a sewage treatment or water system.

In sum, the key factors of conflict resolution in York's interregional agreements included: open communication; full disclosure of supporting documentation; negotiators' previous working relationships; the development of each region's official plan prior to the commencement of negotiations regarding the water and wastewater agreements, and; the equitable sharing of infrastructure and maintenance costs.

Halifax Regional Water Commission

The Halifax Regional Water Commission (HRWC) was created by the Halifax Regional Municipality Act S.N.S. 1995. The Commission, a crown corporation owned by the Halifax Regional Municipality, is a union of the former Halifax County Water Utility, the Dartmouth Water Utility, and the Halifax Water Commission (Rooney 1998). The regionalization of the water system was mandated following a provincially enforced amalgamation. The choices for a model for the Regional Municipality of Halifax's water utility were: a) a municipal department-run system, b) privatization, or c) a Commission structure. A Commission structure was chosen because, of the three former water utilities, the Halifax Water Commission had the best performance record.

The Halifax Regional Water system serves approximately 69,000 connections and a population of approximately 325,000. Pockwock Lake and Lake Major are the main supply sources from which the system draws water. The Pockwock Lake Treatment Plant provides water services to Halifax, Bedford, Saxille, Lakeside and Timberly. The Lake Major Treatment Plant provides water services to Dartmouth, Eastern Passage, Forest Hills and Cole Harbour (Yates 1998). Seven smaller systems, serving a total of 25,000 residents in Halifax County, are operating in conjunction with the HRWC. No decision has been made whether or not these smaller systems will be integrated into the regional water system.

Issues and Strategies Concerning Regionalization and Loss of Control

The Regional Municipality of Halifax is the process of developing growth management strategies. Prior to amalgamation, each of the former municipalities initiated capital projects that would have been pursued under normal circumstances, thus depleting their financial reserves (Meech and Vodicka 1997). It is less expensive now to develop in "unserviceable" areas, although some of these areas have water quality and quantity problems (Dickson 1998).

The basic plan for growth management will be to have serviceable boundaries marked. Serviceable development will be permitted within the boundaries and only non-serviceable development will be permitted outside of the boundaries. The Halifax Water Commission also will assist in defining the growth boundaries, by examining which water trunks can be extended.

A Capital Cost Contribution Policy has been developed to manage the sharing of infrastructure cost for new and existing developments serviced by the Commission. The policy is designed for developers and deals with issues of who pays for infrastructure extension. The basic principle of the policy is “whoever benefits, pays.” The Capital Cost Contribution Policy applies to the entire municipality, with the implementation of specific charges to the Bedford South Water Service District. The policy has been developed in order to plan for the Regional Municipality’s anticipated new development and the accompanying demands for new infrastructure.

Political critics have denounced the merger for several reasons: (i) the transition cost are double the estimate made by Nova Scotia’s merger coordinator ($22 million instead of $10 million); (ii) property and business taxes (predicted to decrease following the merger) have increased by nearly 10 percent in some areas; (iii) costs have increased owing to higher service levels in outlying areas and the equalization of municipal employees’ salaries and wages, and; (iv) the merger was completed without local approval (McDonough 1997; Hamilton 1996).

All current partners initially were reluctant to join but had little choice because the amalgamation was a ‘shotgun merger.’ All four partners had concerns about losing their identity, absorbing each other’s debts, and changes in service levels. The City of Halifax felt the least impact from the amalgamation because the Commission structure remained the same and thus view the ‘new’ water system as having no net loss or gain. Dartmouth’s water rates have increased, but they realize that through regionalization their water quality problems will be resolved. Halifax County’s rates have decreased since the merger (Yates 1998).

Regionalization of the water and sewage infrastructure will prove to be a benefit to Dartmouth because the quality of water will be improved through the Lake Major Treatment Plant upgrade (Yates 1998). The merger also has given the area more “political clout” and stronger justification for additional provincial funding. The amalgamation of the municipalities however, has distanced the taxpayers from the decisions that most directly affected their lives.

Lessons for Manitoba's Capital Region: Conclusions and Recommendations

The study has examined three case studies to understand how communities have dealt with the challenges of urban sprawl, annexation, and loss of control in decision making in conjunction with water and wastewater infrastructure development. This approach has been employed to allow Manitoban municipalities to assess the processes other regions have undergone through an analysis of their dealings, benefits, lessons to be learned, and conflict resolution techniques.

The proposed Cartier Regional Water System Plan (Manitoba) included an infrastructure project, with an estimated cost of $30 million, to bring potable water to Headingley Municipality, construction of a water treatment plant in St. Eustache, and the connection of Portage la Prairie’s pipeline to Winnipeg. Under the plan, Winnipeg would sell 240,00 gallons/day to a regional authority that would then sell the water to the rural municipalities of Headingley, Cartier, St. Francois Xavier and Portage la Prairie. The proposed agreement would allow Headingley to pump 75,000 gallons/day of sewage into the City’s westland sewage treatment facilities but limited the amount of additional sewage treatment to five percent each year. In return the City of Winnipeg would receive annual revenue of $200,000 for its surplus water (Santin 1998a). Purported secondary benefits to Winnipeg and surrounding areas would include the development of region-wide waste management strategies, the attraction of new residents, and the attraction and development of industries.

Resolution of the dispute between the City of Winnipeg and the surrounding rural communities over the extension of Winnipeg's water and sewage system has come to a stand-still. In February 1998 the City Council announced that the City will not supply water and sewage services to the surrounding fringe communities as outlined in the Cartier Regional Water System Plan. The absence of a sewer line and treatment facilities restrict urban development in Headingley and other surrounding communities. Although the provincial government would provide a grant of $2.1 million for the proposed project, Headingley's 1,600 population (1996 statistics) could not support the additional $4.1 million of borrowing required for the project (Cole 1998).

The City of Winnipeg contends that the extension of water sewage services to the surrounding rural areas will lead to urban sprawl and a decline in its tax base. In particular, the City Council contends that most of the "new growth" in Headingley would consist of relocated Winnipeg residents. Other critics of the proposed project feel that once Winnipeg extends its services, other bedroom communities will want to join, and this will further increase urban sprawl issues (Santin 1998b). Others criticize the plan on the basis that Winnipeg will need all of its current excess water sewage capacity if it hopes to attract large industries.

The surrounding rural areas are concerned that forming a partnership with the City of Winnipeg would result in a loss of control over land use planning and other local issues. Winnipeg and Headingly have a history of conflict, which resulted in Headingly's secession from Winnipeg in 1992 over a dispute regarding water related issues.

Proponents of the Cartier Regional System Plan contend that without a water and sewage treatment agreement, Winnipeg will lose whatever 'say' it has on development in outlying communities, since the agreement puts limits on how rapidly the outlying areas can grow. Santin (1998c) notes that for political reasons, the provincial government is unlikely to agree to a deal that creates uncontrolled growth. The provincial authority however, has stated that Headingley and the fringe communities will receive water and sewage services regardless of whether or not Winnipeg provides them (Thompson 1998).

In light of the three Canadian experiences, the following recommendations have been formulated for addressing the emerging water and sewage infrastructure related issues in Manitoba:

(i) The Province should establish an information base that includes population projections, current and future water and wastewater demands, expectations on quality of life, and the environment;

(ii) Each potential partner should establish a statement of goals and an official plan for development;

(iii) The Province should establish a negotiation process that encourages clear and open communication, the full disclosure of supporting documents, and local acceptance;

(iv) The Province should assess 'what-if-scenarios' with consideration of the long-term consequences of the agreement, and attempt to create a situation where all parties would benefit;

(v) The Province should establish a commission to select a preferred solution from the 'what-if-scenarios';

(vi) Public participation should be utilized in selecting a preferred solution as it would create the grounds for making the agreement responsive to local needs and in establishing a solution reflective of the area's concerns, and;

(vii) Any agreement should be comprehensive enough to include definitions of levels of service, cost-sharing, growth management policies, and a formal arena in which regional issues can be discussed.

Acknowledgements

The authors would like to express their gratitude and thanks to Manitoba Rural Development for funding this research project as well as the councilors, public work commissioners, mayors and water services managers who participated in the interview processes.

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A survey of attitudes and perceptions towards CXY, Brandon: environmental and safety issues

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Abstract: The primary objectives of this study are to determine public perception and attitudes toward CXY Chemicals, in Brandon, Manitoba; to examine the regulatory bodies that govern activity at CXY; and to examine their remediation efforts. Four hypotheses are tested to determine the differences in awareness about activities at CXY within the public and the employees of the plant. In general, the results indicate that the public is aware of CXY but unaware of remediation; employees of CXY were found to be significantly more knowledgeable than the public. Results also indicate that the majority of the public believes that advertising is the best way to be educated about issues at CXY. Remediation efforts by CXY through the efforts of the Steering Committee and Community Advisory Panel are exemplary. The study suggests that further research should incorporate a more in-depth questionnaire, working groups, objective scientific research, and an employee history of the plant to analysis the evolution of workplace safety in connection with the environmental movement.

Introduction

The Canadian Chemical Industry is the fourth largest industry in the country in terms of sales (CCPA 1995). The products of this industry are essential components of everyday life, but emissions from these plants can have serious adverse effects on human health and the environment. The areas of concern within the chemical industry include air, water and soil pollution. Chemicals of concern are benzenes, cyclohexanes, chlorinated solvents, polychlorinated biphenyls (PCB's), chlorofluorocarbons (CFC's), oxides of nitrogen (NOx), butanes, hexanes, chlorine, and nitrogen gas emissions (Wilson 1996). Public concern over safety in the chemical industry peaked in 1984 with the Bhopal, India disaster. Two thousand people died and an additional 300,000 people were injured when the Union Carbide pesticide plant leaked a massive amount of methyl isocyanate into the air. Many people are still suffering from exposure to this toxin and have continuing health problems (Earth Base 1994-96). There is evidence that this disaster was a direct result of lack of safety training as well as faulty operation of the plant. As a result, many studies on industrial safety were commissioned both in Canada and internationally. The Bhopal accident led to the development of the Responsible Care program by the Canadian Chemical Producers Association (CCPA 1995).

CXY Chemicals is a member of the CCPA and participates fully in its Responsible Care program. The responsibilities involve adherence to the six codes of conduct which are (i) community awareness and emergency response (CAER); (ii) research and development; (iii) manufacturing; (iv) transportation; (v) distribution; and (vi) hazardous waste management. The company is responsible to ensure that these codes are strictly complied to. This study focuses on the first code of Responsible Care, which stresses the importance of informing the public of the hazards and risks associated with operating the plant.

There is extensive literature regarding numerous aspects of the chemical industry. In order to understand issues pertaining to CXY, a brief literature review concerning perception and attitudes, public opinion, risk perception and remediation is presented. In addition, the regulatory bodies that are applicable to the chemical industry are examined. The remainder of this paper presents the history of CXY in Brandon and their current efforts of remediation; the methodology of the study and survey results; and finally, the concluding remarks will discuss implications of the study.

Perceptions and Attitudes

Disasters such as the Bhopal accident have tainted the image of the chemical industry, and the media has played a critical role in society's perceptions (Williamson 1994). People have become concerned about living near or being exposed to chemicals, even though it has been noted that chemical sources are one of the lowest causes of cancer and other health related problems (Greenberg 1986; Williamson 1994).

Numerous studies have examined how subjective perception of reality is confused with objective reality (Tuan 1975; Yalow 1995; Hendee 1995). This confusion is perpetuated through a distrust of science. Perception of risk is commonly dependent on knowledge, opinions of trusted individuals, cultural heritage or our physical environment (Hendee 1995). Ignorance can therefore, be a source for fear about an unknown; this factor was demonstrated in a study of construction workers at a pulp plant (Kovac 1993). In this investigation it was revealed that these workers viewed themselves at a higher risk to gas exposure than did regular employees of the same plant. There have been numerous other studies on the subject of risk and risk perception, some of which have involved surveys of the public as well as employees of the chemical industry (Viscusi and O'Connor 1984; Slovic 1987; Farid and Lirtzman 1991). For the most part perceived risk is understood to be much higher than actual risk (Williamson 1994; Hendee 1995).

Regardless, public attitude is a driving force for change. Widespread public concern and action can cause changes in legislation and influence the environmental behavior of a company (Wilson 1996). Research indicates that attitudes are linked to an individual's social experience (Converse, 1987). For example, if a person has health problems because of chemical exposure this is likely to influence their attitude toward the chemical industry.

This study of CXY was initiated to determine what the residents of Brandon knew about CXY, and to see where they may have received their information. If they had negative views of the industry was this formulated because of the media? Was it because of the *image* of the chemical industry? Were their perceptions based primarily on lack of information?

Public Opinion and Risk Perception Public Opinion and Risk Perception

Public opinion is a force that has the potential to influence change in our society. It is founded on attitudes, perceptions and the flow of information. This is important because, in most cases, a person's risk perception represents an emotional response rather than a reasoned one. For example, many people are afraid to fly even though statistics indicate that flying is safer than driving a car (Taczanowski 1992). When a risk arises concerning human health, people may blame industry despite the fact that some studies indicate that the health risks from industry are lower than cigarette smoking (Hong 1992; Williamson 1994). It has also been demonstrated however, that people tend to accept a high degree of risk rather than change their behavior (Macdonald 1992).

Risk perception is influenced by three factors: (i) the current state of knowledge of authorities; (ii) how this information is passed on to the public through media, and; (iii) how credible these authorities are to the public. The media plays an important role in educating the public, but it can also sensationalize and induce mass hysteria (Taczanowski 1992).

Thus, the attitudes and perceptions of the communities in Brandon are invaluable to determine public opinion towards CXY. The media's role in educating the public about CXY is crucial and cannot be underestimated.

Remediation

Remediation projects are an important dimension of the modern chemical industry. This often includes bioremediation, or the relocation and excavation of hazardous dump-sites (Board 1996). Remediation is a controversial issue. Some suggest that remediation can positively affect the environment and can help improve production, company profits, and public image (Green 1994; Williamson 1994; Wilson 1996), while others argue that the cost of cleaning-up is too great and cuts profits (Walley and Whitehead 1994). This latter view is especially evident when out-of-date plants need to be upgraded to comply with stricter environmental emission regulations.

The Super Fund plan in the United States was set up by the Environmental Protection Agency (EPA) to regulate remediation and hazardous waste cleanup operations (EPA 1998). Critics of the program state that this has been a costly venture without resolution (Hong 1992). In Canada remediation has been voluntary, except in a few cases where legislation has forced companies to upgrade.

Remediation efforts at CXY Chemicals began in June 1995, when it signed a Memorandum of Understanding (MOU) with the provincial government. This voluntary initiative was one of the first of its kind in Canada. Remediation has resulted in the cleanup of various toxic sites within the plant boundary and will be discussed later in this paper.

Regulation

There are many institutions that regulate the activities of the chemical industry in Canada. Environmental legislation, both federal and provincial, involves bodies such as the Canadian Environmental Protection Agency (CEPA) and the Canadian Council of Ministers of the Environment (CCME). The Canadian Chemical Producers Association (CCPA) also plays an important role. Internationally, organizations such as the Organization for Economic Cooperation and Development (OECD), the United Nations Environment Program (UNEP), and the European Union (EU) regulate and recommend procedures for safety and for protection of the environment (Bisset 1993). The International Standards Organization (ISO) is an environmental management system standard that also acts as a regulator for its members. ISO 9000 is primarily concerned with production quality and ISO 14000 involves the implementation of an environmental policy. All of these organizations have provisions and requirements for membership. Although voluntary, membership in these organizations gives industry a certain status and demonstrates a desire to protect the environment. Environmental legislation, on the other hand, is not voluntary and outlines the procedures that industry must abide by or risk prosecution.

Canadian Federal Legislation

The Canadian Environmental Law Guide (Wilson 1996) outlines the major Canadian environmental regulations. It points out that Canadian environmental legislation is mainly compiled in the Canadian Environmental Protection Act (CEPA), enacted in 1988. CEPA consists of 26 regulations and provides for the identification, assessment and management of toxic substances. The Act authorizes regulations controlling the discharge of these substances into the environment. CEPA is divided into several sections including toxic substances, environmental quality objectives, guidelines and codes of good practice, international air pollution, and ocean dumping. Part II of CEPA has the greatest potential implications for the chemical industry. This section covers the classification and regulation of toxic substances and sets up a "cradle-to-grave" system of controls for listed toxins.

Every year the Federal ministry publishes a National Pollutant Release Inventory (NPRI). This inventory is a current listing of toxic substances. Industries which use, manufacture or process listed toxins must report to the Ministry. For instance, in 1995 there were 176 substances on the list that were considered a threat to human health or the environment.

CEPA also requires mandatory reporting of a release and remedial action in the case of spillage of a toxic chemical. A company (which includes manufacturers, processors, importers, retailers, or distributors) may also be required to give notice of any dangerous substance to the public, manufacturer, processor, importer, retailer, or distributor of the substance. CEPA has been criticized however, due to its failure to address issues related to environmental emergency management, and some have suggested that CEPA should be amended to allow for this important issue (Bisset 1993).

Manitoba Provincial Legislation

In Manitoba, health concerns related to pollution were originally dealt with under the Public Health Act and this stood until 1935, when the Prevention of Water Pollution Control Act was enacted. This was the beginning of pollution control in Manitoba. In 1968 the Clean Environment Act was passed, issuing orders to limit and control pollution. Throughout the 1970s regulations were developed under this act to control and regulate pollution (Province of Manitoba 1981).

The Environmental Management Division and the Manitoba Environment Council were also governing bodies during the 1970s. The Environmental Management Division was responsible for such areas as air monitoring, solid waste and water systems, and water quality. The purpose of the Manitoba Environment Council was to advise the ministry of environmental problems and issues of concern to Manitobans (Keleher 1974).

During the late 1980s and the early 1990s many provincial acts were passed; chief among these was the implementation of the Manitoba Environment Act (1988), which replaced the Clean Environment Act. The goal of the Manitoba Environment Act is to prevent environmental damage and to protect Manitoba's environment for future generations. It covers the issuing of permits as well as environmental assessments. Under the Act a State of the Environment Report must be published every two years in order to keep the public informed of government progress. Fines under the act range from $100,000 for an individual to $1,000,000 for a corporation (Manitoba Environment 1991). The following section will present the history of CXY Chemicals and examine their remediation efforts.

CXY Chemicals CXY Chemicals

CXY Chemicals is located approximately 7 km east of Brandon, on Richmond Avenue (Figure 1). The plant was built in 1968 by Dryden Chemicals Ltd. At that time the plant produced chlorine, caustic soda, sodium chlorate, hydrochloric acid, and soda ash.

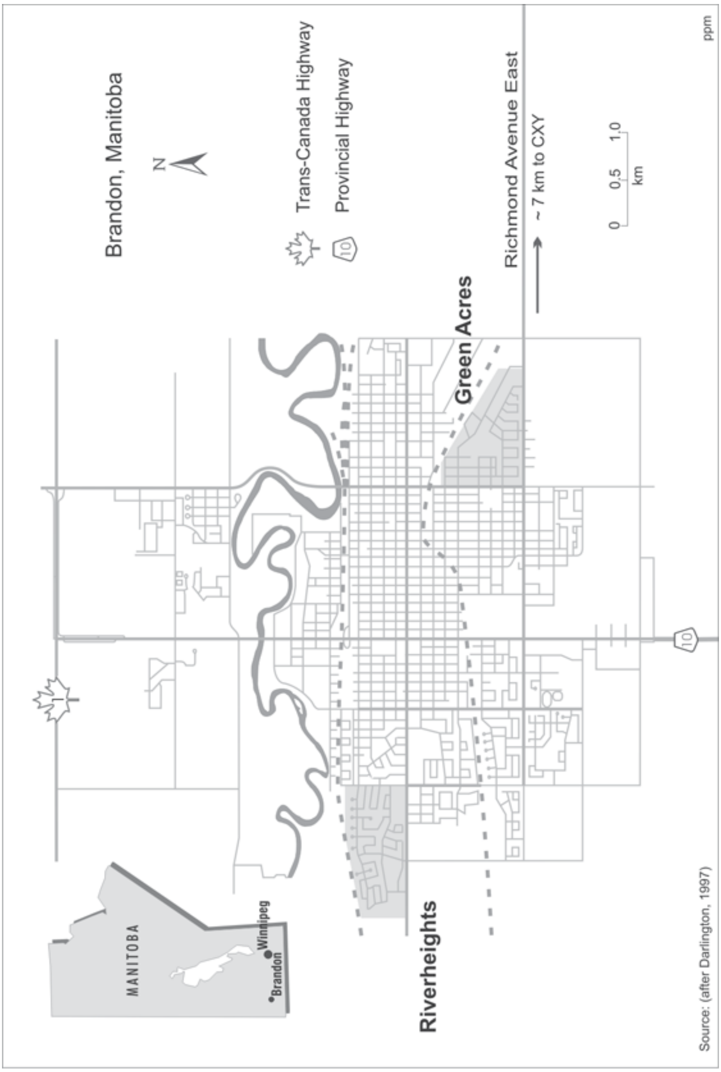

Figure 1: *The study area.*

Other materials used or produced by the plant included asbestos, and sodium chloride (Wotton and Elias 1996).

In 1974 CanadianOxy Chemicals (Canadian Occidental Petroleum Ltd.) bought the plant and subleased it to Hooker Chemicals. Four years later, CanadianOxy Chemicals took over the management of the plant, and developed it as a "sodium chlorate only" facility. Sodium chlorate is used in the process of bleaching paper in the wood and pulp industry. CanadianOxy was renamed CXY Chemicals in 1995 when a partnership was made between CanadianOxy (based in Calgary) and Occidental Chemical Corporation (headquartered in Los Angeles, California) (CXY Chemicals, n.d.). CXY Chemicals is the second largest producer of sodium chlorate in North America. Of the seven CXY plants located across Canada and the U.S., the Brandon plant is the second largest producer of sodium chlorate (CXY Chemicals, n.d. (b). It is also one of the lowest cost producers of sodium chlorate in North America (Bunting 1998).

Environmental legislation was not stringent in 1968 when the Dryden Chemical Ltd. plant opened. Accepted practices at the time included open and unlined sludge pits (Figures 2a and 2b), surface runoff into ditches and the Assiniboine River, and chlorine emissions, which adversely impacted the vegetation around the plant in the 1970s. Areas on the plant site which were impacted by facility operations included the settling pond, the PCB building area, the rail car loading area, the cooling tower area, the current and former burn pits, the construction landfill, and the septic field (Figure 3). The soil and groundwater in these areas were mainly impacted through spills, unsafe disposal of wastes, and release of effluent (CXY 1996).

On June 9, 1995, CXY Chemicals and Manitoba Environment signed a Memorandum of Understanding (MOU). This document was signed to support legislation that would ensure remediation of contaminated sites. The MOU solidified CXY's intent to voluntarily clean up the plant site. An interesting aspect about this MOU is that it is an entirely voluntary initiative with no legally binding obligations and it is among the first voluntary initiatives to deal with site remediation in Canada (CXY 1995). In June 1996, the following studies were commissioned by the Steering

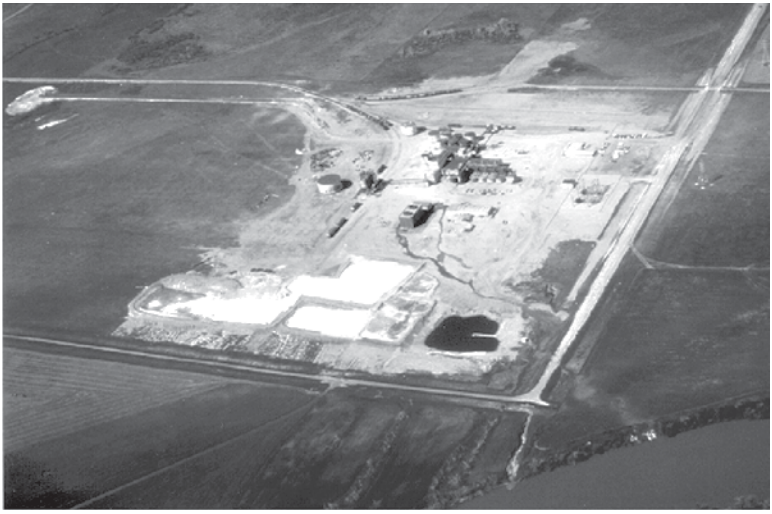

Figure 2a: *CXY circa 1974 (Source: CXY Chemicals, Brandon, Manitoba).*

Figure 2b: *CXY circa 1996 (Source: Al Rogosin, Brandon, Manitoba).*

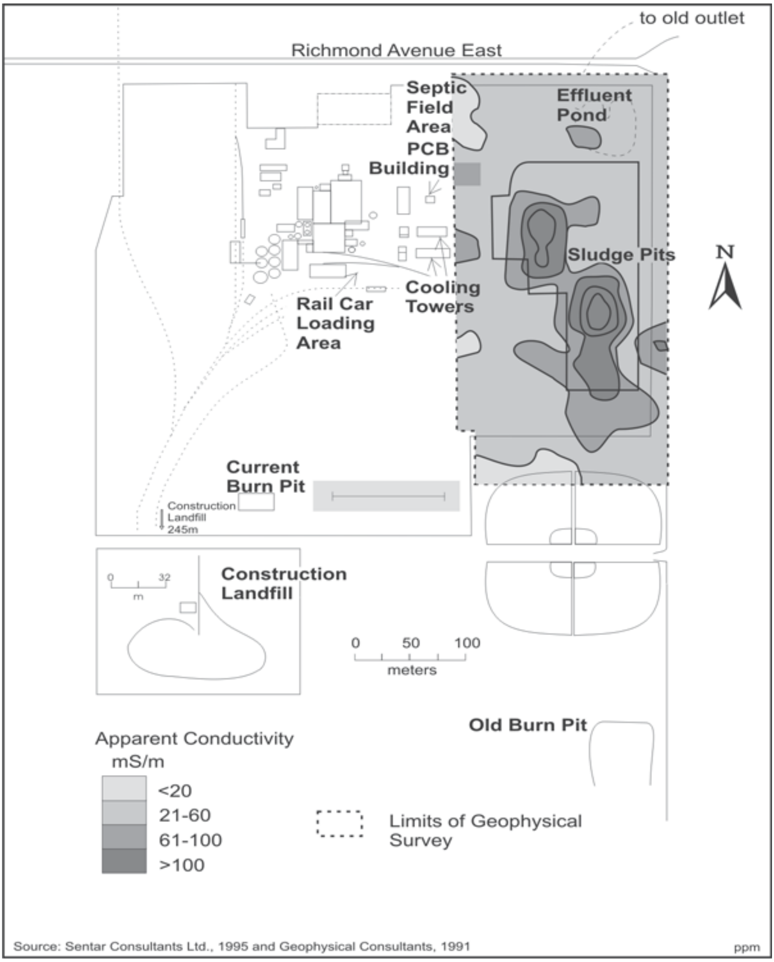

Figure 3: *CXY 's remediation sites.*

Committee / Advisory Panel (SC/CAP): (i) regular semi-annual groundwater monitoring of the site; (ii) additional soil testing and other research to fill gaps in information; (iii) additional health risk analysis including examining results of 1996 groundwater monitoring, and; (iv) development of remediation options for each site (The Steering Committee 1997).

At the November 1997 meeting the SC/CAP discussed remediation options for the sludge located in the lagoons and the settling pond. The majority of the contents of the sludge are non-hazardous, but there is concern about asbestos. It is likely that the sludge pits will be excavated and the contents transferred to a suitable landfill site, but the final destination has not yet been determined (SC/CAP Nov.1997).

The studies on groundwater have shown that the water does not meet drinking water guidelines for chloride and chromium. This is not a concern for local potable water wells or dugouts because these are located upstream from the plant. These contaminants would be of concern however, if the site were to revert to agricultural use in the future. The SC/CAP hopes that remediation efforts will cleanup the source of contamination and ensure safety for any type of potential land use in years to come (The Steering Committee 1996). The subsequent section will outline the study area, methodology and present the results of the questionnaire survey.

Study Area and Methodology

The study area for this research includes two communities within the City of Brandon and the CXY Brandon plant site. The City of Brandon is located approximately 200 km west of Winnipeg, Manitoba. Present population of Brandon is approximately 40,000 people. The two communities that were targeted for survey analysis in the city were Riverheights in the west end and, Green Acres in the east end. These communities were chosen because of their different proximities to CXY and because of their socioeconomic differences. According to Welsted, Everitt and Stadel (1988), historically the east side of Brandon was occupied by the working class and the upper class settled in the west end. Their research suggests that people at the extremes of a social scale will often locate at opposite ends of the city. In Brandon, the west end has newer, more expensive homes and is inhabited mostly by the middle and upper-middle social class. The east end has older, less

Table 1: *Response Rates, Brandon, 1988*

Sample	Surveys	Distributed Frequency	Percentage
Green Acres	92	38	41
Riverheights	81	42	52
CXY	43	27	63
SC/CAP	12	6	50
Totals	228	113	**50**

expensive homes that are owned or lived in by lower-middle social class.

The research methodology included direct personal interviews and a questionnaire survey. In order to obtain a higher response rate both a mail and a telephone survey were employed in this study as they are considered as complementary survey methods (Lounsbury and Aldrich 1986). Its major advantage is that it is relatively inexpensive and flexible. Its major disadvantage is that respondents are often highly suspicious and reluctant to cooperate. The mail survey, on the other hand, is relatively low-cost and easy to distribute. Response rates for this study are outlined in Table 1.

Hypotheses

Four hypotheses were tested in order to examine various aspects of public perception and knowledge of CXY. The pertinent components for this study include: (i) proximity to CXY; (ii) education of respondents; (iii) involvement of respondents, and; (iv) the determination of community awareness.

In the context of this study, the flow of goods and information are elements of spatial interaction. Characteristically, spatial interaction declines with distance (a phenomenon otherwise known as the distance decay function) (de Souza 1990). Green Acres is the closest residential community to CXY in Brandon. It would be expected that knowledge and interest in activities at CXY will decrease with distance, and since Riverheights is at the west end of Brandon, it was hypothesized that this community would be less interested or knowledgeable about activities at the plant.

> **Hypothesis #1**: that the Green Acres community in Brandon will be more knowledgeable than Riverheights about activities at CXY because of its proximity to the CXY plant.

In this study, education was used as a proxy variable for socioeconomic status. Various studies support the assumption that people with more education will be in a higher income bracket than people with less education (Smart and Pascarella 1986; Whitaker and Pascarella 1994). People who have a higher level of educational attainment (in this case, university education) should have more exposure to environmental issues, more opportunity to study issues, and will thus develop a more educated assessment of issues than people who have attended only high school or college.

> **Hypothesis #2**: that people with a higher level of formal educational attainment will be more knowledgeable about CXY and its activities than people with less formal educational backgrounds.

Employees of Manitoba Environment, of CXY, and members of the Steering Committee/Community Advisory Panel (SC/CAP) are involved in the decision-making processes related to CXY's activities and thus will have more understanding about the issues.

> **Hypothesis #3**: that persons involved within the chemical industry will be more knowledgeable about issues pertaining to CXY than the general public.

The goal of the Community Awareness / Emergency Response (CAER) code under the Responsible Care mandate is to reduce public concern vis-à-vis chemicals in their community. Although CXY has conducted open houses, plant tours, and published information for public use, it is hypothesized that community awareness is lacking. In fact, unless a major chemical accident occurs, people are not likely to be interested in the activities of CXY.

> **Hypothesis #4**: that the Community Awareness/Emergency Response (CAER) code of conduct within the Responsible Care mandate is not effectively informing the general public about activities within the plant.

Survey Results and Discussion

The first hypothesis postulated that because Green Acres is closer to CXY than Riverheights, its residents would be more knowledgeable about issues relating to the plant. In order to test this hypothesis, this section analysed a series of questions concerning knowledge and awareness. Respondents were asked whether they were aware of remediation efforts at the plant. This question was important to this study because it indicated whether the communities had an intimate knowledge about activities at the plant. Overall, 30 percent of both communities knew about remediation at the plant, but a substantial proportion of respondents were unaware (70 percent).

Two survey questions concerned safety training of employees and preparedness of CXY for emergencies. The majority of people in both communities had no opinion on this subject; however, 47 percent of Green Acres' respondents agreed that CXY is adequately prepared for emergencies, compared with 36 percent of Riverheights respondents (Table 2). It is apparent that residents in Green Acres are more confident about emergency preparedness than Riverheights respondents, implying that proximity does indicate more knowledge or more confidence in terms of emergency preparedness.

Table 2: *Distribution of opinion on "CXY is adequately prepared for emergencies" (percentage)*

Responses	Green Acres n=38	Riverheights n=42	Total n=80
Strongly Agree*	13	10	11
Agree*	34	26	30
No Opinion*	53	62	58
Disagree	0	2	1
Strongly Disagree	0	0	0

X^2 ($p<0.001$; df = 2) = 79.00 (Significant)
* only these three categories were used for chi-square analysis

Education was chosen to be the representative socio-economic variable. The educational levels were categorized as: (i) high school, (ii) college and, (iii) university. It was hypothesized that people with university education would have more knowledge and interest in activities at the plant. Interest in activities of the plant was measured by asking respondents if they would be interested in attending an open house. Survey data indicates that 65 percent of university graduates and 56 percent of high school graduates would attend an open house. Among the college graduates, only 31 percent were in favor of attending an open house. From these results it could be concluded that the university sample is slightly more interested in activities at the plant.

When asked whether CXY had a negative impact on the local environment 54 percent of respondents with high school and college background, and 46 percent of the sample with university background had no opinion. However, 46 percent of the college-sample, 42 percent of the university-sample, and 41 percent of the high school-sample indicated that they did not think CXY has caused a negative impact on the local environment (Table 3). Thus, there is very little difference in response between the three education levels on this question. Other survey results suggest that there is little difference between education level and knowledge of issues

Table 3: *Distribution of opinion on "CXY has a negative impact on the local environment" (percentage)*

Responses	High School n=41	College n=13	University n=26
Strongly Agree	5	0	4
Agree	0	0	8
No Opinion	54	54	46
Disagree	34	46	31
Strongly Disagree	7	0	11

pertaining to CXY. Further comprehensive study would substantiate and provide more accurate results on these issues. Interest in activities at CXY could be more dependent on other factors, such as social contacts, than on education level.

One critical issue in this study is to examine the perceptions of the common public vs. those who are directly involved with CXY. It would be expected that the general public would be less knowledgeable about activities at CXY than would management, regulators, and employees. For this section the term "Insiders" is used to include employees of CXY and regulators who participated in the survey.

Insiders were more interested in attending open houses at the plant (88 percent) than were the community members (54 percent), indicating a stronger interest in activities of the plant on the part of insiders. In terms of whether CXY has a negative impact on the environment, 51 percent of the community had no opinion and 43 percent disagreed with the statement. This contrasted with 6 percent of the insiders who had no opinion and 88 percent who disagreed. Surprisingly 6 percent of both samples felt that CXY did have a negative impact on the environment. The insiders were more convinced that CXY's efforts had changed public perception of the chemical industry than did the general public: 70 percent of the respondents agreed or strongly agreed with the statement,

Table 4: *Distribution of opinion on "Public perception of the chemical industry has improved because of CXY's efforts"(percentage)*

Response	**Community** n = 80	**Insiders** n = 33
Strongly Agree	1	3
Agree	26	67
No Opinion	64	27
Disagree	9	3
Strongly Disagree	0	0

X^2 ($p<0.001$; df = 2) = 113.00 (Significant)
* these categories were grouped into three categories: somewhat agree, no opinion and somewhat disagree, for chi-square analysis.

compared to 27 percent of the community. The community had a higher rate with no opinion (64 percent) than did the insiders (27 percent). This question indicates how different the view from inside the industry is compared to outsiders, such as community members. Community members, who have little understanding about activities at CXY, do not believe that perception has changed, whereas individuals within the industry disagree with this notion.

Another interesting comparison between the community and the insiders was the ranking of factors that motivates industry to change its processing methods. Both the community and the insiders ranked compliance to environmental legislation as the number one choice. The second choice was management directives (such as Responsible Care and the MOU) for insiders and public pressure for the community. This was interesting because the community ranks public pressure higher than the insiders do. The community ranked management directives last on the list. Personnel who are involved in the industry have more understanding about how management can influence the activities of CXY, because of management directives.

CXY has attempted to increase public awareness through open houses, newspaper advertisements (Brandon Sun 1997), and contributions to public libraries. Even with these attempts it would appear that the respondents in this survey are unaware of activities at the plant. Results show that the public believes that advertising is the best way to learn more about CXY. Suggestions for advertising included public television programs or advertisements in the newspaper. The public rated open houses as the second best choice; however, 41 percent of respondents indicated that they would not attend an open house. Notably, 39 percent of respondents who knew about changes at CXY learned about them from the media. This supports the fact that the media is perhaps the best way for CXY to communicate to the public. Perceptions of the public are dependent upon the media and misconceptions can occur. It is extremely important that the media be responsible in properly educating the public about objective risk (Taczanowski 1992).

Overall, it seems that Green Acres is slightly more knowledgeable than Riverheights about activities at CXY. Therefore the first hypothesis was accepted. It was also found that there was no difference in awareness and knowledge by education levels, thereby not allowing acceptance of the second hypothesis. The employees of CXY definitely have more knowledge than the general public, which supports hypothesis three. The CARE code was found to be generally ineffective, which supports hypothesis four.

Conclusions

The results of this study indicated that the two residential communities in Brandon are aware of CXY, but not aware of remediation there. It also indicates some degree of confidence in safety training for employees and emergency preparedness of CXY. Results also indicated that the public felt that advertising was the best way for CXY to communicate about remediation. This was interesting because it shows that the media is perceived to play an important role in public education. This makes it important for the media to be responsible in dealing with public issues. It also shows how unbiased reporting can educate the public responsibly, so that people can decide for themselves where they stand in terms of the issues concerned. This is an essential component of societal change.

Another issue that deserves attention here is the size of Brandon. Brandon is a small city and, relative to larger cities, social contacts between people are likely to be more frequent. The perceptions and attitudes of friends, or peer groups will be more likely to influence how people make inferences about CXY rather than open houses, tours, media coverage or other sources of information.

It was somewhat disappointing to receive many “no opinion” responses in the survey. This was indicative however, of the nature and state of the perceptions and attitudes of the general public. They are mostly unaware of issues relating to CXY. For the most part, respondents found the questionnaire difficult to complete. This is also an indication of lack of knowledge. It is firmly believed that unless something dramatic was to happen, which would affect people personally, for example, an explosion at CXY, or a chemical truck spilling over, there is little interest in the chemical industry.

The results from this study demonstrate that CXY could be used as a model for larger industry. CXY is a small company, employing only 45 people and producing small amounts of toxic chemicals. The products of this industry however, are generally targeted towards a non-agricultural endpoint making it unique in this area. This is an interesting contrast. While CXY is working towards remediation and a better public image, they are supplying the raw materials for one of the most environmentally damaging industries, the pulp and paper industry. Certainly the methods by which CXY has voluntarily remediated areas on site, sets an example for larger industries. The efforts by the SC/CAP have been invaluable in this regard. It is important that all stakeholders involved become engaged in dialogues and address the issues cooperatively. It is also essential that members of the general public are able to contribute to this process.

Further in-depth studies could refine our knowledge of the perceptions and attitudes of people in Brandon. The study should contain a more statistically representative sample. The results from such a survey could be then be used to show a more accurate proportion of the population. It would also be interesting to develop working groups that would involve more of a cross-section of the public than is already represented on the panel. Other research could involve testing the soils and groundwater for contamination. Although these tests have been performed by independent consultants (e.g. SENTAR Consultants Ltd., Geophysical Consultants, and Associated Mining Consultants), it would be interesting to compare them with results from independent academic research. Another interesting research project would be to interview past employees of CXY and examine the workplace safety initiatives in the early days of the plant compared to the current procedures.

Overall, the results and analysis of this study have been very favorable. The chemical industry is only a small part of industry in Canada, and only a small portion of the pollution problem. There is a need for more effective legislation concerning pollution in Canada. Regulations, fines and prosecutions need to be stiffer, inducement need to be established, and grandfather clauses need to be eliminated. These clauses were established in the days of less stringent environmental legislation, and are not applicable in today's society. Society needs to take its stewardship role more seriously and thus be more proactive against industry in order to induce change. As results indicate in this study, knowledge and awareness in society are sadly lacking, and there is an urgent need to address this problem.

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Way down yonder, down Mexico way: tourists, snowbirds and expats in Mexico

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Abstract: In recent years Mexico has become not only an increasingly important tourist destination, but also a winter target for Canadian "snowbirds" and indeed a home for retired expatriate Canucks. Although tourism is now much more common, there are still relatively few Canadian snowbirds, and an even smaller number of people who can afford to become retired expatriates. However, increased leisure time, higher incomes, and a greatly enhanced mobility have meant that numbers in each category have increased, and have reached a high enough level for each cohort to have an impact – economic, social and possibly environment – upon their destinations. In this paper we shall discuss how physical and human geography of the Lake Chapala area has positive and negative influences upon the decision-making process of Canadian visitors. Lake Chapala is Mexico's largest lake and is located about 49 minutes south of downtown Guadalajara – the second largest city in the country – in the state of Jalisco. The purpose of our research project is to illuminate the process whereby Canadians choose a particular destination in Mexico, and to begin to explore the impacts of the tourists upon this destination.

Introduction

In recent years Mexico has become not only an increasingly important tourist destination, but also a winter target for Canadian "snowbirds," and indeed a home for retired expatriate Canucks. Such movements represent a luxury for all involved, at least when compared to the expectations of the recent past, and consequently, up until the last few years, participation was restricted to a select few. Although tourism is now much more common, there are still relatively few Canadian snowbirds, and an even smaller number

Figure 1: *Location of Guadalajara and Lake Chapala.*

of people who can afford to become retired expatriates. However, increased leisure time, higher incomes, and a greatly enhanced mobility have meant that numbers in each category have increased and have reached a high enough level for each cohort to have an impact – economic, social and possibly environmental – upon their destinations (McIntosh and Goeldner 1990; Pearce 1989).

The purpose of our research project is to identify the reasons for the choice of a particular destination in Mexico, and to begin to explore the impacts of the tourists upon this destination. It is hoped that this case study, apart from being of inherent interest, may lead to the development of models of tourism, and thus a stronger base for its related sub-discipline within geography (Pearce 1995). Mexico has been chosen because of its growing importance as a destination for Canadians. This importance is likely to increase (perhaps dramatically) as the value of the Canadian dollar falls (Rafferty 1993) curtailing visits to many conventional sites in the USA, and as the perceived advantages of Mexico become more

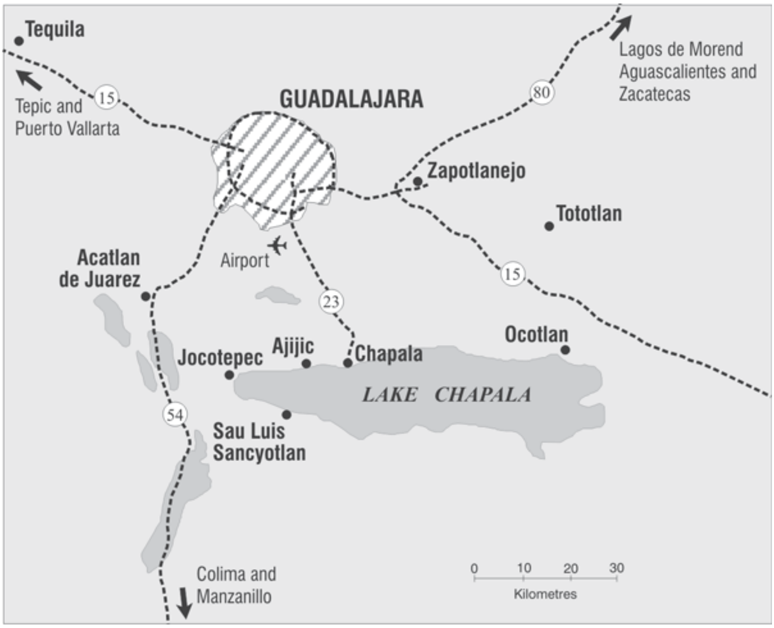

Figure 2: *Guadalajara and Lake Chapala settlements.*

widely known. In this paper we shall discuss the case of Lake Chapala, a major destination point near Guadalajara (Figure 1).

Lake Chapala is Mexico's largest lake and is located about 40 minutes south of downtown Guadalajara – the second largest city in the country – the state of Jalisco (Figure 2). Although there are several settlements around the lake (the three main ones being Chapala, Ajijic and Jocotepec), the most popular with Canadians is Ajijic, and it is this town that will be a focus within this paper (*http://www.mexconnect.com/mes_/chreares.html*). Chapala is the main seat of government for several of the villages that sit near the lake. Insides the town's colonial buildings are housed almost all the agencies and departments that administer to the legal, civic and ecological life of the area. Jocotepec has relatively few foreign residents at present.

Characteristics of the Destination

Physical Geography

Lake Chapala is a remnant of a much larger water body – Lake Jalisco – that during the late Pleistocene, perhaps 30,000 years ago, covered much of the state of Jalisco and spread into the states of Michoacan and Aguascalientes. Lake Jalisco probably resulted from volcanic damming of natural outlets, and volcanism is still active in the general area. Gradually, Lake Jalisco emptied leaving behind a series of lakes the largest of which is Lake Chapala. All of the lakes are shallow and some (e.g. Lake San Marcos west of Lake Chapala) are water covered only during the wet season of the year (*http://www.mexconnect.com/mex_/geolog.html* Leyden 1994).

Like all lakes, Chapala is doomed to extinction by natural processes of erosion, such as the lowering of the outlet, and deposition, with sediment being deposited by inflowing rivers; for example the Lerma River has deposited a sizeable delta at the east end of the lake. Moreover the natural lake level fluctuates markedly between the wet and dry seasons. Added to this is the fact that the lake is being negatively affected by cultural processes such as: (i) the removal of the water from inflowing rivers (for irrigation and water supply), (ii) increased phosphorus levels, algae blooms and increases in heavy metals, and (iii) infestations of aquatic weeds (Burton 1997). To quote one observer of the Lerma River:

> “Right now, it is not a river but a gigantic, stagnant latrine of human waste from scores of cities and towns, of tons of chemical fertilizers and manure from agri-businesses, of toxins from private factories, the government’s oil monopoly Petroleos Mexicanos (PEMEX) and its energy monopoly Comision Federal Electridad” (Hunt 1998:20)

A critical question with respect to our research is “how far will these physical and cultural processes negatively affect tourism in the foreseeable future?”

An important variable for all three cohorts of visitors is climate - as it is the Great Canadian Winter that “impels” many of these visitors to leave their homes in the Snow Belt for varying lengths of time. In the Lake Chapala area, average high temperatures range from 24 degrees Celsius in December and January, to 30 degrees Celsius in May. Lows range from 8 degrees Celsius in January to 16 degrees Celsius in June. Consequently Ajijic's climate has (reputedly) been called one of the best in the world by *National Geographic*, and has been described by boosters as having an "eternal spring." This means that residents "do not need heating or air conditioning in their homes." Certainly such artificial aids are unusual, and often unused. The climate has a low humidity, which - as boosters point out - cannot be said for the coastal resort areas (*http://virtualmex.com/ajijic/climate.htm*), which represent major competitive destinations within Mexico. The climate results in general from the location of the region within world climatic systems, but specifically it is a function of the local mountainous environment (Ajijic is at 5200 feet/1585 m asl) and the existence of Lake Chapala, which has an ameliorating effect upon the local microclimate. Of course, if the lake is destroyed, the genial climate of a great part of the Jalisco highlands will go with it.

Lake Chapala has been an attraction for human groups since pre-Hispanic times, with thriving settlements scattered around the lake and its environs. Since the late nineteenth century it has been an area of tourism for both Mexican nationals and foreigners. The building of a railroad connection early in this century cut the journey from Guadalajara from twelve to three hours (*http://www.mexconnect.com/MEX/paraiso/localhistory.html*). More recently the lake shore has attracted an artistic community, and increasing numbers of Anglo American visitors, as well as continuing to cater to the growing population of Guadalajara.

Human Geography

It is often suggested that tourism - and by extension "snowbirdism" and "expatism" - can be powerful and beneficial agents of both economic and social change within the host country (Mathieson and Wall 1982). Certainly these movements generally stimulate employment and investment, modify land use and the economic structures of destination areas, and make positive contributions to the balance of payments of these areas, and there is no reason to believe that this is not true in the present instance. These migrations are gaining momentum as the quality of the tourist/residential experience in the Lake Chapala area becomes better known through word of mouth and through promotional materials - such as those contained on a multitude of World Wide Websites.

One of the many (now) freely available "promotional" websites (*http://virtualmex.com/ajijic/ajijic1.htm*) designed to promote the Lake Chapala area claims that:

> Ajijic is a comfortable, safe place for you to retire or just spend your winters. The town and area have the largest concentration of Americans outside of Canada, and the largest concentration of Canadians outside of the US. But the village itself is still a quaint Mexican town with cobblestone streets, little shops, and a lovely town square. English is spoken everywhere. More than 200 English speaking support groups exist in the Lake Chapala/ Guadalajara area. Everything from libraries, shopping tours, colonial city tours, beach tours, arts and crafts, social clubs, legal services, tourist advice, etc.

In truth, Ajijic is not the perfect destination that these words make it appear. It is still characterised by a high degree of poverty, as is almost any area of the "South," and has numerous social, economic, and environmental problems that are independent of the tourist phenomenon. Ajijic however, does possess many positive characteristics that attract both short and long term visits from foreign countries - particularly from Canada and the United States.

Conversely, the growth of tourism in areas such as Ajijic has raised questions concerning the social, economic, and environmental desirability of encouraging further expansion. For example, tourism may be encouraging negative characteristics (crime etc.), and the local government bodies may be giving valuable resources over to tourist facilities rather than using them to improve the state of the host population.

Characteristics of The Visitors

Although there is a mix of foreign visitors, citizens of the United States and Canada predominate. One estimate has some 8,000 “Norte Americanos” living around Lake Chapala, with perhaps 35,000 in the larger Guadalajara region (Slemko 1998). At present, in total, the Canadians slightly outnumber the Americans, although this appears to reflect a recent change in migration patterns, with three out of five new visitors now reportedly being Canadian (*http://www.southmex.com/wwwboard/messages/104.html*). A so-far-unexplained fact is that Canadians appear to be more dominant in Ajijic, and Americans in the town of Chapala. This perhaps reflects different migrational streams, but may also reflect a social distance between these two groups. Field observation and interviews indicate that although all age groups can be found within the visitor cohorts, older people predominate, particularly (and not at all surprisingly) among the snowbird and expatriate groups. Although only a small minority of these visitors can probably be classified as “wealthy” in a North American context, all will have a significantly higher spending power than most Mexicans, and thus a greater potential for social, economic, and environmental impacts.

The “mix” of population clearly has an important effect upon the amount and variety of cultural landscape development that takes place. Thus the Lake Chapala region, compared for instance with the coastal resorts, has less to offer a younger cohort of tourist, with fewer bars and clubs, and few facilities oriented towards children. This also impacts upon the level of usage of the local region, and possibly upon what Doxey (cited in Mathieson and Wall 1982: 138) terms the level of irritation that might be aroused within the host population.

Environmental Impacts

It is hard to separate and disentangle the role of people from the role of nature. Similarly, *ecological* impacts of the incoming “Norte Americanos” are hard to measure, as it is difficult to separate these from the local/host impacts. Certainly the presence of the 8,000 visitors has an impact, and it would be greater per person than for the host/local population (Ryan 1991: 95), but it is probably not the most serious threatening influence upon the local environment, which has at least eight million local inhabitants. The most serious impact appears to be the effect of agricultural effluents reaching the lake, and the impact of the removal of water for irrigation purposes. These negative effects are both direct and indirect via the impact of streams that flow into Lake Chapala (principally, the Lerma River). The River Lerma-Lake Chapala drainage basin supports 3,500 diverse industries, 750,000 hectares of irrigated farmland, and fourteen cities in excess of 100,000 population - in addition to the rural people. Burton (1997) suggests the contamination of the lake means that its future “does not look too promising.” “Fishing, for instance, has gone from five-six tons at Chapala to about half a ton (for 400 fishermen) in 20 years.” (Hunt 1998: 20). Although state and federal governments have committed themselves to the preservation/reclamation of the lake, these “signed vows” have not been adhered to (Hunt 1998: 20). This is in part because Mexico is not currently equipped for a holistic proposal that could protect the entire ecosystem. It is also in part because it is naive to expect that Lake Chapala will be “protected” or “conserved” without “first trying to ensure improved living standards for all the basin’s 8 million inhabitants” (*http://www.mexconnect.com/mex_/travel/tonysarticles/tblagunasaved.html*).

Recent rains have led to rising lake levels once again, and may indicate the onset of a wetter cycle (Murray 1998). But these improvements may be only temporary, and may simply mean a postponement of the inevitable (*http://www.guadalajara.reporter.com/no_password/chapala.html*).

The social effects are, as is common in such situations, difficult to separate out into different variables. Interestingly however, there does appear to be a difference between visitor groups. The tourists are more likely to be involved in tourist-host relationships, which are unfavourable whereas the snowbirds and particularly the expats often work at promoting more favourable situations. One promoter, for instance, exhorts the employment of a house cleaner by snowbirds and expats as a means of boosting the local economy. On the other hand there does seem to have been a rise in crime as a result of the "easy pickings" presented by the richer North Americans, and many of the housing estates now being constructed are "gated communities" protected by armed guards. Not a trouble free paradise, to be sure.

It is easier however, to recognise the impact of the visitors upon the cultural landscapes of the region (Hoffman 1992). Once again these vary from group to group. Interestingly however, there has been an apparently conscious attempt to preserve the basic form of this landscape, as this is seen as one of the attractive features of the region Thus, for instance the scale of the host landscape has been maintained, high rise buildings are not present, and large services ("malls") catering to the visitors are not to be found. Many services - including golf courses (with casual caddies available), restaurants, art and handicraft galleries, permanent stores, and periodic markets - have however, grown up to cater to the foreigners. Hotels and bed and breakfasts (B&Bs) supply the tourist and snowbird market, with houses and villas commonly being built, singly and in estates, to cater to the snowbird and expatriate visitors. Although most services and forms of shelter are too expensive for the host population they are often relatively inexpensive compared to their North American counterparts. In addition taxes are much lower, and the visitors can learn to take advantage of stores (etc.) that cater to the host population - at a lower price.

Conclusion

Movements between Canada and Mexico seem likely to increase in the foreseeable future. In part this reflects the widening horizons of Canadian travelers, as tourism "abroad" has become an accepted, accustomed, and even an expected part of the lifestyle of a large and growing number of Canadians (Mathieson and Wall 1982). In part it reflects the relative power of the Canadian dollar in Mexico compared to the USA - or indeed, Canada. Although this may not be a permanent condition for the "loonie," it is likely that at least some of the "streams" of Canadians visiting Mexico as a result of this economic reality will maintain their allegiance to Mexico in the future. In part it seems to reflect the fact that tourists often become snowbirds who often become expatriate retirees; as tourism continues to increase the whole set of processes is continually reinforced. In part it reflects high levels of "customer satisfaction."

Socio-economic problems do not appear to be of major significance at present. Economically the visitor populations are still most commonly seen to be a benefit - at least by the more dominant members of the host population, They also provide an alternative market in many instances, for poorer sections of the population. Socially, and using Doxey's "index of tourist irritation" as a guide (Mathieson and Wall 1982: 138), the host population falls into either the "level of euphoria" category, or the "level of apathy" category. There is little or no evidence of "irritation" or "antagonism." Although the presence of the North Americans has, perhaps, stimulated the crime rate, it is difficult quantify this increase.

The migrants to the Lake Chapala region appear to be quite satisfied with their new experiences, citing everything from "tranquility" to "better sex" as advantages of the region, and the increasing number who return emphasize their appreciation of the various experiences (*http://www.mexconnect.com/mex_/sml/gwfntn youth. html*).

The environmental challenges remain however, and are perhaps becoming more severe, which could mean that although Mexico in general may continue to grow as a destination, Lake Chapala may not be quite so popular as it has been in the recent past.

Acknowledgments

We would like to acknowledge Dr. John Mallea, who made the contacts that enabled this research to take place, and Brandon University and the Autonomous University of Guadalajara who helped supply funds for our field work. Tom Slemko, a Canadian "snowbird" helped us with local data and information. Diane Murray, an expatriate, was also of assistance. The World Wide Web also proved to be invaluable.

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Visitor use and satisfaction of the Meewasin Trail system in Saskatoon

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Abstract: A multi-use trail system, such as the Meewasin Valley Trail in Saskatoon, provides many recreational opportunities for both tourists and city residents. Such interaction between individuals and the environment is related to perception, values, and attitudes towards the environment. Factors such as culture and its related social and political aspects influence the 'person-environment' relationships that exist, and these in turn, influence behaviour towards recreational space. Constraints and conflicts are characteristic limitations that exist in recreational situations. This paper notes that consideration of the needs and desires of different individuals can improve recreational experiences. Preliminary survey results of Meewasin Valley Trail users suggest that there is a preference for natural surroundings, which should be maintained in order to provide a wilderness recreation resource within the city of Saskatoon.

Introduction

The Meewasin Valley Trail, situated along both sides of the South Saskatchewan River, provides many recreational opportunities for people in the Saskatoon area. The trail system is used by both visitors and city residents. Certain areas of the trail system appear to be used more heavily than others, while various modes of transportation are utilized by the trail users. Society's perceptions, values and attitudes have major roles in the selection of an individual's recreational space. It is important to consider the identity of trail users, as this is significant in terms of understanding the use and demands that are placed upon the trail system.

Environmental Perception and Behavioural Research

The environment plays an important role in outdoor recreation. Whether it is in its natural form or modified by human action, it is viewed as a contribution to most recreational experiences. Most forms of recreation involve the interaction of an individual with others and the environment (Wall 1989).

Environmental perception and behavioural research study the geography of space and place, and require knowledge of how people experience, perceive, organise and attribute meaning to environmental information, as well as the individual's actions taken upon this information (Aitken *et al.* 1989). Problems may result from the use of the recreational resource base. Concern for the quality of a recreational experience contributes to the physical and mental well-being of recreation participants (Pigram 1983). The environment and its users have a reciprocal relationship. In order to maintain participant satisfaction, environmental values should not be used at a faster rate than they can be produced.

The concept of carrying capacity is concerned with the capability of the resource base to continue to provide for recreational use (Pigram 1983). While ecological aspects are important, the social component is of particular relevance to outdoor recreation. The social realm involves individual tolerance levels and sensitivity to others, as these aspects are personal and subjective notions that are linked to human psychological and behavioural characteristics. These aspects are the most difficult to measure, as they differ between individuals, as well as for an individual at different times or situations (Pigram 1983).

Recreation and Behavioural Responses

Those individuals who do not participate in recreational activities may be categorized as those who do not desire to participate, and those for whom a certain constraint exists (Searle and Jackson 1985). External constraints, existing outside the person or that are characteristic of the environment, may take the form of trail supply and availability, and costs in travel and fees. Non-participation may also include internal constraints within the person, including perceptions related to personal capacities, knowledge, resources, and interest.

Incompatibility and the resulting conflicts between opposing recreationists, as well as between outdoor recreation and other forms of resource use, may detract from the enjoyment of a recreational experience (Pigram 1983). Incompatibility depends upon the degree to which two or more activities can co-exist in a certain recreational area. Confrontation over the use of recreational space is not due only to inter-activity conflict. Different types of participants that engage in the same activity may also experience conflict situations, due to the complexities of human behaviour (Pigram 1983).

An 'outgroup' may be identified as a group to which an individual does not belong. Unfavourable evaluations of an outgroup lead to attributions of conflict when the outgroup is encountered. There appears to be a tendency to evaluate others upon the basis of group membership, and when recreation users are asked to make judgements about goal interference, the responses may be based upon beliefs about the outgroup, rather than what has been experienced (Ramthun 1995).

Survey of Meewasin Valley Trail Users

The Meewasin Valley Trail, developed in 1982, encompasses over 15 kilometers of asphalt paths and several kilometers of other trails, along both sides of the South Saskatchewan River. It is a multi-use path that is available for recreational enjoyment throughout the year. Due to increased trail demand, it was found that a more comprehensive look at the trail system was needed and that future development was inevitable. Previous research of the trail system has been concerned with the environmental impacts of trail use (Hilderman *et.al* 1990; Beak Associates 1988; Golder Associates 1985). Social aspects are unknown, including the amount of trail use, the frequency of use in various areas, the modes of transportation that are used, and the benefits of the trail system to the residents of Saskatoon. These social impacts would not only include the positive aspects of the trail system, but would also involve any negative spin-offs that may result from increased trail use. It would be beneficial to determine whether the expectations by the public are being met by the current trail system, or whether there are any concerns that may demand increased trail access.

During the summer months of 1998, a preliminary study was conducted by utilizing trail-side surveys. The views of trail users were recorded in response to a short questionnaire. These surveys included the following areas of interest: where the person came from to use the trail, why the trail was being used, where the trail was entered, how far was travelled to get to the trail, level of activity while using the trail, frequency of trail use, areas of improvement, and likes or dislikes about the trail. A longer survey, dealing with the same areas of interest, will be mailed out to a sample of the residents of Saskatoon in order to reach both trail users and non-users.

Three main areas of concern were examined in the scope of the study. First, the types of use or modes of transportation were considered, as well as the areas of the trail system that were most frequently used. Secondly, the social and economic impacts or benefits to the community were investigated, relating trail use to the areas of the trail system that were most frequently used. A third area of study involved the impact of the trail system on the community and the identification of any negative impacts.

Initial determinations were made, based upon the works of Jackson (1988) and Bialeschki and Henderson (1988). First, it may be suggested that the further one must travel to use the trail system, the frequency of trail use declines, while non-pedestrian forms of transportation must be utilized. Secondly, the downtown core would receive the most trail use that would mainly involve tourists and business people. The outlying areas would receive the least use, mainly by people living in the most closely associated residential areas, or by athletic types. Thirdly, in terms of negative aspects, any major environmental impact that occurs would be found away from the paved primary path, while safety concerns would be an issue in high traffic areas.

Results

Of the sample of one hundred trail users, 78% indicated that they had come from home to use the Meewasin Valley Trail. The rest of the users had either come from school (4%), work (10%), or another place (8%). Of those in the "other" category, 5% were visiting the city. Many of the respondents intended to enter and leave the trail from the same spot (64%), while 25% used a different entrance and exit point. The others (11%) indicated that their route was undecided.

The majority of trail users did not travel far in order to use the Meewasin Valley Trail. Thirty-two percent travelled less than three blocks, and 27% travelled between 3 and 8 blocks. Of those who came from a further location, 34% travelled over 9 blocks, and 7% were from out of town. The respondents indicated that just over fifty percent of Saskatoon's neighbourhoods were represented, and that the areas of residence were fairly evenly distributed across the city. The main form of transportation to the trail (Table 1) was by foot (41%).

Table 1: *Mode of transportation to trail.*

Walk	41%
Cycle	33%
Car	17%
Public transit	1%
Other:	8%
rollerblading (3%)	
running (3%)	
powerchair/handicycle (2%)	

Many individuals (41%) indicated that they would be using the trail between a half an hour and an hour on the day of the survey (Table 2).

Table 2: *Length of time utilizing trail.*

Less than half an hour	7%
Half an hour to one hour	41%
One to one and a half hours	27%
Over one and a half hours	25%

It was indicated that 71% of trail users used the trails more than once a week (Table 3). Of those respondents, 26% indicated use occurred more than twice a week.

Table 3: *Average use of trails.*

Once a month	7%
Once each two weeks	7%
Less than once a week	7%
Once a week	8%
More than once a week	71%

Many respondents indicated that the scenery, serenity, and the proximity to the river were the most attractive aspects of the trails (Table 4). Of things that were liked the least, crowded conditions (especially downtown), bikes and rollerblades, and high speeds of bikes were the most common concerns (Table 4). Many individuals indicated that they would not change anything about the trails, and that it should be kept natural (Table 5). If they were asked to change anything, it was suggested that the trails be extended and developed to a further extent, and that the trails should be widened (Table 5).

Table 4: Favourite and least favourite aspects of the trail system.

Favourite aspects (%)	Least favourite aspects (%)
Natural scenery/wildlife (39%)	Trail design (26%)
Proximity to river (13%)	Outgroup related (26%)
Provides serenity (10%)	Upkeep (22%)
Trail design (7%)	Crowding (12%)
No traffic/not crowded (6%)	Other (5%)
Vegetation (5%)	Safety (4%)
Access (4%)	Nothing (4%)
Provides place for exercise (4%)	Distance from home (1%)
Upkeep of trails (4%)	
Other (8%)	

Table 5: Trail improvements

Items to remain the same (%)	Desired changes (%)
Natural beauty/vegetation (43%)	More maintenance (21%)
Everything (28%)	Extend trails (18%)
Paths, all types (9%)	Widen trails (13%)
Maintenance (8%)	Nothing (12%)
Proximity to river (5%)	Rules/more signs (9%)
Other (4%)	Safety (8%)
Not overdeveloped (3%)	Less bikes/separate trail (6%)
	More water fountains (5%0
	More washrooms (5%)
	Other (3%)

Conclusion

It is apparent that the initial suggestions of recreational behaviour are fairly accurate. Those individuals using the trail could access the trails fairly easily from their neighbourhood. The downtown area was used quite frequently, and the crowds in this area were noted to be a concern. The trails were enjoyed by most of the respondents, as they provide a place to enjoy nature within the City of Saskatoon.

Environment is important in terms of a person's perception, values and attitudes, which in turn influence the individual's choice of recreational space. Constraints and conflicts also play a major role in an individual's selection of recreational activity and the location of such an activity. Consideration of the needs and desires of different individuals in society will allow for more specific improvements of recreational experiences.

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Down by the riverside: recent developments along the Assiniboine Corridor in Brandon

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Abstract: In the past few years, the previously neglected Assiniboine River corridor within the city of Brandon has shown signs of significant change and development. These changes have largely been the result of a realization, by both city officials and community members, that an important local recreational resource has been neglected or ignored by the majority of Brandon's inhabitants for many years. A series of public meetings sponsored by the city led to the acceptance of a plan for the riverbank and the formation of a not-for-profit group to bring planned changes into reality. In the past three years, pre-existing developments have been brought under the auspices of Riverbank Inc. and a series of new initiatives have been started. This paper briefly describes the past and contemporary development of Brandon's Assiniboine river corridor.

Introduction

The purpose of this paper is to outline and report upon the development of the Assiniboine River Corridor by "Riverbank Inc." Riverbank Inc. is a non-profit "arms length" organisation incorporated by the Province of Manitoba in 1994. The aim of the organisation is to develop the tract of land along the banks of the Assiniboine River within the city of Brandon as a recreational area for the city and its region, and as a possible ecological focal point for tourist activity within southwest Manitoba (Figure 1). The ongoing transformation of the river valley has the potential to be one of the major changes to the face of Brandon since its incorporation in 1882.

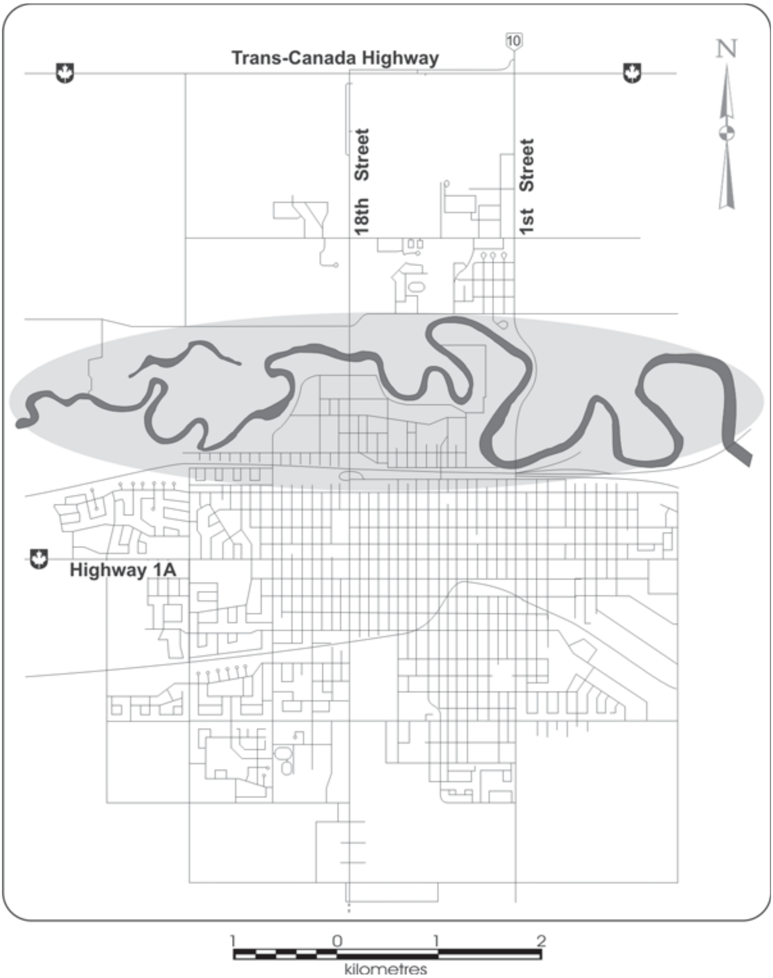

Figure 1: *Map highlighting the Assiniboine River Corridor at Brandon, Manitoba (adapted by author, 1998).*

Background

Although aboriginal peoples have been in southwestern Manitoba for the past few thousand years, and undoubtedly passed through what is now the City of Brandon on many occasions, there is little evidence to suggest more than a transitory presence along the Riverbank Corridor. Clearly the locational advantages of this site for a railway divisional point, as perceived by General Rosser, were not viewed as positively by First Nations' peoples. Brandon was chosen as a townsite by General Rosser in May 1881, after he rejected a floodplain site at "Grand Valley," an incipient settlement located a few kilometres to the east (Everitt and Stadel, 1988: 62). For the most part Brandonites continued to overlook or avoid the river until what was to become "Riverbank Inc." brought the Assiniboine River Corridor into the collective consciousness of Brandonites in the early 1990s.

This is not to say that the Assiniboine was collectively ignored (Welsted 1988). At times, the river has forced itself upon the city as a consequence of its propensity to flood. Flooding has occurred more than once every three years (on the average) and property damage has resulted from at least half of these floods. Consequently, the Shellmouth Dam near Russell, and a series of dikes, have been built to protect the city from its river. The Assiniboine has also been used for waste disposal by the city and by some industries, although such uses are now tightly controlled.

There have been more positive uses of the Assiniboine River within Brandon, such as its utilization as a means of transportation, water supply and recreation. Although commonly stopping to the east of the present built-up city at Currie's Landing ("The Rapids"), some steamboats used the river as far as Fort Ellice, and even Fort Pelly (near Kamsack) in Saskatchewan. The river has usually been the major water source for the City, with its level being maintained by the Third Street Dam. Some industries (such as the Hanbury lumber mill, and a number of natural ice producers) once used, and indeed depended upon, the river for their survival. It has also been used for recreation over the years, with the Sixteenth Street swimming hole and beach becoming legendary, boating and (more recently) water-skiing being occasional uses, and fishing becoming a tradition. A number of parks (Curran, Queen Elizabeth, Eleanor Kidd, Dinsdale) are located on the floodplain, but have promoted little direct contact with the river. Such uses remained the norm until the early 1990s when the seeds for Riverbank Inc. were sown.

The Origins Of Riverbank Inc.

During the summer of 1993, the foundations of what would become Riverbank Inc. were laid at a City of Brandon councillor's retreat (Borotsik 1998). It was early in Rick Borotsik's term as mayor, and the council was trying to determine the city's development future. Borotsik, who had been the former manager of Brandon's premier shopping mall, had a vision involving the Assiniboine River. He viewed this corridor as an untapped resource that the city had thus far disregarded. Borotsik had witnessed the potential of river corridor development in the Credit River redevelopment programme undertaken in Mississauga, Ontario.

The Assiniboine River Corridor had become an afterthought for the city and was mostly ignored by Brandonites. The city's Parks & Recreation Department and the pre-employment program known as Westbran had done some valuable work along the Assiniboine Corridor, but mostly on a ad hoc basis, rather than by following a strategic plan. Consequently, the councillors and city administrators quickly supported Borotsik's proposed holistic approach to the Assiniboine Corridor development as a central natural venue and a source of civic pride.

The project involved a complete overhaul of the facilities and uses along the riverbanks. It was recognised that throughout the whole process there must also be continued public involvement, to allow the weaving together of input from all the communities of the city, and to have a truly "made in Brandon" product. An initial $350,000 investment from the city was put forward to establish a task force to initiate and carry out the redevelopment. This move on behalf of the city sparked the genesis of Brandon Riverbank Inc., a non-profit organization whose task was to explore the public's opinion about such a project, and to identify sources of funding not available to municipal governing bodies.

The Planning and Development Officer of the City of Brandon, Dave Wallace, was selected for the job of President of the incipient organization.[1] During his career at the City, Mr. Wallace had made numerous attempts at breathing some life into what he saw as the neglected area along the Assiniboine. As recently as 1991, Wallace had proposed an elaborate design for the relocation of the City's

Parks and Recreation headquarters to a site in the heart of Brandon's river corridor. He was now given the authority to pursue a similarly spirited vision of riverbank development via Riverbank Inc.

One of the earliest steps Dave Wallace took was to organize a walking tour of the River Corridor area in the fall of 1993, for the city councillors and officials.[2] This gave council and city department heads an opportunity to examine the future project site, a first visit for several of them, and cemented the perceived need by council for action. The tour featured existing structures and highlighted some of the disadvantages such as trails that were not maintained and an overflow from the city refuse dump. The field trip allowed for brainstorming about some of the possible improvements that could be made.

The decision of how to advance the project was aided by Brandon's successful bid to host the 1997 Canada Summer Games. This allowed the city to prioritize some of the earliest improvements to the city's already impressive inventory of outdoor sport facilities (such as baseball fields, and soccer and rugby pitches) along the corridor. These structures, along with cycling and walking trail improvements, were some of the more visible changes that were made in the initial development stages of the project. The city administration quickly realized that the decision making process should involve the participation of the community at large and not simply the directives of city officials.

The Public Role

To contact and inform as many people as possible, public input advertisements were placed in the local daily newspaper, the *Brandon Sun*. These were supplemented by public service announcements on the local radio and television stations. The advertisements included a "cut-away" section, designed so that members of the public could return these portions to Riverbank Inc. with their thoughts and suggestions. At the same time the city was aggressively searching for a professional planning firm to be contracted to develop a master plan that would represent the long-term vision and public interests that the present administration had called for.

By the late winter of 1994 Lombard North Group, a Winnipeg landscape architectural and planning firm had secured the consultancy position. Their magnum opus, The City of Brandon Assiniboine River Corridor Master Plan, was a culmination of intense public examination, data gathering, and the prioritization of immediate needs and long-term goals. There was, and always had been, a full realization that a project like this could not be completed within a year or even five years. The plan thus recognizes that over the next 20-25 years the river corridor can realize its potential as a community focal point and as an integral centre for habitat restoration and environmental study. The river corridor can become a vibrant centre of Brandon social activity and a recreational opportunity, as well as a "destination point" for tourists from elsewhere. The planners recognized the need for the plan to be a "living, breathing document", adaptable to variations in funding, and to fluctuations in popular opinion.

The Plan

Lombard North Group began its tenure by examining the initial public input to the city's ad campaign. The firm's chief executive David Palubeskie, in concert with the city, organized a series of three public forums. The first "Needs Assessment" workshop was attended by approximately 70 diverse members of the Brandon community, many of whom attended two related follow-up functions. All facets of society were represented including culture, education (secondary and post-secondary), heritage, First Nations, sports and recreation, public services, business, environmental and naturalist communities. Representatives from the provincial and federal governments as well as the Brandon and Area Planning District also rounded out the "Assiniboine River Corridor Planning Group."

As the name implies, the mandate of the "Needs Assessment" workshop was to answer the question "What do we want?" The workshop was designed to build an understanding of community objectives, expectations and priorities as provided by the initial public input that had been collected as a result of the media campaign. The workshop process paid particular attention to the perceived benefits, objectives and themes for development, and tried to identify the community needs that had to be served. The next two workshops attempted to answer the questions "How do we get there?" and "What do we do now?" The job the consultancy firm did was well received by those involved for their ability to understand the communities vision and to identify and procure funding, which helped to move the project forward.

Early Works & Westbran

An element that proved to be critical to the success of the Riverbank development was the Westbran Employment Development Centre (known locally as "Westbran"). The organization was developed to undertake community projects, like riverbank development, while reintroducing social welfare and unemployment recipients back into the workforce (Pedlow 1998). Westbran had begun the work of riverbank development following its inception 25 years ago (1973). Westbran, and its other work-fare project, Crew 10, have since completed most of the work that has taken place along the city's floodplain.

Westbran's involvement with the new Riverbank Inc. was seen as an opportunity to provide more work experience for its clients, and access to its job creation abilities as provided by its management. For instance, Westbran has been responsible for the creation of countless small jobs along the corridor, including clearing of the brush along new trails, site preparation for projects such as the center piece Red Willow Trail pedestrian bridge, or the Ducks Unlimited/ Travel-Idea Conservation Centre, in addition to most of the site preparation for Canada Games facilities. Essentially Westbran had been able to provide the labour to bring to fruition the ideas of Riverbank Inc.

Riverbank Inc. added a whole new dimension to the work agenda in the area. Some of the earliest works of the organization include:

a) The inventory of flora and fauna that call the river-bottom forest home. This was done in conjunction with the Brandon Naturalists society and the local office of Provincial Natural

Resources. The information is presently being compiled to fulfill public requests for natural interpretive signage and environmental education.

b) The construction of the Red Willow Trail pedestrian bridge. The $1.25 million structure is a center piece of present development. Its presence provides a long-needed link between the northern portion of the city and it's central business district, enabling pedestrians and cyclists to avoid the automobile corridors of Eighteenth and First Streets. The bridge is also invaluable for observing beaver and other river wildlife. In addition, it provides an incentive for curious citizens to explore the area's extensive paved and pristine trails.

c) The production by Riverbank Inc. of a trail map that makes it possible for people to explore the riverbank along 17.4 km of trails.

d) The organization also keeps in touch with close to 20,000 Brandon homes through the regular publication of the River Review. This thrice-yearly publication keeps citizens abreast of developments, and includes historical research and discussions of landform processes that have shaped the River Corridor over the past 10,000 years.

e) In addition, trail development and maintenance continues, as does the provision of signage. Over the summer of 1998 work also continued on the lighting network along selected trails.

A Public Survey

During the summer of 1998, Riverbank Inc. conducted a survey of nearly 100 people who were using the trails and facilities along the Assiniboine Corridor. Its purpose was to find out who was using the Riverbank, what they were using it for, why they chose to go there, when they used it, and which parts of the recreation system were chosen. It was also designed to be a baseline survey, the results of which could be compared with others over time, in order to record changing patterns of demand and use within the Corridor. As the questionnaire was administered during the summer months, winter recreational opportunities (although mentioned by several respondents) were almost certainly severely undercounted.

As expected, most (73%) of the respondents were from Brandon, with the majority of the balance coming from other parts of Manitoba. Ontario as well as the other western provinces however, were represented, as were two European countries (France and the UK). There was, by design, a roughly equal male-female balance amongst respondents, and most age groups were represented. A range of family income levels was also represented. The median income proved to be lower than expected ($20-34,999), perhaps reflecting in part the relative youth of the sample. The median age group was 35-39 years old, which is low compared to the overall regional population.

The range of activities taking place along the corridor was wide, reflecting the considerable number of opportunities available, but the largest number were "hiking/ running/walking" or "cycling/ boarding/blading" on the tarmacked sections of the trails. Nature watching was a major activity, with many people also taking the opportunity to picnic, or simply relax.

Clearly the Riverbank Corridor was chosen because it offered a range of outdoor experiences and opportunities not available elsewhere in Brandon, or even in the immediate hinterland of the city. It also offered the option of a single or group experience, with family groups being by far the most common users of the facilities.

To aid in the planning process, and continue the tradition of public involvement in Riverbank Corridor decision making, respondents were asked a question that attempted to obtain their "wish list" for the Riverbank. The first ranked desire was to connect the trail system along the Assiniboine Corridor with other city bike paths, in order to create a city-wide network. This is one of the future aims of the City and Riverbank Inc. — constrained at present by budgetary considerations. The second request was the provision of more garbage receptacles. This is also being explored by Riverbank Inc., but clearly has to be connected to a (possibly expensive) collection and disposal system. Third, was a desire to keep out developments that would take away from the natural experience of the Assiniboine Corridor.[3] It has always been the aim of Riverbank Inc. to maintain the Assiniboine River Corridor as a natural, low-tech, environmental experience reflecting the Master Plan theme “Country in the City” and promoting a healthy lifestyle. Although some lower ranked items did suggest certain varieties of “development”, most of these are not intrusive (“improve fishing,” “water fountains,” “more bathrooms,” “improve boat launch,” “reestablish the Participark” etc.). Some of these (fishing, boating and the Participark) are already under consideration, and opportunities for others can be improved by better signage to existing facilities, or to those currently under construction.

The survey fulfilled its desired goal of providing a baseline for future research, and gave a useful insight into the demographic characteristics of current Riverbank users, and of their views on future improvements along the Assiniboine Corridor.

Board of Directors

Although having a strong representation from the City of Brandon, the Board of Directors for Riverbank Inc. has been drawn deliberately from various facets of the Brandon community, and its composition reflects this diversity.[4] It meets once a month at the Westbran centre. One of the duties of the board members is to communicate, as far as possible, the views of a broad section of the Brandon populace and to ensure that developments are “made in Brandon.” The Board also attends to, and is responsible for, the financial aspects of the overall development along the corridor. These include the recognition and retention of corporate support from a number of local businesses (a list of which can be found at various improvement locations), and fundraising from individual and family community members (for instance, by “buying” a metre of riverbank for $100 - with 224 donations to date). In addition, bonds and partnerships with other levels of government and their departments have been formed. Over the past five years a number of important partners have helped in this initiative.[5] They include, in particular:

a) The City of Brandon, which gave core funding for various capital projects and contributed the time of several of the City administration staff.

b) The Government of Canada, which provided funding for the Red Willow pedestrian bridge, as well as employment contributions through the Brandon office of Human Resources Development Canada.

c) The Human Resources Development Canada Centre, which has created and contributed to almost 20 employment positions since 1994.

d) The Province of Manitoba, which supplied funding for the Red Willow pedestrian bridge and for the Master Plan.

e) The Westbran Employment Development Centre supplied labour and material in kind (enabling, for instance, riverbank trail developments).

f) The Brandon Naturalists Society, gave information and advice re bird and plant species in river bottom forest.

g) The Manitoba Department of Natural Resources supplied information and advice about wildlife species, gave advice re design of trail signs, and reviewed trail design.

The Board was also successful in obtaining a loan from the Western Canada Economic Diversification Fund. This long-term loan will allow the people of Brandon to see the progress in development without having to pay immediate high interest on the loan.

Contemporary and Future Works

Although Riverbank Inc. is very busy completing projects already under way, it is eager to push ahead with new initiatives (Figure 2). In the fall of 1998 the newly built Ducks Unlimited/ Travel-Idea Conservation Centre will come into operation. The building, built and operated by Riverbank Inc., will be the “crown jewel” of the River Corridor. The Centre could become a major tourist attraction not unlike the environmental learning experiences that Fort Whyte or Oak Hammock Marsh, both in the Winnipeg area, provide. The development theme of “Country in the City” dovetails with both

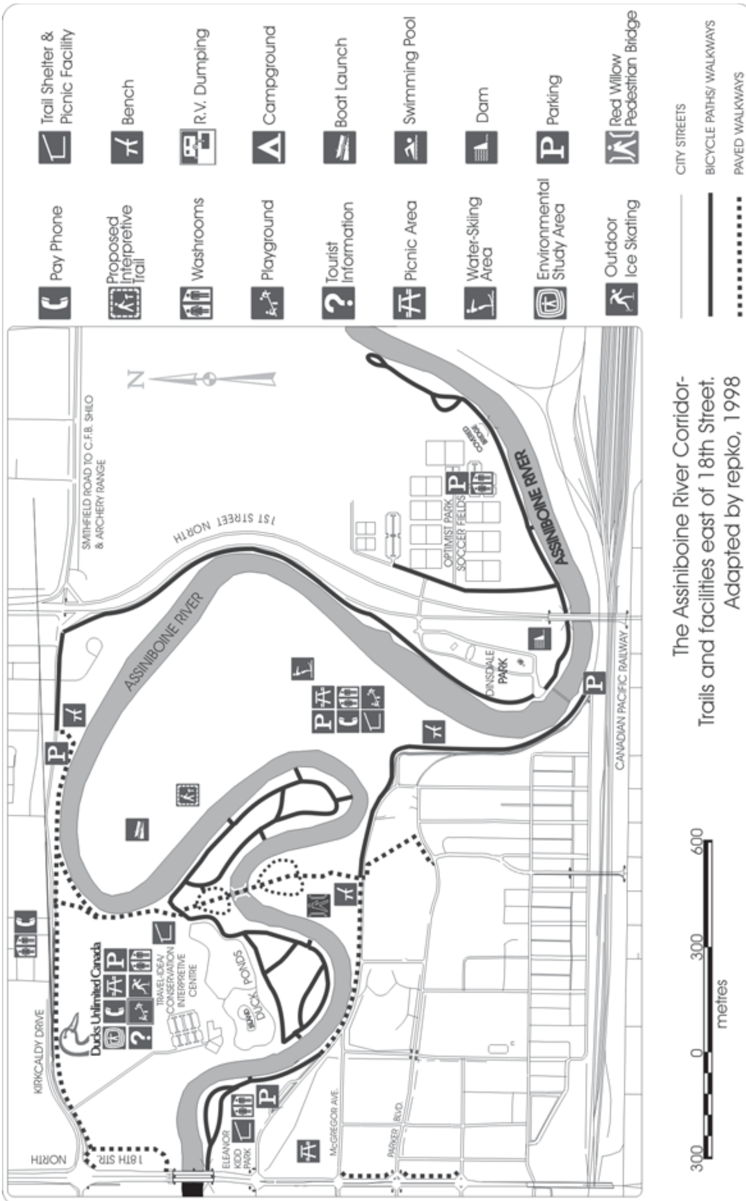

Figure 2: The Assiniboine River Corridor-Trails and facilities east of 18th Street (adapted by Repko, 1998).

artificial and natural wetland habitats that are already home to many bird species as well as an abundance of animals, including the White Tailed deer. This construction project relied almost exclusively on financing from the Western Canada Diversification Fund — which would have been unavailable to municipal governments, but which could be tapped by Riverbank Inc.

Projects currently underway include the development of a plaza and fountain as a center piece to a terrarium. This site will also be the home of Peter Sawatzky's first animal sculpture. Sawatzky is a world renowned sculptor who lives in nearby Glenboro, and his piece of two fawn and their mother was designed to exemplify the family focus and natural theme of the corridor developments.

Conclusion

Although Canada is "blessed with rich and varied opportunities for people to participate in outdoor recreation" (Wall 1989: vii) these opportunities are not evenly distributed throughout the country, and are not all developed to the same extent. The recent decision by the City of Brandon to improve the recreational opportunities along the Assiniboine Riverbank Corridor represents an attempt to counter these inequities of distribution and development, by the betterment of its own physical and cultural environments. Thus the development by Riverbank Inc. acts as a means of serving the needs of city and regional residents, as well as hopefully providing a "destination point" for tourists who may be attracted to, or are passing through, southern Manitoba. Although the riverbank is still very much in a stage of nascent development, the facilities already in place, and those that are under construction, should guarantee that improvements continue to be made along the Assiniboine, and that the recreational opportunities and thus the quality of life for the residents of Westman will be substantially increased.

Endnotes

1...The first support group to proceed with the forming of a Board, and with undertaking the constructional portion of the Brandon River Corridor Master Plan as approved by City Council, included Dave Wallace, Ted Snure (City Engineer), and Robyn Singleton (City Solicitor), Mervin Pedlow (former Westbran manager), Rick Borotsik (former Mayor) and Earl Backman (former City Manager).

2...The City Council of 1990-92 included: Rick Borotsik (Mayor), Margo Campbell, Rod Ficek, Arnold Grambo, Jeff Harwood, Joe Kay, Don Kille, Ross Martin, Dave Melcosky, Dan Munroe, and Jim Reid. For 1993-95 it included: Rick Borotsik (Mayor), Drew Caldwell, Margo Campbell, Brian Deacon, Rod Ficek, Arnold Grambo, Joe Kay, Don Kille, Romeo Lemieux, Ross Martin, and Jim Reid.

3...For instance, the "Forks" development in Winnipeg, although highly successful for that city, is very much a "Festival Market" type of enterprise, and this is not the model that the Riverbank Inc. board seeks to emulate.

4...**The Brandon Riverbank Inc. Board of Directors**

Executive:

Dave Wallace, President *(Planning and Development Officer, City of Brandon)*
Theodore E. Snure, Secretary *(City Engineer, City of Brandon)*
Robyn Singleton, Treasurer *(City Solicitor, City of Brandon)*

Board Members*:*

Mayor Reginald Atkinson *(City of Brandon)*
Glen Laubenstein *(City Manager, City of Brandon)*
Brian LePoudre *(Manager, Parks and Recreation, City of Brandon)*
Janet Kinley *(Intergroup Consultants, Community Member)*
Dr. John Everitt *(Department of Geography, Brandon University)*
Cindy Solon *(Brandon Chamber of Commerce representative)*
Wayne Adolphe *(Manitoba Hydro)*

Rod Wiebe *(Rural Construction Association)*
Merv Pedlow *(Community Member)*
Keith Timmons *(Community Member)*

Former Board Members:
Rick Borotsik, M.P. *(Former Mayor, City of Brandon)*
Earl Backman *(Former City Manager, City of Brandon)*
Rod Burkard *(Former Treasurer, City of Brandon)*
Wanda McFadyen *(Brandon Economic Development Board, Tourism Committee Representative)*
Bill Burbank *(Manitoba Hydro)*

5...A number of important corporate sponsorships have been made, but these are continually changing and are not listed here.

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The geography of aging: a geographical contribution to gerontology

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Abstract: The relevant role of geographical investigation within social gerontology was identified in the early 1970s as it became recognized that the environment affects the aging process. Geography's synthesizing and holistic tradition represents an effective methodology to evaluate the complex interaction between elderly persons and their environment. The geography of aging however, has followed social geography's model of describing the spatial context of seniors and the analysis of an older person's relationship to the environment remains in the early stages. In this discussion, it is demonstrated that geography can make a further contribution to gerontology by addressing the inadequacy of conceptual frameworks developed primarily using an ecological approach and which do not establish a comprehensive definition of the environment. Furthermore, it is suggested that to address the inadequacies of these frameworks, gerontological geographers must return to the roots of the Vidalian tradition whereby the interrelationship between environmental and human factors is regarded as an indivisible whole. It is concluded that the application of Vidal's conceptualization of the interplay of society and environment will assist in identifying ways to enhance the quality of life of older adults through the improvement of environmental settings.

Introduction

Contemporary geography's evolution has been characterized by its diversity of approach and its increasing specialization within an auxiliary of sciences (Pinchemel 1983; Cloke *et al.* 1991). One area of study that is pertinent to geographical investigation is the scientific inquiry of social gerontology that endeavors to increase understanding of human aging processes and society's responses to the requirements and preferences of different age groups (Warnes

1990). Since the early 1970s, a geographical contribution to gerontology has been identified based on the application of geography's theoretical and methodological perspectives (Anuchin 1973). Rather than focusing on a description of the accomplishments of individual geographers within this sphere of inquiry however, it is essential to examine the broader issue that there has been limited recognition of the effectiveness of geographical investigation to issues of aging (Eyles & Smith 1978). Initially gerontological geography followed social geography's model of describing the elderly population's residential spatial patterns. In order for the geography of aging to define its unique role within gerontology however, it must go beyond spatial analysis to identify the influence of environmental parameters and the adaptability of older persons. The application of geography's basic organizing principle of human-environment interactions is necessary for the discipline to remain dynamic within gerontology (de Martonne 1983; Rudzitis 1984).

The Aging Process: A Geographical Perspective

With the advancement of gerontological research, it became evident that elderly people occupy, utilize and experience environments in ways distinctly linked to the aging process. Furthermore, it was proposed that the social problems, injustices and inequalities that afflict older persons were associated with their locations and environments. Therefore, it followed that the manipulation or modification of the locations or environments of older people could relieve age-related stresses (Golant *et al.* 1989). As a result, there has been an evolving recognition that the circumstances of elderly people have spatial and locational dimensions. More specifically, a focus on environmental influences over the life experiences of older people has led to the identification of a relevant role of geographical investigation in social gerontology since the early 1970s (Golant *et al*. 1989). Unfortunately, "the clear potential of a geographical contribution is unexplored and only a minute share of its now considerable research capacity is devoted to the tasks" (Warnes 1982: 5).

In a report of the Association of American Geographer's Task Force on Environmental Quality (Lowenthal 1973) it was outlined that geography's concern with locational variation and spatial relationships increase the researcher's awareness of the causes of differences among environments. Furthermore, while other social and behavioral sciences addressed singular components of human-environment interactions, geography's synthesizing and holistic tradition represented a more effective approach to the study of these complex interactions (Golant 1979). An analysis of an older person's relationship to his or her environment however, remains in the early stages of development as a comprehensive approach has not yet been adopted.

Progress has been made in describing the spatial context of elderly persons. This emphasis on spatial patterns reflected social geography's strong alignment with analytical methods and models of an explicitly spatial type (Hewitt & Hare 1973). Although historically the theme of geography was the relationship between humankind and its environment, the excesses of environmental determinism brought environmental studies into disrepute (Spate 1968; Berry 1978). After 1930 geography began to emphasize areal differentiation, and, as a result, the development of social geography was characterized by a multifaceted perspective on the spatial organization of social phenomena and areal differentiations which emanate from society (Buttimer 1968). It followed that the geography of aging would also examine the spatial patterns of older persons.

An emphasis on the spatial organization of the elderly population remains important for the identification of the spatial components of service provision. Nevertheless, it has been imperative that geographical research adopt a more comprehensive approach in order to establish a greater understanding of how transactions between older persons and their environment affect their quality of life and ability to remain independent. Research on activity patterns, service implementation and housing does represent a trend to incorporate the effect of environmental influences on elderly persons. It is important to note however, that while this shift in emphasis illustrates a greater awareness of the environmental implications of an aging population, it does not represent a comprehensive analysis of the complex interplay between elderly persons and their environment. In order for geography to make a significant contribution to gerontology, a holistic and integrated conceptualization is required of the relationship between the older person and environment (Rowles 1986).

The Ecology of Aging

The investigation of the interface of aging and environment has been dominated by an ecological approach (Haldemann & Wister 1993). Social and behavioral scientists now recognize the need to conceptualize the enivironments occupied by people in order to understand the aging process. Nevertheless, most efforts to define the meaning and measurement of environment in terms of transactions with elderly persons have been largely unsuccessful. What emerges "from such discipline-focused approaches is an artificially fragmented environment, the parts of which belie their membership in an interdependent system" (Golant 1979:6). The inherent weaknesses of non-geographical approaches is clearly exemplified by the ecological model of aging proposed by M.P. Lawton, an environmental psychologist (Lawton & Nahemow 1973).

Lawton's ecological model of aging is considered to be the most comprehensive conceptual model relating the individual, the environment and aging (McPherson 1990). The model postulates that the components of individual capability and environmental demands are the major predictive components of behavioral responses of older persons. While Lawton has expanded his interpretation of individual capability in the ecological equation, he has failed to characterize the environment in a manner that allows for an appropriate operationalization of the model (Lawton 1989). Revisions of the model have resulted in a shift "from the impact of the environment to the role that individuals play in the interpretation and shaping of their environment" (Haldemann & Wister 1993:

38). The revised models which have advanced the concepts of proactivity (Lawton 1989), autonomy-security (Parmelee & Lawton 1990), and temperament (Lawton 1998) demonstrate the increased importance allocated to the individual component of the model.

In contrast, the environment has remained comparatively static. Lawton (1970) proposed that the environment be divided into five distinct dimensions which include the personal, the interpersonal or small group, the suprapersonal, the social and the physical environments. These original efforts were considered to be a first step "to operationally disentangle objective and subjective dimensions of environmental experience" (Rowles & Ohta 1983: 236-237). Despite the original advances made by Lawton, his subsequent revisions of the ecological model of aging have not included further development of a more comprehensive typology of environmental characteristics that affect the aging process. The subsequent stagnation of any further conceptualization of the environment has resulted in a limited research agenda (Ward, la Gory & Sherman 1988). The five defined components of the environment are inexact and do not promote a standardized taxonomy of environmental elements that can be replicated and compared in multidisciplinary research which considers the effects of the person-environment interaction on the aging individual. It is this lack of a functional description of the environment which will block further progress to person-environment research (Parr 1980). Lawton has acknowledged that a major problem for the study of environment and aging is the lack of consensus regarding the dimensions of the environment (Lawton 1977; 1979; 1982).

The concept of the environment is a complex interplay of forces that interrelates physical, social and cultural properties to elicit patterns of behavior (Ward, La Gory & Sherman 1988). This interrelationship creates difficulties both conceptually and methodologically to develop a broad definition that incorporates all possible dimensions of the environment (Golant 1984; Markson 1984). The ecology of aging lacks a research agenda that incorporates a unified consensus on what environmental attributes are important and how they should be measured to analyze the person-environment transaction. The development of a holistic, integrated conceptualization of the environment can best be addressed within a geographical perspective. Geography has begun to reassess the significance of person-environment research and new opportunities have opened for the application of concepts and methods that recognize the interwoven character of organism and environment (Spate 1968; Hewitt & Hare 1973). The work of Rowles (1978; 1981; 1983; 1991) demonstrates that advances are now being made towards a greater conceptualization of the implications of interactions between older persons and their environment. Rowles (1978) has identified the need to consider person-environment relationships within a holistic framework that incorporates social, psychological as well as physical dimensions of spatial experience.

This new emphasis on a concept of the environment as an integrated system related to the individual's environmental experience represents a reaffirmation of gerontological geography's roots in the Vidalian school of thought. Vidal's recognition of the essential interdependence of environment and human factors must be considered as the cornerstone of a comprehensive approach to the geography of aging. Only with the development of a conceptual framework that defines the complex interplay between the elderly person and environment will a geographical contribution to gerontology be firmly established.

The Vidalian Tradition: A Comprehensive Approach

Paul Vidal de la Blache, the founder of French geography, is considered to be one of geography's greatest entrepreneurs (Dickinson 1969). In *Principles of Human Geography* (published posthumously in France in 1921 and in English in 1926), Vidal postulated that, as a result of increasing knowledge concerning physical laws and the relations between living beings, the scientific inquiry of geography offered a new conception of interrelationships between the earth and humans. His main objective was to establish a principle of "the conception of the earth as a whole, whose parts are coordinated, where phenomena follow a definite sequence and obey general laws" (Vidal de la Blache 1926: 6-7). He considered geography to be the essential unity of a region whereby the complex interrelations between environmental and human factors make up an indivisible whole (Dickinson 1969). He introduced:

> an essentially geographic concept: that of environment as composite, capable of grouping and of holding together heterogeneous beings in mutual vital interrelationships. This idea seems to be the law governing the geography of human creatures. Every region is a domain where many dissimilar beings, artificially brought together, have subsequently adapted themselves to a common experience (Vidal de la Blache, 1926: 10).

In contrast to determinism, Vidal emphasized the idea of territorial unity in which human activity was an active element, not merely a passive recipient of environmental influence (Cloke *et al*. 1991). According to their level of development and cultural heritage, humans utilize the range of possibilities provided by the natural environment, and are thereby active agents in the creation of habitats (Dickinson 1969; Pinchemel 1983). Accordingly, it is the human element that gives character to a region (Watson 1951).

Social geography is rooted in Vidal's conception of *genres de vie*. Society, according to Vidal, could not be explained entirely by biological, psychological or environmental interpretations (Buttimer 1968). Rather, he considered that society consists of an intricate network of ideas and bonds that provide stability and orientation to human life in a particular geographical setting. He expressed the complex interplay between society and environment as particular patterns of living or *genres de vie* (Eyles & Smith 1978). Vidal specified that *genres de vie* represented society's ongoing contact with nature as humans use a set of techniques, derived from past experience, to obtain the material necessities of life within a functional social order (Buttimer 1968).

The essence of Vidal's approach to geographic study is based on the interaction of human communities with their environment. He regarded human geography to be the study of living landscapes that have recorded humans' interpretation and utilization of their environments. *Genres de vie*, or styles of living, represented the integrated result of physical, historical and socio-cultural influences surrounding human relationships with their milieu. These *genres de vie* were a fundamental innovation for social geography because they demonstrated that humankind's relationship to milieu in concrete living situations was a social phenomena (Buttimer 1978).

Finally, Vidal envisioned an analytical approach to the relationship between society and environment that is relevant to the current study of gerontological geography:

> The essential geographical issue was neither the influence of man on the earth nor the influence of the earth on man; methodologically it implied neither analysis of ecological processes *per se* nor the analysis of socio-cultural and historical forces; rather its central aim should be to grasp the ongoing dialectic of milieu and civilization, the perennial tension between the milieu externe (physically observable patterns and processes) and the milieu interne (values, habits, beliefs and ideas) of a civilization. The external milieu provided a range of possibilities, the internal milieu dictated the parameters of choice within that range (Buttimer 1978: 61).

This conceptualization of the "milieu externe" and the "milieu interne" is particularly significant for the geography of aging. It suggests that there are both objective and subjective components of the environment that must be considered when evaluating the human-environment dialectic of older adults. Such a comprehensive definition of the environment will assist in identifying ways to enhance the quality of life of older adults through the improvement of environmental settings. Therefore, the incorporation of the Vidalian tradition in the conceptual framework of environment and aging presents new parameters in which social geography can contribute to a greater understanding of the environmental implications of aging.

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