PRAIRIE PERSPECTIVES:
GEOGRAPHICAL ESSAYS

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Preface

The 26th annual meeting of the Prairie Division, Canadian Association of Geographers was hosted by the Department of Geography, Brandon University. The conference was held at the Vivian Motor Hotel, Neepawa, Manitoba on September 25th through 27th, 2002. A total of 30 papers were presented in six sessions entitled: Rural Economy, Physical Processes and Techniques, Built and Imagined Landscapes, Floods and Rats: Environmental Hazards and Responses, Environmental Management, and Historical Geography of the Prairies. In addition, seven posters covering a variety of topics were presented during a dedicated poster session. Three concurrent afternoon fieldtrips entitled "East to Arden Ridge: Cultural Icons and Landscapes of the Prairies"; "Multiple Stream Captures of a Glacial Spillway: Huns Valley Manitoba"; and a self-guided tour of the town of Neepawa showcased the cultural and physical diversity of the region.

This volume contains thirteen of the papers presented at the conference and two papers derived from the cultural and physical fieldtrips. As usual, several of the papers in this volume are authored or coauthored by undergraduate or graduate students and the variety of topics illustrates the diversity of research conducted by members of the Prairie Division of the CAG. All papers in this volume were subjected to a rigorous peer-review process in which each paper was evaluated anonymously by no less than two experts in the relevant field.

The editors wish to acknowledge the efforts of all those who participated in the organization of the conference and publication of this year's volume. In particular, we wish to recognize our colleagues in the Department of Geography, Brandon University for assisting with the organization and delivery of the conference; the authors for their contributions to this volume; the reviewers for ensuring the quality of the manuscripts presented in this year's volume; and finally Weldon Heibert and the University of Winnipeg for providing the technical assistance and resources for the final production of volume 6 of *Prairie Perspectives: Geographical Essays*.

The editors would also like to thank the following individuals and organizations for sponsoring this year's volume: ESRI Canada; Office of the Vice-President (Academic and Research), Brandon University

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Some observations on peak stages during the 1826 Red River flood and the "Fleming Conundrum"

W. F. Rannie, University of Winnipeg

Abstract: The 1826 flood in the Red River Settlement provides an important event for designing measures for reducing the flood risks in the city of Winnipeg. During recent hydraulic studies for an enlarged Floodway, the "Fleming Conundrum" was identified -- an anomaly between peak stages in the Winnipeg and Selkirk reaches and a zero-gradient zone on the water surface in the reach immediately downstream of the Forks. It is suggested here that strong winds immediately prior to the 1826 peak stage may have induced setup on the water surface; if so, this would exacerbate the "Conundrum" but may partially account for the zero-gradient zone. The latter may also reflect Sir Sanford Fleming's method of reporting peak stages surveyed from anecdotal accounts.The historical record provides some support for the suggestion that ice jamming early in the flood may have caused the reported peak water levels in the Selkirk area to have been anomalously high. The possibility of an unusually large input from the Assiniboine River is also noted.

Introduction

The 1826 flood was the largest known in the Red River Valley, with an estimated peak discharge about 40% greater than the natural flow in the 1997 "Flood of the Century" (Figure 1).The conditions which caused the 1826 flood have been described in detail by St. George and Rannie (2003). The event devastated the struggling Red River Settlement, led to the exodus of German and des Meurons settlers, precipitated the relocation of the Hudson's Bay Company headquarters from Upper Fort Garry (in present-day Winnipeg) to flood-free Lower Fort Garry (near Selkirk, 40 km downstream), and figured prominently in the debate in the 1870s about the location of the railway crossing of the Red River Moreover, the flood

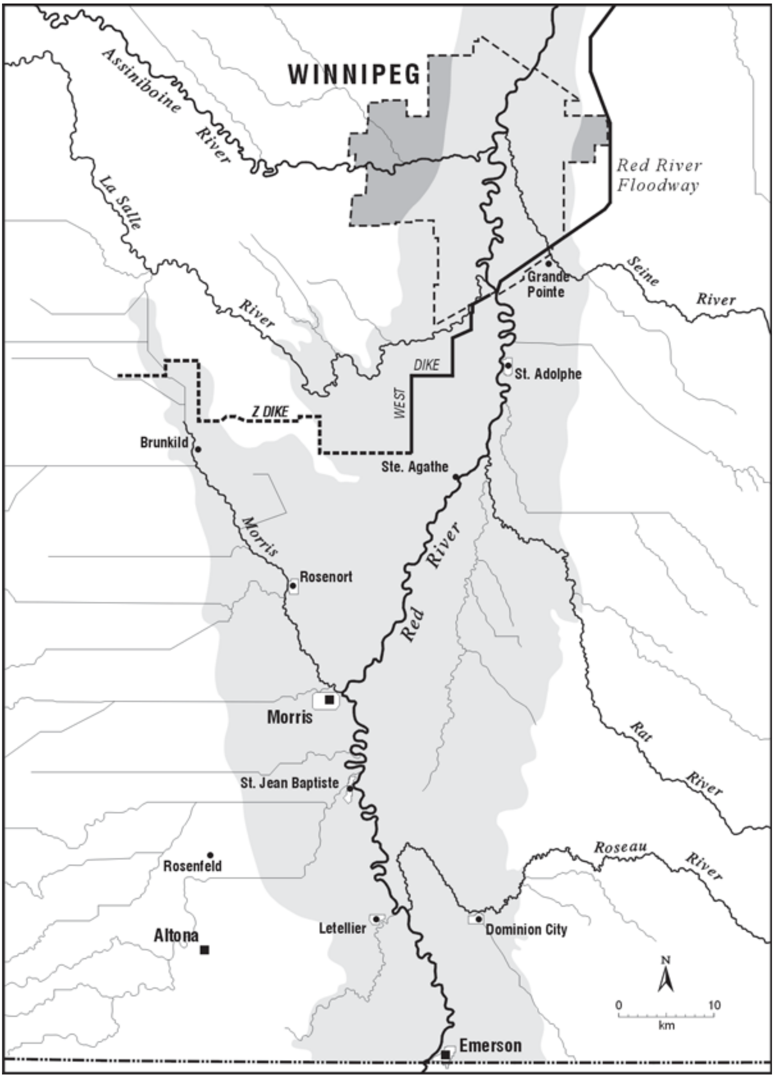

Figure 1: *Generalized extent of 1826 flood in Manitoba.*

had effects that reached beyond its importance in the early history of the Winnipeg region. Indeed, it can be speculated that without the example of the severe flood threat 1826 provided, a lower, more common, and less expensive standard might have been adopted for the flood protection system for Winnipeg after 1950; had that been the case, it is unlikely that Winnipeg would have escaped major damage from the 1997 flood.

This paper explores several factors which may have affected the peak stage (water level) in the Winnipeg area, particularly as they relate to the "Fleming Conundrum" which emerged during post-1997 hydraulic studies for an expanded Red River Floodway.

Peak Stages in 1826 and the Nature of the "Fleming Conundrum"

In the late 1870s, Sir Sandford Fleming commissioned surveys of the high water marks for the 1826 and 1852 floods as part of a study to determine the best location for the Canadian Pacific Railway crossing of the Red River (Fleming, 1880). The surveys, conducted by James Rowan, were based on interviews with long-time residents and the results from several independent testimonies were found to "agree closely" (Fleming, 1880, p. 276). Fleming's original data for eleven locations along the Red are given in Table 1. These elevations were subsequently adjusted (shown in Table 1) to reflect a change in the reference section from the Main St. bridge to the James Avenue Pumping Station and to the City Datum of 727.57 feet above sea level (Red River Basin Investigation, 1953b).

These adjusted high water marks became the standard reference points for all subsequent studies of the 1826 and 1852 floods. After the 1950 flood, the Red River Basin Investigation (RRBI) used these high water marks and a slope-area (Manning-type) methodology to estimate the 1826 discharge for two reaches, one just upstream of Lower Fort Garry (199,800 cfs or 5658 m^3/sec) and the other between Lower Fort Garry and Selkirk (256,000 cfs or 7250 m^3/sec). The conventionally-accepted 1826 peak discharge of 225,000 cfs (6372 m^3/sec) was taken as the approximate average of these two estimates. In similar fashion, Fleming's 1852 high water marks for four reaches yielded an average of 165,000 cfs (4673 m^3/sec) and the 1826 and 1852 values were then used to define the upper region of the stage-discharge relation for the Red River at the Redwood Bridge.

The "Fleming Conundrum" (so-named by Carson *et al.*, 2002) arose when Fleming's high water marks were used by KGS Group during hydraulic studies for expanded flood protection for Winnipeg (KGS Group, 2001). KGS Group found that when the water surface was projected upstream from the Selkirk area or downstream from Winnipeg, the resulting profiles didn't agree with Fleming's data: *either* downstream water levels (from Lockport to Selkirk) were considerably higher than would be

Table 1: Fleming's High Water Mark Elevations and Subsequent Adjusted Values (Fleming, 1880; RRBI, 1953b)

	Miles from Mouth of Assiniboine	Height of 1826 Flood (feet asl)	Adjusted Heights Used by the RRBI
Mouth of Assiniboine	0	769	764.5
Point Douglas	2	769	764.5
North of St. John's Church	4	769	764.5
North of Kildonan Church	7	768	763.5
South of Tait's Creek	12	766	761.5
Near St. Andrew's Church	18	759	754.5
About 2 miles above S. Fort	20	755	750.5
Stone Fort (Lower Fort Garry)	22	752	747.5
About 2 miles below S. Fort	24	748	743.5
Selkirk	27	738	733.5
St. Peter's Church	31	730	725.5

expected for peak flows associated with the levels reported inWinnipeg, *or* the peak stages in Winnipeg were considerably lower than could be explained by flows that would be required to generate the downstream maximum stages (Figure 2).

A secondary puzzling aspect of Fleming' s data was also noted by KGS: three identical water elevations over a 4-mile (6 km) reach immediately below the Forks (Table 1), suggesting zero slope in the water surface. Since some gradient would have been required to sustain flow, KGS Group raised questions about the accuracy of Fleming' s surveyed data.

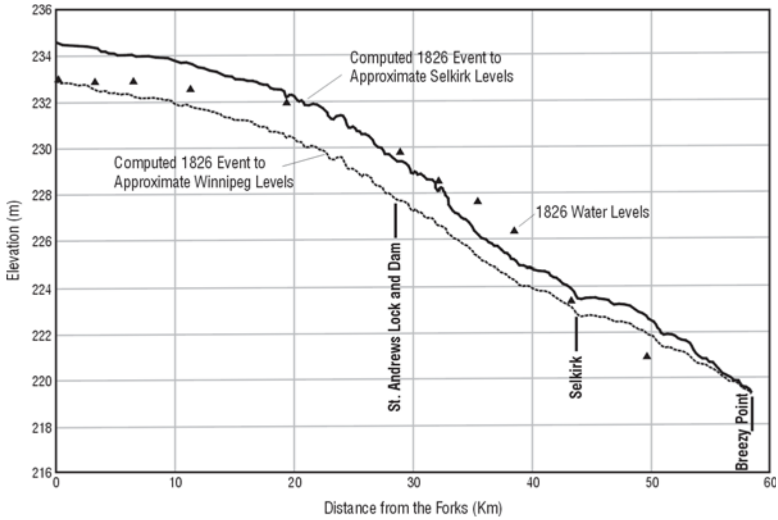

Figure 2: *The "Fleming Conundrum" (modified from Carson et al., 2002)*

KGS Group considered numerous possible explanations for the anomaly and concluded that it probably arose from a combination of possible errors in high water marks reported by Fleming and/or possible temporary elevation of water levels by ice jams early in the rising limb.

Wind Setup

Wind setup is defined as "the vertical rise in the still-water level on the leeward side of a body of water caused by wind stresses on the surface of the water" (American Geological Institute, 1966, p. 322) (Figure 3). Although setup can be ignored in most floods elsewhere because of their limited spatial extent, it can seriously aggravate flood conditions in the

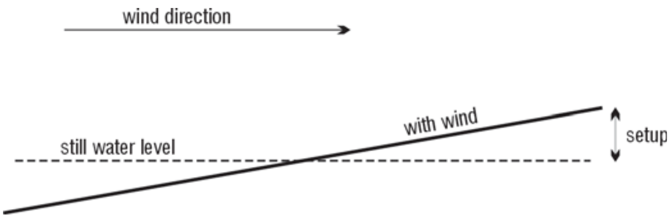

Figure 3: *Schematic definition of wind setup.*

northern Red River valley where the inundated area during major floods is exceptionally large; in 1997 this area became popularly known as the Red Sea and for convenience this name will be applied to the 1826 flood zone in this paper. In 1997, the Manitoba portion of the Red Sea covered about 2000 km^2 and the 1826 area would have been somewhat larger. With a flooded area this large, wind setup on the northern margin of the Red Sea may add significantly to the water stage which would otherwise be achieved by hydrologic conditions alone (i.e. under calm conditions where stages are governed only by discharge).

The 1826 flood occurred long before systematic monitoring of the weather began but fortunately, a great deal of knowledge about the event is preserved in archival materials. Much of this information is summarized in the RRBI reports, in Rannie (1999, 2001), and in St George and Rannie (2003). Particularly important are the journals kept by Francis Heron and Reverend David Jones which provide considerable detail about weather conditions during the flood, as well as its progress, and human consequences. These sources indicate that peak stage occurred about May 20-21 (Table 2).

Table 2: Indications of Peak Water Stage Date

May 20	We were considerably encouraged this morning by hearing that the river had fallen considerably at Pembina; we were confirmed in this hopeful information from the water being almost stationary in both our rivers since last night. (Jones, 1826)
May 22	We were much comforted this morning in finding that the Main River has lowered two inches during the night. (Jones, 1826) The inundation seems to have reached at length, its extreme height, it being imperceptible whether the water rose or fell during the last thirty-six hours. (Red River Journal, 1826)

Wind directions and strength reported by Heron and Jones during May 1826 are given in Table 3. The most striking feature is the period of strong winds from southern quadrants for at least four days (May 15-18) just prior to the peak (and possibly longer since wind directions were not reported from May 10-14 or on May 19). On May 20, when Jones first reported the river to be “almost stationary”, wind direction had switched to Northwest.

A commonly used method for estimating wind setup is given in Equation 1 (Saville et al., 1962; Bruce and Clark, 1966):

Table 3: Wind Conditions, May, 1826
(Red River Journal; *Jones Journal*)

	Direction	Strength
May 1	NE	
May 2	as yesterday	
May 3	E	*stormy in extreme*
May 4	SE	
May 5	SW	strong
May 6		
May 7	variable	
May 8	NE	
May 9	NW	
May 10		tempest
May 11		tempestuous
May 12	same as yesterday	
May 13		tempest
May 14		*unusually stormy*
May 15	SE	blowing hard; storm all night
May 16	SW	Strong
May 17	SW	Windy
May 18	SW	
May 19		high; quite a hurricane
May 20	**NW**	**Strong**
May 21	**W**	**strong gale**
May 22	variable	*very furiously*
May 23	variable	*still raging furiously*
May 24	SW	strong gale
May 25		
May 26	SE	
May 27	W	Windy
May 28	variable	
May 29	SW	
May 30	wind and weather the same	
May 31		

$$S = \frac{V^2 f}{KD} n \cos \theta \qquad (1)$$

where S = setup (ft.); V = wind velocity (mph); f = fetch (mi.); D = average water depth (ft.); n = coef ficient depending on lake shape; θ = angle between wind direction and fetch; K = coefficient (1400-1600)

Table 4 shows estimated setup calculated from Equation 1 for various combinations of average wind velocity, water depth, and effective fetch,

Table 4: Estimated Setup in 1826 Calculated from Equation 1

Wind Velocity (kmph)	Setup (m) for Fetch of 75 km			Setup (m) for Fetch of 30 km		
	D = 2.0 m	D = 2.5 m	D = 3.0 m	D = 2.0 m	D = 2.5 m	D = 3.0 m
30	0.50	0.40	0.33	0.20	0.16	0.13
40	0.89	0.71	0.60	0.36	0.29	0.24
50	1.39	1.11	0.93	0.56	0.45	0.37
60	2.01	1.60	1.34	0.80	0.64	0.53
70	2.73	2.18	1.82	1.09	0.87	0.73

assuming winds from due south ($\cos\theta$ = 1.0), no correction for lake shape (n), and K = 1500.

The actual wind speeds in 1826 are not known but the descriptions suggest they were strong and, given their duration, probably persistent. On the Beaufort Scale a velocity of 40 kmph is characterized as a "strong breeze" and this seems a minimum which might have engendered the historical comments. Water depth would have varied along the line of fetch but based on peak stages reported in Fleming (1880) and 1997 conditions, an average depth of 2.5 m is reasonable. The appropriate fetch to assume for 1826 conditions is also uncertain. Although no topographic barrier exists between Lockport and Morris (or even beyond), a greater wooded area on the floodplain and particularly along the La Salle River (Hanuta, 1998; 2001) may have reduced ef fective fetch or impeded the full development of setup. Thus, Table 4 gives estimates for two fetches: 75 km (approximately from Lockport to Morris) and 30 km (approximately from Lockport to the La Salle River). For wind speeds of 40-50 kmph, water depth of 2.5 m, and a fetch of 75 km, Table 4 indicates that a setup 0.71-1.11 m (2.3-3.6 ft.) might have occurred; for the shorter

30 km fetch, the calculated setup was 0.29-0.45 m (1.0-1.5 ft) for the same conditions.

Equation 1 was developed to predict setup on a horizontal water surface whereas the surface of the 1826 "Red Sea" would have sloped northward (i.e. in the same direction as the wind) and river flow in that direction would have relieved some of the wind stress on the water surface. Faure *et al.* (2000) of the Canadian Hydraulics Centre (CHC) used a two-dimensional hydrodynamic model to estimate setup which could be expected from 10- and 50-year winds (45 and 62 kmph respectively) acting on an 1826-magnitude flood *occurring over a modern landscape*. Their results are shown on Figure 4 for several locations on the dykes and in the vicinity of the Red River Floodway inlet (the locations B, C, E, and F are probably the most relevant to the 1826 peak stages in the Winnipeg area because they lie on a line orthogonal to south winds).

The CHC study was not intended to simulate actual 1826 conditions but rather was designed to investigate water levels in the vicinity of the Floodway inlet should an 1826 magnitude discharge occur in the future. Thus the circumstances assumed in the CHC study differed from those which would have existed in 1826. The modern dyke on the downwind boundary would maximize setup in comparison with the 1826 flood when no such retaining wall existed and water would have been able to spread across gentle gradients downstream. In addition, as was noted above, a greater wooded area on the floodplain in 1826 might have impeded the full development of setup in comparison with the modern condition. In these respects, then, the setup which might have occurred in 1826 would probably have been somewhat smaller than the values calculated by CHC. However, the fetch used by the CHC study was much shorter (10-15 km) than might have been the case under natural 1826 conditions, limited in the north by the dyke wall and to the south by road elevations on the modern landscape. The duration of the south winds assumed by CHC (sustained peak velocity from the south for 11 hours) was also considerably shorter than the three or more days which might be inferred from the historical data.

Despite the difference in methodology, the results from Equation 1 and the CHC study appear to be comparable. For example, CHC data for their "cross-section" are representative of conditions at Points E and F on Figure 4. If their fetch and average depth from that "cross-section" are used in Equation 1, predicted setups for 45 and 62 kmph winds are 0.29 m and 0.54 m respectively. It is concluded, then, that the difference between the CHC and Equation 1 setup estimates is principally attributable to differences in fetch.

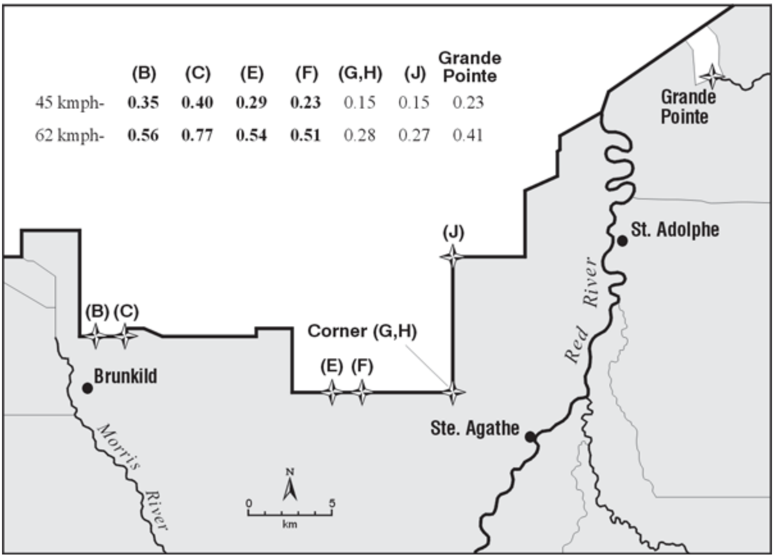

Figure 4: *Estimated setup on the dykes adjacent to the Red River Floodway for an 1826-magnitude flood (modified from Faure et al., 2000)*

Setup of 0.3-1.1 m in 1826 would have offset some of the downstream slope of the water surface and thus may partially explain the flat slope indicated by Fleming's survey data for the vicinity of the Forks. However *setup would also compound the main element of the Conundrum because its effect would have been to increase stages in the Winnipeg area*. If a setup component were subtracted from Fleming's high water marks, the stages in Winnipeg would have been even lower than Fleming reported and the Conundrum would be even more pronounced.

The coincidence in the timing of the peak stage on May 20-21 and the reversal of wind direction from strong south to strong north on May 20 (or possibly May 19) is also notable. Could the relaxation of the wind stress have contributed to stabilization of water levels?

Fleming's Survey Methodology

Although wind setup might address some of the concern over the "zero slope reach", this element of the "Conundrum" might have another solution. As was noted above, Fleming's original data were modified to reflect changes in reference section and a precisely defined City Datum.

A notable effect of these adjustments was the addition of one decimal place to Fleming's original elevations (Table 1), giving the appearance of greater survey accuracy than was implied in Fleming's report. Whereas Fleming only reported the high water marks to the nearest foot, the adjusted values provided for one decimal place, implying survey accuracy approximately to the nearest 0.5 ft. Fleming's high water marks clearly were rounded to the nearest foot, a sensible treatment given the methodology and the long time-span since the flood. It is possible that if the upstream elevation was rounded downward and the downstream elevation was rounded upward, then a gradient of as much as 1 foot (0.3 m) *could* have existed over the 6 km between the upper and lower stations without this being apparent from subsequent versions of Fleming's data. This is approximately the gradient which KGS Group estimated should have occurred in this reach in both 1997 and 1826. Thus the "missing gradient" may be a product of Fleming's data treatment and some flattening by wind setup. This scenario, if true, would reduce slightly but not resolve the main element of the Conundrum because rounding could account for only 0.15 m (0.5 ft) of the 0.5-0.75 m "shortfall" in Fleming's elevations at the mouth of the Assiniboine and as was noted above, consideration of wind setup would exacerbate the shortfall.

Ice Conditions

KGS Group (2001) suggested that the anomalously high water levels in the Selkirk area may have been caused by temporary ice jamming early in the flood and thus were not a reflection of open water peak flows. In their Scenario #2, they hypothesized that "the water levels in Winnipeg occurred as reported, and the high water levels near Selkirk were caused during the early stages of the flood, and resulted from a temporary ice jam that was subsequently washed downstream and dissipated." (KGS Group, 2001, p. 15).

Historical references to ice conditions and changes in stage from breakup to the flood peak are given in Table 5. The descriptions during the first days of May indicate that the ice was very thick (4-4.5 feet) and remained strong and intact as the water began to rise. Breakup occurred over a 3-4 day period from May 4 to May 8. On May 4, Jones (1826) reported that the ice "started" but a general breakup and evacuation of the ice did not begin until May 5. The following day (May 6), the rising water carried the ice away "in immense masses" and Jones reported that by the end of the day most of the ice was gone. The Assiniboine broke up early on the morning of May 7 and by May 8, both rivers had "become almost

Table 5: References to Ice Conditions in Jones and Red River Journals

May 1	Every creek pours in its tributary flood and the water has already overflowed its banks in many places, though there is scarcely any diminution of the snow in the plains around...The ice has not yet moved though elevated nearly up to the level of the banks and it is unusually weighty being in general Four feet thick; in consequence the houses, which are set upon the edge of the river are in the greatest danger of being swept away. (Jones, 1826) The ice in the Rivers begins to rise in consequence of the flush of waters pouring into them from the plains... (Red River Journal, 1826)
May 3	The river rose six feet last night perpendicularly... The ice has just started towards the lake; the water keeps rising alarmingly... (Jones, 1826) The ice in the Rivers has attained the height that floods reached at the highest pitch last summer, and the water in several places has overflowed the banks... (Red River Journal, 1826)
May 4	No apparent sign of deliverance yet, last evening when the ice started, the river slackened considerably; but rose again in the morning. The ice continued stationary all this day...The water is now within 4 feet of the Church... (Jones, 1826) The water in the Rivers rose about 5 feet perpendicular during the last twenty-four hours, and the ice is now on a level with the highest banks, but is still so thick and strong that even the present flush of waters have not sufficient force to break it up... (Red River Journal, 1826)
May 5	On a point of the river above us four houses and a barn were swept off by the force of the ice and the ruins floated past us to-day on the surface thereof... The ice is uncommonly weighty being generally four feet & a half thick. The force of it is inconceivable; the loftiest elm trees are carried away like the most inconsiderable things... (Jones, 1826) About 2 P.M. the ice in the Red River at length broke up in an awful rush; carrying away cattle, houses, trees and every thing else that came in its way-The river overflowed its banks every where, and carried the ice with great velocity to a greater distance from its course, than had ever been seen before by the oldest inhabitants... (Red River Journal, 1826)
May 6	Most part of the heavy ice is now gone which must be so far in our favour...The water rose considerably during this day... (Jones, 1826) The waters continued to increase during the last night and this day-The ice during the same time ran past without intermission in immense masses, mingled with the wrecks of houses, fences, trees etc. (Red River Journal, 1826)
May 7	About 4 A.M. the ice in the Assiniboine River broke up and the waters therein rose as high as those of the Red River. The immense discharge of ice poured in from the former, into the latter mentioned, made this scene as destructive as terrific... (Red River Journal, 1826)
May 8	The rivers have become almost clear of ice, but the waters increase apace... (Red River Journal, 1826)
May 9	The waters still rose, and the whole country has assumed the appearance of a large Lake... (Red River Journal, 1826)
May 11	The floods continued to rise, considerably throughout the last twenty four hours... (Red River Journal, 1826)
May 13	The water during the whole week has been gradually rising... (Jones, 1826)
May 14	The waters rise so rapidly... (Red River Journal, 1826)
May 15	During the night the water rose six inches which is a great deal considering the extent of the surface which it now occupies... (Jones, 1826)
May 17	The waters rise at the rate of two feet in twenty four hours... (Red River Journal, 1826)
May 18	The waters continue to rise at the rate of 10 inches in the space of twenty four hours... (Red River Journal, 1826) ... we were glad to find that it had only risen one inch above a mark I made on the casement of the window yesterday. (Jones, 1826)
May 19	The waters rising at the rate of four inches in twenty four hours... (Red River Journal, 1826)
May 20	...the water being almost stationary in both our rivers since last night. (Jones, 1826)
May 22	We were much comforted this morning in finding that the Main River has lowered two inches during the night... (Jones,1826) The inundation seems to have reached at length, its extreme height, it being imperceptible whether the water rose or fell during the last thirty-six hours... (Red River Journal, 1826)

clear of ice" (Red River Journal, 1826). Stages increased dramatically during this entire period.

The historical accounts make no direct mention of ice jamming but Jones' statement on May 4 that "when the ice started… the river slackened considerably" suggests that some of the rapid early rise in stage was attributable to an ice jam downstream. Both of the historical observers were located in the Winnipeg area and thus their comments do not necessarily reflect conditions as far downstream as Selkirk. Nevertheless, the indication that ice jamming did occur, however briefly, in the Winnipeg area and the descriptions of the quantity, integrity, thickness, and strength of the ice discharged from May 5-8 support KGS Group's suggestion that ice jamming may have occurred at Selkirk as well, producing a temporary peak water level in excess of the stage which would have been achieved under open-water conditions. After May 8, the water level in the Winnipeg area rose continually but more gradually, such that the peak stages reported in the vicinity of the Forks were clearly unrelated to ice jamming.

The historical record, then, is not incompatible with the KGS Group Scenario #2 explanation of the Fleming Conundrum quoted above.

The Contribution of the Assiniboine River

A further complication arises from uncertainty about the contribution of the Assiniboine River. In an earlier paper Rannie (2002) argued that the Assiniboine also experienced extreme discharge in 1826, that the Assiniboine contribution may have been as much as 20% of the upstream flow, and that the peaks on the two rivers may have been unusually synchronous. The Assiniboine joins the Red at the Forks where Fleming's surveys began and thus the effects of its contribution would appear to have been reflected in the downstream peak stages reported by Fleming. However, the high stage of the Red would have moved the actual confluence considerably to the west of its normal location (perhaps to the vicinity of Sturgeon Creek). Under these conditions, the water arriving from the Assiniboine would probably not have been a "point" addition but may have been distributed along a reach of the Red extending from the La Salle River in the south to some distance north of the present confluence.

Conclusions

The peak stage of the 1826 flood is a complex matter. The secondary puzzle identified by KGS Group in Fleming's high water data – that of the zero gradient reach – might be accounted for by a combination of wind setup on the northern margin of the Red Sea and Fleming's data treatment. Setup, however, would exacerbate the main element of the "Conundrum" – the anomaly in water levels between Winnipeg and Selkirk. There is some support for, and no data to contradict, the suggestion that the anomalously high peak stages in the Selkirk area were caused by ice jamming early in the flood. These factors and the role of abnormally large influx from the Assiniboine should be considered in future discussions of 1826 flow conditions.

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Monitoring anthropogenic nutrients in a modified natural wetland; Riding Mountain National Park, Manitoba

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Abstract: In recent years, extensive research has been conducted and several studies published detailing the ecology of wetlands, in particular the roles that wetland plants and soils serve in the removal of anthropogenic nutrients from wastewater. Ominnik Marsh is a natural wetland located in Riding Mountain National Park. A three-cell lagoon system discharges annually (single event flush) into the marsh. This study examines the impact of the spring melt, the single event lagoon discharge and the seasonal vegetation growth sequence on the phosphorus and nitrogen levels in Ominnik Marsh.

Seasonal observations of nutrient concentrations in the Ominnik Marsh wetland indicate that there is an uptake of nitrogen and phosphorus by the natural vegetation reducing these nutrient concentrations to background levels. Nutrient monitoring at points throughout the marsh supports the conclusion that the forcemain conduit leading into the sewage lagoons is leaking into the marsh. The data presented indicates that a significant area of the marsh is being "short-circuited" during the spring single event release from lagoon Cell 3.

Introduction

The role that wetlands play as natural water purifiers is an aspect of wetland ecology that has received considerable study in recent years (Mitsch and Gosselink 1993; Kadlec and Knight 1995; Kirby 2002). Wetlands have the capacity to receive, hold, and recycle potentially damaging nutrients washed from upstream and upland regions. In North America natural wetlands have been used as wastewater discharge sites as long as sewage has been collected (IWA Specialist Group 2000).

Ominnik Marsh is a natural wetland located within the Clear Lake watershed, in Riding Mountain National Park, Manitoba. The marsh receives an annual effluent flush from the Wasagaming sewage lagoons, and ultimately drains into the South Lake - Clear Lake complex. Clear

Lake is the focus of summer recreational activity in Riding Mountain National Park. Consequently, water quality throughout the Clear Lake watershed is a fundamental concern identified in both the Park Management Plan and the Ecosystem Conservation Plan (Dubois 1997).

The Study Area

Ominnik Marsh is a natural wetland system located within Riding Mountain National Park, about 100 km north of Brandon, Manitoba (Figure 1a). It is a part of the Octopus Creek - South Lake sub-basin of the Clear Lake watershed, which ultimately drains into Clear Lake. Ominnik Marsh is "Y" shaped. The trunk of the Y from sampling site O1 to O2 is approximately 440 m in length (Figure 1b). Two small beaver ponds (less than 0.25 ha) have been constructed at and near the Ominnik 2 sampling site. Vegetation common to the reach includes rooted willow (*Salix spp*.), reeds (*Phragmites spp*.), rushes (*Juncus spp*.) and sedges (*Carex spp*.); open water vegetation includes common reed (*Phragmites spp*.), duckweed (*Lemna minor*), water calla (*Calla palustris*), and cattail (*Typha spp*.)

The northeast branch of the "Y" (sampling sites O2-O5) is 760 m in length and approximately 160-250 m in width. This area of the marsh is the former course of Octopus Creek and during the spring freshet, flows can be measured at the O5 sampling site (Figure 1b). Since 1961, Octopus Creek flows have been diverted to the west, draining from the marsh into South Lake by way of a constructed channel (Figure 1b). The "old" Octopus Creek channel drops approximately 2.0 m from the O1 site at Provincial highway 10 to the outlet at the Boat Cove (O5). Channel slope is calculated to be 0.002 or 0.2%. Prominent vegetation common to this area of the marsh is rooted willow, (*Salix spp*.) alder (*Alnus spp*.), aspen (*Populus tremuloides*), sedges (*Carex spp*.) and blue joint grasses (*Calamagrostis canadensis*); open water vegetation includes *Lemna minor*, *Phragmites*, and *Typha*. Boat Cove Road provides access to the O5 sampling site.

The western branch of the Ominnik Marsh "Y" includes a shallow pond (generally less than 1.5 m in depth), which can be subdivided into two areas; the open water pond and the floating vegetation with occasional open water (Figure 1b). This region of the marsh has an estimated length of 350 m from sampling sites O2 to O3 (the head of pond) and an additional 225 m across the pond to sampling site O4 (Figure 1b). The distance from sampling sites O2 to O4 is estimated to be 540 m. The region is approximately 125-250 m wide. The pond has an estimated elevation of 615.8 m above sea level. An upland ridge, rising approximately 3 m above

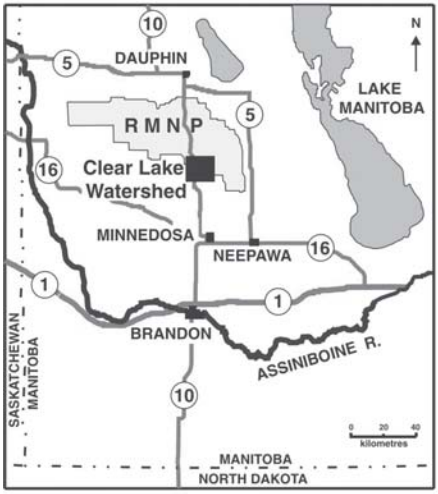

Figure 1a

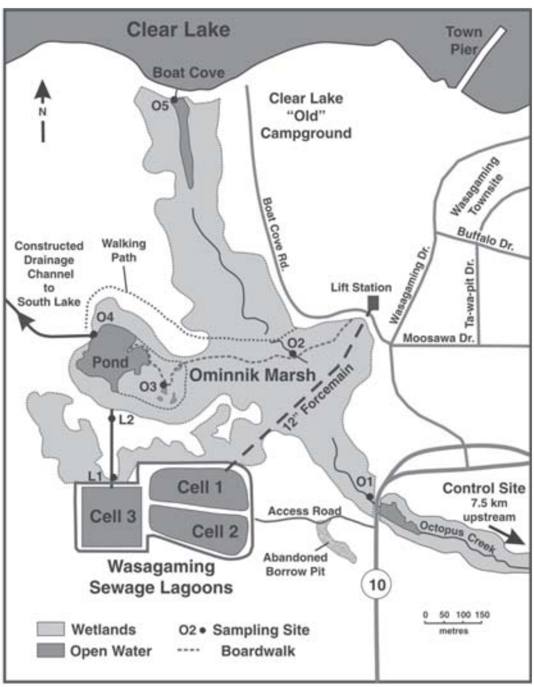

Figure 1b

Figure 1: a) *Location of the Study Area,* ***b)*** *Ominnik Marsh and the Wasagaming Sewage Lagoons, Clear Lake Watershed, Riding Mountain National Park.*

the marsh, bisects the western branch of the "Y," and separates the pond and marsh proper from a narrow wetland region adjacent the lagoon system (Figure 1b). White spruce (*Picea glauca*), alder (*Alnus spp*.), aspen (*Populus tremuloides*) and shrub species (hazel, *Corylus spp*.) are found on the uplands, willow (*Salix spp*.), sedges (*Carex spp*.), blue joint grasses (*Calamagrostis canadensis*), marsh marigold (*Caltha palustris L*.) and reeds (*Phragmites*), are common in the marsh. *Lemna minor*, *Calla palustris, Juncus* and floating mats of cattail (*Typha latifolia*) are common in the open water pond.

Wastewater Treatment in Wasagaming, Manitoba

In the early 1950's greywater waste from the old campground and the townsite was discharged directly into Ominnik Marsh (Rousseau 2002). A small earthen dam (the walking path on Figure 1b) held the wastewater discharge in the marsh throughout the summer In the fall outflow conduits through the dam were opened and the following spring, the snowmelt freshet flushed the system directly into Clear Lake.

In the late 1950's and early 1960's a single cell lagoon (Cell 3) was constructed southwest of the town of Wasagaming within the Park boundaries (Figure 1b). Wastewater was pumped to the lagoon cell through a 12-inch (30 cm) diameter forcemain conduit buried beneath Ominnik Marsh. The lagoon cell was excavated out of in-situ coarse soils (sands, silty sands and clayey sands) and is approximately 168 m square (2.83 ha), 2 m deep, and unlined. At the time, it was believed that the settled solids would seal the pervious bottom of the lagoon in a few years. A concrete spillway and regulated outlet conduit, located on the north side of the lagoon cell, discharges into an excavated ditch which is approximately 75 m long, 4 m wide and up to 2.5 m deep. The ditch, designed to convey an annual spring release and accidental overflows from the lagoon cell into Ominnik Marsh, enters the marsh south of the pond (Figure 1b). This relatively straight man-made discharge channel contains four artificial dams, approximately 1.5 m in height that create temporary "holding ponds" in the ditch. The dams are easily overtopped, however, and during the annual spring release the channel flows continuously. It is speculated that the baffles or small dams were originally constructed in an effort to reduce flow velocities and/or to "hold" small accidental releases associated with overtopping of the lagoon cell during heavy rainfalls.

In 1961, as part of this free water surface wetland system, a 390 m drainage channel, connecting the pond in Ominnik Marsh to South Lake, was excavated. This and the original "walking path" dam effectively diverted the Octopus Creek flows to South Lake and only peak flow events were able to overtop the "walking path" dam and flow directly into Clear Lake. The constructed channel drops approximately 1.0 m over the 390 m length. The slope is calculated to be 0.002 or 0.2%.

The primary treatment single cell lagoon system of the early 1960's allowed "a considerable amount of pollution" to be released into Ominnik Marsh (Bazillion et al., 1992). In drier years, significant exfiltration and evaporation losses often obviated the necessity for a release into Ominnik Marsh. The lagoon, however, was hydraulically overloaded in the summer, could not store the annual volume of wastewater generated, and during heavy rainfall events overflowed into the marsh (Rousseau 2002 and Wruth 2002).

Two additional cells, Cell 1 and Cell 2, were constructed in the early 1970's to the east of the original lagoon cell (Figure 1b). The expanded system (three cells) covers 7.25 ha (17.9 acres), and has a potential storage capacity of 97,284 dam^3 (21.4 million imperial gallons) of wastewater (MacLaren 1979). The additional cells were excavated out of the in-situ coarse soils. The banks and bottom were lined (Pratt 1991). Valve controlled conduits connect the three lagoon cells in series. Generally the conduits, positioned 1.5 m (5 feet) above the bottom of the lagoons, drain surface waters from Cell 1 to Cell 2 and from Cell 2 to Cell 3. Cell 1 is anaerobic and the primary settling cell. Cell 2 is anaerobic in the spring and aerobic throughout the summer and Cell 3, the finishing cell, is aerobic throughout the year (Paton 2002). Submerged and floating aquatic vegetation was sampled near the shores of Cells 1 and 2 using a long handle rake and grab samples taken from a boat. *Ceratophyllum demersum* (Coontail) was practically a monoculture, very abundant forming thick submerged mats (Rogosin 2002). *Lemna minor* (Duckweed) and *Zannichellia palustris* (Horned-Pondweed) were present but relatively sparse. *Ceratophyllum demersum L.* present in Cell 2 appeared to be less vigorous and bushy and generally a paler green than those present in lagoon Cell 3 (Rogosin 2002). Emergent plants growing along the borders of the lagoon cells 1 and 2 consist of *Typha spp.* (Cattails) grasses and sedges (mostly *Carex spp.*) (Rogosin 2002).

Wastewater is pumped to lagoon Cell 1 through the existing 30 cm (12 inch) diameter forcemain conduit buried beneath Ominnik Marsh. There is a suspicion that this conduit was not properly installed and leaks (MacLaren 1979). Pressure testing in 1991 supports this hypothesis (Pratt 1991). However, the most recent pressure test (summer 2002) indicates that the line is not leaking (Wruth 2002).

Wruth (2002) describes the operational procedures for the Wasagaming three-cell lagoon wastewater treatment system. While the system operates throughout the year, discharges during October through to late May are minimal, effectively shutting down the system for a seven-month period. Consequently, the three-cell lagoon wastewater treatment system operates from late May to mid-October. Peak wastewater volumes occur in July and August when the population of the resort town is estimated to average 8,000 (Huissman 2002). Untreated wastewater is pumped into lagoon Cell 1. During the summer recreational season the valves controlling the conduits which link the three cells remain open allowing transfer of surface wastewater from Cell 1 to Cell 2 and finally to Cell 3. In the spring the three cells are isolated for a short period (usually May) and the effluent in Cell 3 is tested for total and fecal coliform bacteria count, biochemical oxygen demand and other water quality parameters. Once the fecal coliform counts and the five-day BOD meets the provincial public health standards there is a release of approximately 36,350 dam^3 (8 million imperial gallons) from Cell 3. This effluent release normally occurs in mid to late June. Following the spring release the valves are reopened and remain open for the remainder of the summer. Occasionally, following a rainy summer or autumn, there is a mid-October drawdown release of approximately 18,000 dam^3 in preparation for the following spring operations. Operational procedures similar to those followed in the spring are employed; the cells are isolated, effluent in Cell 3 is tested and then released into the marsh as a single one-day event.

Federal and provincial guidelines for the design of standard lagoons require that stabilization ponds have a one year storage capacity and a maximum organic load on the primary cell of 50 lb per acre per day (Pratt 1991). In 1976 the three-cell lagoon system was hydraulically and organically overloaded (MacLaren 1979). Organic loads exceeded the provincial standard and the three lagoons could not meet the federal storage requirements (MacLaren 1979). Following the implementation of recommendations in the MacLaren Study (1979), the average seasonal sewage flow from April to October was reduced from 200,000-225,000 imperial gallons per day (approximately 100 dam^3 day^{-1}) to approximately 150,000 imperial gallons per day (68 dam^3 day^{-1}) (Pratt 1991). Since the three-cell lagoon storage is 97,284 dam^3 (21.4 million imperial gallons) and the annual volume is estimated to be 145,927 dam^3 (32.1 million imperial gallons) the present system fails to meet the federal storage requirements. Exfiltration, the water losses through the base and sides of the Wasagaming lagoon cells, is considered to be significant and probably accounts for the fact that the annual sewage volume can be stored in the three cells.

In 1976, lagoon exfiltration losses including leakage from the forcemain conduit were estimated to be approximately 50 million imperial gallons (227,300 dam^3) annually, a volume that was approximately 80% of 1976 influent flow (MacLaren 1979). This volume may be an overestimate as it does not include summer evaporation losses which can be significant. Pratt's (1991) estimate of exfiltration losses considers seasonal evaporation losses. Pratt estimates a conservative evaporative loss of one-foot (30 cm) depth from the three lagoon cells (18 acres surface area) or approximately 5 million imperial gallons (22,730 dam^3) (Pratt 1991). Sewage volume for the April to October period was estimated to be 20 million imperial gallons (90,920 dam^3) and the combination of exfiltration and evaporation losses accounted for 15 million imperial gallons (68,190 dam^3) or 75% of influent volume (Pratt 1991).

Pratt (1991) estimated the organic loading for the three-cell system. Organic loading is evaluated by the five day BOD per acre and total coliform count. Assuming a mean BOD loading of 150 mg L^{-1} in the sewage and a mean daily flow of 150,000 imperial gallons per day, organic loading on the system was less than the 50 lb per acre per day. Pratt concluded that the wastewater treatment system was, on average, functional throughout the operation period (April to October). During the summer months, however, the system is overloaded.

Objective of the Study

The general objective of this study is to assess the efficiency of Ominnik Marsh, a modified natural wetland, to sequester anthropogenic nutrients from agricultural runoff and municipal wastewater. Specifically, efficiency will be assessed by sampling marsh waters at a series of strategic points for soluble orthophosphate, total ammonia, nitrate, and nitrite ion concentrations. The study will examine the nutrient concentrations associated with the spring freshet and the sewage lagoon single event discharge release. Attempts at resolving the "leaking forcemain" issue will be addressed.

Theoretical Considerations

Nitrogen and Phosphorus:

In the majority of aquatic systems, either nitrogen or phosphorus is the nutrient that limits aquatic plant production (Hammer and MacKichan 1981). The accumulation of nitrogen and phosphorus will contribute to the eutrophication of lakes and reservoirs (Hammer and Knight 1992).

The main subenvironments to which nitrogen and phosphorus can be transferred from wetland surface waters are the atmosphere, sediment-interstitial water, and living and dead biomass (Neely and Baker 1989). In turn, each of these subenvironments can also serve as the source of nutrients to surface waters. Since the concentrations of these elements in natural environments are usually low (Calow and Petts 1996), they are considered good indicators of anthropogenic nutrient loading. Consequently, the water quality analyses focuses on the concentrations of nitrogen and phosphorus in the water samples.

Ammonia:

Ammonia is a colourless gaseous alkaline compound of nitrogen and hydrogen. It is an inorganic form of nitrogen that is very soluble in water and can be used directly by plants. Natural sources of ammonia in surface waters include the decomposition of plant material and animal waste, weathering of clays, nitrogen fixation by clays and gas exchange with the atmosphere (pure ammonia being a gas present in air).Ammonia is found in water as NH_3 (free ammonia or dissolved un-ionized ammonia gas), and as NH_4^+ (ammonium ions). In water the two forms (NH_3 and NH_4^+) exist in equilibrium and their combined concentration is referred to as total ammonia. Analytical methods are not readily available for the measurement of free ammonia. Consequently, measures of ammonium ion concentration and equilibrium relationships are used to determine total ammonia ($NH_3 + NH_4^+$) concentration. Ammonium is a major component in fertilizers manures and sewage and significant amounts can enter water bodies in runoff from cultivated fields, rural residences and cottages. During application and post application, under the right conditions, volatilization significantly increases the ammonia concentration in the atmosphere.

The toxicity to aquatic organisms of ammonia in an aqueous solution is attributed to the un-ionized NH_3 component of total ammonia (Williamson 2001). Since it is difficult to measure free (un-ionized) ammonia concentrations in a solution, equilibrium relationships are used to estimate the free ammonia concentration from total ammonia measurements. Water temperature and pH regulate this equilibrium. As temperature and/or pH increases the percentage of free ammonia in total ammonia increases.

In unpolluted waters free ammonia and ammonium occur in small quantities usually less than 1.0 mg L^{-1} (Reid and Wood 1976) and pose little or no risk to aquatic organisms. Health Canada's maximum allowable concentration (MAC) of ammonia for drinking water is 2.0 mg L^{-1}. The Water Encyclopedia, page 472 'Guidelines for Evaluating Quality for

Aquatic Life', recommends that free ammonia (NH_3) should not exceed 0.5 mg L^{-1} (Van der Leeden *et al*. 1990).

Nitrates and Nitrites:

Nitrate (NO_3^-) and nitrite (NO_2^-) are two inorganic forms of nitrogen found in water. Along with ammonia they are an important sources of nitrogen for aquatic plants. Nitrates are used extensively as an ingredient in nitrogen fertilizers; thus runoff from cultivated land is a common source of anthropogenic nitrate. Nitrates can also form from sewage, animal waste, plant and animal decay, as well as leachate from igneous rock.

Nitrate ion concentrations in water bodies in western Canada rarely exceed 5.0 mg L^{-1} of nitrogen in nitrate form and are usually below 1.0 mg L^{-1} of nitrate nitrogen (Williamson 1988 and Van der Leeden *et al*. 1990, 422-423). Nitrate nitrogen ($N0_3^-$-N) refers to the mass of nitrogen in the nitrate form. According to Health Canada the maximum allowable concentration (MAC) for nitrates should not exceed 45.0 mg L^{-1} (Health Canada 1996). This corresponds to maximum allowable nitrate nitrogen ($N0_3^-$-N) concentration of 10.0 mg L^{-1} (Williamson 2001 and Van der Leeden *et al*., 443). The nitrate nitrogen concentration in unpolluted waters rarely exceeds 0.300 mg L^{-1} (Reid and Wood 1976).

Nitrite nitrogen ($N0_2^-$-N) is found at lower concentrations than nitrate nitrogen, approximately 0.001 mg L^{-1} in unpolluted waters(Reid and Wood 1976). Sources for nitrite include industrial effluent, sewage and animal waste. The MAC for nitrite is 3.2 mg L^{-1} of $N0_3^-$ or 1.0 mg L^{-1} for nitrite nitrogen (Williamson 2001 and Van der Leeden *et al*. 1990, 443).

Phosphorus:

Phosphorus is an essential nutrient for plant and animal life, and in many systems functions as the growth-limiting nutrient. Plants will readily utilize phosphorus; usually ninety percent or more of total phosphorus in impounded waters is organically bound (Hammer and MacKichan 1981). Phosphorus in natural waters commonly occurs as phosphate, which is classified as orthophosphate (PO_4^{-3}), polyphosphates (polymers of phosphoric acid), and organically bound phosphates, each existing in either a filterable (dissolved) or non-filterable (particulate) form. Filterable orthophosphate concentrations tend to be low in natural water bodies because living organisms assimilate phosphorus. Sources for phosphorous include agricultural run-off from fertilizers and animal feeds, and municipal wastewaters containing detergents and other commercial products. Total mean phosphorus concentration of most lakes ranges from 0.010 - 0.030 mg L^{-1} (Reid and Wood 1976). Total phosphorus (soluble phosphate phosphorus) concentration should not exceed 0.025 mg L^{-1} in any reservoir, lake or pond, or in any tributary at the point where it enters such bodies of water (Williamson 2001).

Methodology

Eight point-sampling sites were identified throughout the Octopus Creek-Ominnik Marsh sub-basin (Figure 1b), including a control site.The control site is located 7.5 km upstream (east) of Figure 1b, near the headwaters of Octopus Creek. The site receives drainage from wetlands, natural meadows, woodlots, and a few small agricultural fields. At the control site there is no recognized point sources of pollution or anthropogenic nutrients (Moore and McGinn 1997). Consequently, the control site is believed to represent natural background concentrations for ammonium, nitrate, nitrite, and soluble phosphate (Moore and McGinn 1997).

Ominnik Marsh 1 (O1) is a point-sampling site located just west of Highway 10, outside the Park gate but inside the Park boundary (Figure 1b). At this site Octopus Creek drainage enters Ominnik Marsh and nutrient concentrations are considered to represent the background values entering Ominnik Marsh. During the spring freshet in 1997, Moore and McGinn (1997) observed ammonia and soluble phosphate concentrations at this site that were an order of magnitude greater than those recorded at the control site. Point sources of anthropogenic nutrients to Octopus Creek include the Elkhorn Resort and the Triangle Riding Stables.

Ominnik Marsh 2 (O2) is located in Ominnik Marsh approximately 440 m further along the drainage path from O1 (Figure 1b). The site happens to be situated downstream from 12-inch diameter forcemain conduit conveying waste from the town of Wasagaming into the lagoon cell 1 (Figure 1b). The O2 site is accessed from the boardwalk and samples Octopus Creek flows distributed through the trunk region of Ominnik Marsh. It was hypothesized that the suspected leakage from the forcemain might augment the ammonia, nitrite and soluble orthophosphate concentrations in the O2 samples compared to the O1 concentrations. In addition it was postulated that lagoon dischar ge flows and associated nutrient concentrations would not show up in the O2 samples.

Ominnik Marsh 3 (O3) is located in a small open water area of floating vegetation, accessible by the Ominnik Marsh boardwalk (Figure 1b). It is positioned slightly to the north and east (upflow) of the locale where the lagoon discharge channel enters the marsh. This sampling site was selected to monitor the dispersion of lagoon releases and associated nutrient concentrations within the marsh.

Ominnik Marsh 4 (O4) is located at the exit point of the pond-marsh at metre 1 of the constructed channel that drains Ominnik Marsh westward into South Lake (Figure 1b). This sampling site monitors the dispersion of lagoon release flows and associated nutrient concentrations and could be used to compare influent nutrient concentrations with outflow concentrations (O1 versus O4). The same site was used by Moore and McGinn (1997) for monitoring nutrient uptake and sorption through the marsh in their 1996 study.

Ominnik Marsh 5 (O5) is located at the site that originally received the drainage from Octopus Creek prior to the construction of the western drainage channel (Figure 1b). Since the diversion of Octopus Creek, this locale serves as a boat marina and launch. A small bar has ponded the natural drainage from the marsh which now enters Clear Lake by way of a small channel. Near the bar the pond is approximately 1.0 m deep. The O5 site samples the flow through the outflow channel. It was anticipated that freshet overflows and nutrient concentrations moving through the system in the spring might appear in the O5 samples.

The Lagoon 1 (L1) sampling site is located at the head of the constructed ditch a few meters downstream of the concrete spillway and outlet where treated wastewater effluent is released from lagoon Cell 3 (Figure 1b).

The Lagoon 2 (L2) sampling site is located at the north end of the lagoon discharge ditch. The site is just upstream of the last "holding" dam in the excavated ditch which discharges into the marsh (Figure 1b).

Sampling and Analyses

Sampling began on May 6, 2002, although overnight temperatures frequently dropped to below zero degrees Celsius up until the end of the month. Point water samples were collected once every four days during the spring freshet (May 6 - May 20) and approximately once a week throughout June and July. Samples were taken near the surface. Following the single event lagoon discharge (June 20), point sampling occurred once every 24 hours for a seven-day period. As the nutrient levels declined in the late summer and fall, samples were routinely collected once a week.

Samples are analyzed on site for temperature, pH, conductivity total dissolved solids and dissolved oxygen. Ammonium, nitrate, nitrite and soluble orthophosphate ion concentrations were measured in the laboratory within 24 hours of sampling. Portable ion specific colourmetric meters (Hach and Hanna Instruments) were used. Observations and results of total ammonia and soluble orthophosphate analyses are presented in this paper.

Observations and Results

Recorded seasonal nutrient concentrations support Moore and McGinn (1997) observation that high ammonium ion and soluble orthophosphate concentrations progress through the lower reaches of Octopus Creek and enter Ominnik Marsh during the spring freshet and following heavy rainfalls. The total ammonia concentrations recorded during the 2001 freshet (May 6-May 20) never exceeded 0.29 mg L^{-1}; soluble orthophosphate concentrations exceed the 0.025 mg L^{-1} Manitoba Surface Water Quality objective for waters in reservoirs, lakes, and ponds (Table 1).

A comparison of the O1 and O4 data (Figures 2a and 2b) indicate that excess runoff nutrients are taken up into the wetland system and/or are diluted to background levels by the end of May and that there is a successful uptake and reduction in nutrients with renewed vegetal growth in June and July.

The one notable exception to this trend is the nutrient concentrations measured at O2, which show a dramatic rise in ammonium ion and soluble orthophosphate concentrations as the recreational season progresses (Figures 2a and 2b). The O2 sampling site is located downstream of the forcemain that conveys wastewater from the townsite across the marsh into the lagoon Cell 1 (Figure 2a). Park managers (Rousseau, 2002) and consultants (MacLaren 1979 and Pratt 1991) had speculated that the pipe was leaking at some point. The nutrient concentration data recorded at the O2 sampling site support the hypothesis that the influent conduit is leaking. The seasonal over all mean soluble orthophosphate concentration (1. 03 mg L^{-1}) at the O2 site is at least twice the recorded concentration measured at the O1 site (0.43 mg L^{-1}) immediately upstream and at least three times the concentrations recorded downstream at sites O3 and O5 (0.29 and 0.18 mg L^{-1}, respectively)(Table 1). During the peak operational months (July and August) soluble orthophosphate concentrations exceeded 1.47 mg L^{-1}, recording a mean value of 1.65 mg L^{-1} (Table 1).

Total ammonia concentrations measured at O2 also support the leaking conduit theory. The seasonal mean ammonium ion concentration (0.33 mg L^{-1}) and the July-August mean (0.54 mg L^{-1}) measured at O2 was at least twice the value recorded at O1, O3 and O5 (Table 1).

It was expected that Ominnik Marsh 3 and 4 would reflect the elevated nutrient concentrations (ammonium ion and soluble orthophosphate)

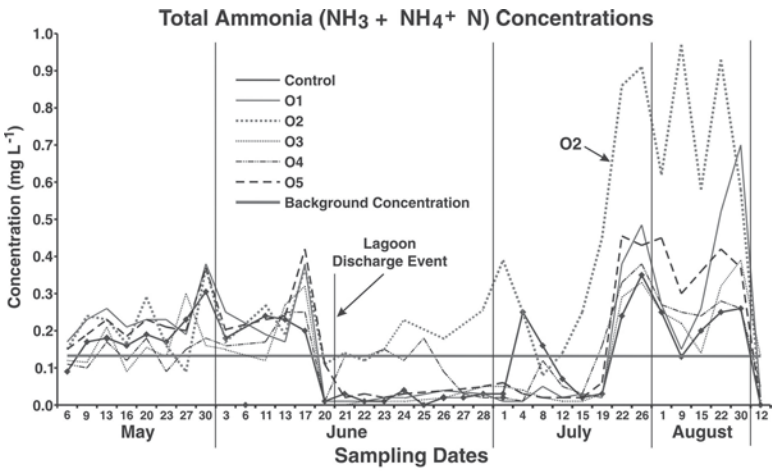

Figure 2a

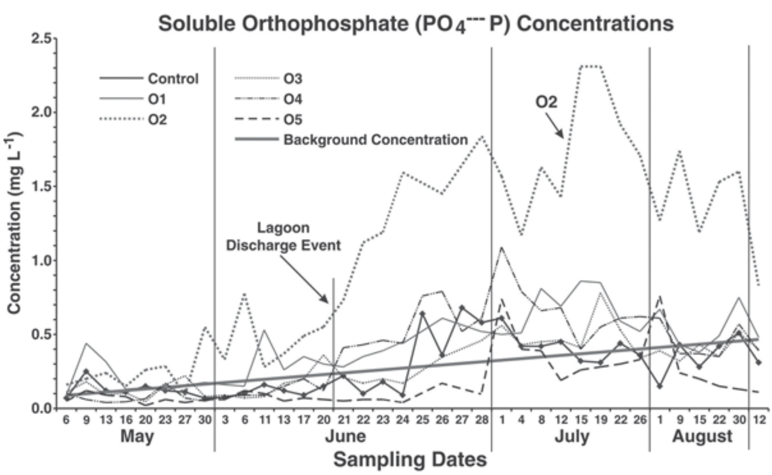

Figure 2b

Figure 2: a) *Total ammonia and* ***b)*** *soluble orthophosphate concentrations recorded at the Ominnik Marsh sampling sites, May-September 2002.*

Table 1: *Mean total ammonia and soluble orthophosphate concentrations recorded at the Ominnik Marsh sampling sites, May-September 2002.*

MEAN TOTAL AMMONIA CONCENTRATIONS

$NH_3 + NH_4^+$ N mg L^{-1}	MEAN mg L^{-1}	SD mg L^{-1}	May mg L^{-1}	June mg L^{-1}	July mg L^{-1}	Aug mg L^{-1}	Jul-Aug Mean mg L^{-1}
Control	0.136	0.105	0.187	0.078	0.144	0.218	0.172
OM 1	0.180	0.176	0.238	0.103	0.126	0.380	0.223
OM 2	0.330	0.265	0.212	0.199	0.416	0.736	0.539
OM 3	0.135	0.118	0.160	0.087	0.098	0.264	0.162
OM 4	0.150	0.095	0.138	0.130	0.138	0.260	0.185
OM 5	0.186	0.154	0.221	0.126	0.137	0.380	0.230
L1	0.264	0.196	0.201	0.411	0.185	0.100	0.152
L2	0.600	0.237	0.000	0.540	0.607	0.712	0.601

MEAN SOLUBLE ORTHOPHOSPHATE CONCENTRATIONS

PO_4^{---} P mg L^{-1}	MEAN mg L^{-1}	SD mg L^{-1}	May mg L^{-1}	June mg L^{-1}	July mg L^{-1}	Aug mg L^{-1}	Jul-Aug Mean mg L^{-1}
Control	0.277	0.183	0.125	0.253	0.416	0.358	0.394
OM 1	0.425	0.435	0.196	0.363	0.666	0.544	0.619
OM 2	1.026	1.051	0.242	0.894	1.756	1.466	1.645
OM 3	0.291	0.297	0.124	0.213	0.495	0.400	0.458
OM 4	0.384	0.391	0.075	0.368	0.675	0.454	0.590
OM 5	0.175	0.179	0.065	0.079	0.361	0.296	0.336
L1	1.953	1.953	0.501	2.485	1.819	1.068	1.530
L2	0.720	0.720	0.000	0.800	0.731	0.546	0.604

associated with the single event lagoon discharge on June 20, 2002. Flow patterns suggested that the discharge from the lagoon outlet channel would fan into the marsh and raise the nutrient concentrations at O3 and O4 (Figure 1b). While this appears to be the case at the O4 site, O3 does not record similar elevated nutrient concentrations.

Ammonia ion concentrations recorded at the O3 site remained at the relatively undetectable background level of 0.01 mg L^{-1} following the June 20 discharge (Figure 2a). Samples taken at the O4 site, however, recorded a tenfold increase in the ammonia ion concentration (0.12 mg L^{-1}) following the discharge event (Figure 2a).

Soluble orthophosphate ion concentration illustrates a similar pattern. At the O3 sampling site, soluble phosphate concentrations rose sharply from the background level of 0.20 mg L^{-1} to 0.36 mg L^{-1} on June 20, 2002 (Figure 2b). During the next four days, the soluble orthophosphate ion concentrations decreased to background levels. Similarly, soluble phosphate concentrations recorded at the O4 site doubled during the release. Concentrations, however, increased during the following week, recording a maximum concentration on June 26 of 0.79 mg L^{-1} (Figure 2b).

The nutrient concentration pattern illustrated during the lagoon discharge release suggests that the lagoon discharge does not fan out into the marsh but effectively short-circuits a large segment of the marsh system and flows directly from the lagoon channel exit point to the South Lake outlet channel (Figure 1b).

Conclusions and Recommendations

The objective of this study was to assess the efficiency of Ominnik Marsh, a natural wetland, in the uptake of nutrients from agricultural runoff and municipal wastewater. Seasonal observations in the Ominnik Marsh wetland indicate that there is a successful uptake and reduction in nutrients during the spring freshet; that the conduit leading into the sewage lagoons is leaking; and that a significant area of the marsh is being "short-circuited" during the annual lagoon discharge release. It is suggested that the leaking inflow forcemain be replaced and that the lagoon discharge channel be re-engineered to enter the marsh at least 150 m east of the present locale.

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Relationships between NDVI and climatological variability in the Prairie ecozone of Canada

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Abstract: Seasonal characteristics of plants are closely related to characteristics of the annual cycle of weather patterns, therefore changes in plant phenological events may signal important year -to-year climatic variations or even global environmental changes. Monitoring ecosystems that are sensitive to climate change can improve our understanding of the relationships between climate and ecosystem dynamics. This improved understanding is critical for future land-use planning purposes. The objective of this paper was to examine relationships between Normalized Difference Vegetation Index (NDVI) and climatic data. Results showed that temperature and precipitation were correlated to NDVI, which was derived from the NOAA's Advanced Very High Resolution Radiometer (AVHRR). The Pearson correlation (r) was about 0.65 between NDVI and temperature, and the number is much lower for NDVI and precipitation (r=0.26). However , the relationships were increased when previous time periods were considered. The highest correlations occurred when mean of 20-day temperature and sum of 60-day precipitation were used (r=0.69 and 0.56 respectively). Comparing among ecoregions and land cover types, higher correlation between NDVI and climate variables occurred in the regions with higher NDVI values, such as the cropland woodland (r=0.86 with temperature and 0.50 with precipitation) and the Aspen Parkland (r=0.83 with temperature and 0.58 with precipitation). In addition, vegetation was strongly affected by climate variability in spring (April and May).

Introduction

Ecosystem processes include the exchange of water , energy, and greenhouse gases between the soil, vegetation, and the atmosphere. The ability to detect changes in ecosystem processes such as carbon fixation, nutrient cycling, net primary production, and litter decomposition is an important part of defining global biogeochemical cycles. Seasonal characteristics of plants are closely related to characteristics of the annual cycle of weather patterns, therefore, changes in plant phenological events may signal important year-to-year climatic variations or even global environmental change. Researchers have been focusing on large-scale changes in terrestrial ecosystems (*e.g.*, Dixon *et al.* 1994; Ojima *et al.* 1994; Lambin and Ehrlich 1997). It is accepted that at the global scale rapid environmental changes are mainly a result of climatic variations and anthropogenic activities. Environmental degradation is also associated with declines in primary productivity that alter biogeochemical exchanges between the earth and atmosphere (Running *et al.* 1994). Monitoring ecosystems that are sensitive to climate change can improve our understanding of the relationships between climate and ecosystem dynamics. This improved understanding is critical for future land-use planning purposes.

Recent advances in remote sensing technology and theory have expanded opportunities to characterize the seasonal and inter-annual dynamics of vegetation communities. Time series analysis of the National Oceanic and Atmospheric Administration's (NOAA) Advanced Very High Resolution Radiometer (AVHRR) 1-km multispectral imagery has allowed scientists to examine larger-scale phenological phenomena such as greenup, duration of green period, and onset of senescence (Reed *et al.* 1994), as well as change in seasonally-dependent biophysical variables such as leaf area index (LAI), biomass, and net primary productivity (Roller and Colwell 1986; Gallo and Eidenshink 1988; Achard and Brisco 1990; Teng 1990). Using time-integrated normalized difference vegetation index (NDVI) data, Yang *et al.* (1998) revealed that spatial and temporal variability in growing season precipitation, potential evapotranspiration, and growing degree days are the most important controls on grassland performance and productivity in the central and northern Great Plains. Wang *et al.* (2001) concluded that NDVI was more strongly related to precipitation than to temperature in the Great Plains of the USA.

Temperature increases over the last century within the Mixed Prairie ecosystem have been among the most dramatic in the world and have resulted in the droughts of the 1930s, 1961, the 1980s, and several others (Wheaton 2000). In southern Saskatchewan, 2001 and 2002 were two of the driest years in decades, causing severe crop damage (Hayward 2002). Anderson *et al.* (2001) concluded that the temperature in the prairie ecozone of Saskatchewan is expected to increase 3.5 ^{0}C to 4.0^{0}C in the next 50 years. Water availability will decrease because of increasing potential evapotranspiration even with increasing precipitation. Climate change will markedly alter the vegetation regime. Global warming may result in an advance of the northern boundary of C_4 species (Davidson and Csillag 2001) in the mixed prairie ecosystem. C_4 species have been defined as "Plants that use PEP carboxylase during initial carbon fixation to make a four-carbon compound that is subsequently transferred to specialized cells where carbon dioxide is internally released and refixed using rubisco" (Ziska and Bunce 1999). Southern Saskatchewan is the approximate northern boundary of C^4 species, and the boundary shifting will be a signal of climate change. From a study conducted by Mitchell and Csillag (2001), precipitation is the primary control factor for vegetation annual productivity in the mixed prairie ecosystem.

However, research into the relationship between vegetation phenology and climate variability has not been fully investigated. The objective of this paper is to examine relationships between NDVI and climate data, specifically for temperature and precipitation.

Study Area

The study area is southern Saskatchewan. This is bounded by 49^0 N latitude in the south, the Boreal forest ecozone in the north, and extends between longitudes 101.5^0 and 110^0 W (Fung 1999). The area falls within the prairie ecozone according to the ecological land classification developed in 1991 by the Ecological Stratification Working Group of the federal, provincial and territorial governments. This framework, primarily based on soil, climate and vegetation, comprises three levels of stratification, namely ecozone, ecoregion, and ecodistrict. Ecozone "lies at the top of the ecological hierarchy , and as such, it defines, on a subcontinental scale, the major physiographic features of the country", while ecoregion is defined as "subdivisions of the ecozone, characterized by distinctive climatic zones or regional landforms, and constitute the major bridge between the subcontinental scale ecozones and the more localized ecodistricts" (Acton *et al*. 1998, 3).

The prairie ecozone encompasses four ecoregions extending from the southwest corner of Cypress Upland northward to Mixed Grassland, Moist Mixed Grassland, and Aspen Parkland. The Cypress Upland was eliminated from this study because it has only three weather stations, which are not large enough to develop correlation or regression models. The prairie ecozone is dominated by a temperate climate with 1,800 growing degree-days and annual precipitation of 310 mm (Sauchyn and Beaudoin 1998). These dry conditions subside moving northward and eastward to the Aspen Parkland. Prior to European settlement, southern Saskatchewan was covered with natural vegetation, mixed prairie ecosystem. The natural grasslands are fragmented by settlement and agriculture. However, even in the most altered areas, there are pockets of native vegetation, which allow us to visualize the landscape as it was. Recently, human settlement and, in particular, agricultural development have been the predominant forces in the evolution of the Saskatchewan landscape (Fung 1999).

Methods

Canada-wide 1-km AVHRR 10-day composite maps were derived from NOAA AVHRR data by the Canadian Centre of Remote Sensing (CCRS) for the CCRS Northern Biosphere Observation and Modelling Experiment (NBIOME) project. NDVI, as a vegetation index, is a ratio of the difference between channels 2 (near-infrared wavelength region) and 1 (red wavelength region) to the sum of these two channels. It has the advantages of enhancing vegetation signals, reducing the effects of soil and other non-vegetation features, and standardizing the values. NDVI has been used as a greenness index for vegetation because the green vegetation has high near-infrared reflectance and low red reflectance. Bare soil or areas with low vegetation cover have low or negative NDVI values. During the vegetation growing cycle the NDVI value acts as an indicator of the density of chlorophyll on the ground and increases as the vegetation starts to green up. It reaches a maximum at the highest productivity level and starts to decrease as vegetation senesces. According to Acton *et al*. (1998), ecoregions were classified based on vegetation, climate, and soil. Therefore, the NDVI has the potential ability to signal the vegetation features of different ecoregions and provides valuable information as a remote sensing tool in studying vegetation phenology cycles at a regional scale. Multitemporal 10-day composite AVHRR data were obtained covering growing seasons (April 11 to October 21) of six years from 1993 to 1998 (data were obtained from Geogratis, *http://www.geogratis.gc.ca/* , Natural Resources Canada). NDVI values were derived for all weather stations (See Guo 2002 for details).

To reflect the land cover types, the digital Land Cover of Canada map (Cihlar *et al*. 1998) was clipped to the boundary of the Prairie Ecozone in southern Saskatchewan. Land cover type for each weather station was determined by laying the weather station layer over the land cover map. The five land cover types in the prairie region include: 1) grassland, land with herbaceous (non-woody) vegetation cover; the ground cover area of trees or shrubs is less than 10%; 2) medium biomass cropland, cropland dominated by crops with medium biomass, due to cover type or climate (subhumid); 3) low biomass cropland, cropland dominated by crops with lower biomass, due to cover type (e.g., grain) or climate (semiarid region); 4) cropland-woodland, mosaic land in which cropland is more prevalent

<table>
<tr><td></td><td></td><td colspan="5">MT5 - mean temperature of 20 days</td></tr>
<tr><td></td><td></td><td></td><td colspan="4">MT4 - mean temperature of 20 days</td></tr>
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<tr><td>10-day</td><td>10-day</td><td>10-day</td><td>10-day</td><td>10-day</td><td>10-day</td><td>NDVI (10-day composite)</td></tr>
<tr><td>P7</td><td>P6</td><td>P5</td><td>P4</td><td>P3</td><td>P2</td><td>P1 - precipitation (10-day total)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">SP2 - total precipitation for 20 days</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">SP3 - total precipitation for 30 days</td></tr>
<tr><td></td><td></td><td></td><td colspan="4">SP4 - total precipitation for 40 days</td></tr>
<tr><td></td><td></td><td colspan="5">SP5 - total precipitation for 50 days</td></tr>
<tr><td></td><td colspan="6">SP6 - total precipitation for 60 days</td></tr>
<tr><td colspan="7">SP7 - total precipitation for 70 days</td></tr>
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Figure 1: *Variables used in analyses include NDVI, temperature (T), and precipitation (P) from 10-day period when NDVI was derived to previous six 10-day periods.*

than forest cover (mostly broadleaf deciduous forest); and 5) woodland-cropland, mosaic land in which tree cover (mostly broadleaf deciduous species) and shrubs are more prevalent than cropland.

Historical climate data including daily temperature and precipitation were obtained from Environment Canada.Among 2,225 weather stations in Saskatchewan, 141 active weather stations in the prairie ecozone during the 1993 to 1998 period were selected for analysis. Climate data were processed to a 10-day period of total precipitation and mean temperature to match 10-day NDVI values for each weather station. There were 36 10-day periods each year, and this resulted in 216 10-day periods over the six years. Temperatures were averaged with values from previous 10-day 30-day, and 40-day temperatures. Similarly, precipitation was also summed with values from previous 10-day, 20-day, 30-day, 40-day, 50-day, 60-day periods. These variables are illustrated in Figure 1.

Statistical analyses were performed on the dataset described above; including climate and NDVI data, on different ecoregions and land cover types. Pearson Bivariate Correlation analysis was conducted to test the relationship between NDVI and climate variables. Since the correlation analysis can't provide the magnitude of the relationship, a stepwise multiple regression analysis was further performed to test how well the NDVI variance can be explained by climate variables as well as the most significant climate variables contributed to NDVI's variability (Clark and Hosking 1985). To validate models derived by the linear regression analysis, adjusted R^2 was used because it "estimates how much variance on y [NDVI] would be accounted for if we had derived the prediction equation in the population from which the sample was drawn" (S tevens 1996:96). Among these analyses, the relationships between NDVI and climate variables were also tested for temperature and precipitation considering previous periods up to 60 days earlier. Based on the knowledge that spring is a critical time for the prairie region and the climate change has occurred significantly in spring, a further regression analysis was tested on monthly basis for different ecoregions.

Results

NDVI, Temperature, and Precipitation Variations:

The mean NDVI, temperature, and precipitation for the study area were plotted along a six-year time series (Figure 2). The graph was able to visually show that the maximum NDVI values changed from one year to another. From Figure 2, the general pattern of NDVI responds to the pattern of temperature well and is also related with previous year's precipitation. The highest maximum NDVI occurred in 1996 following a wet year of 1995, and the lowest maximum NDVI was in 1995 with a dry year of 1994 in advance. However, with the large study area, the climate influences on vegetation may differ on different ecoregions or land covers. Therefore, a simple mean for the whole area is not representative, and further evaluation is necessary.

Correlation Between NDVI and Climate Variables:

Pearson's product-moment correlation analysis results revealed that temperature was more strongly correlated with NDVI than precipitation (Table 1). When the correlation analysis was performed for all weather stations, the correlation coefficient (r) was 0.26 between NDVI and precipitation and 0.65 between NDVI and temperature; however, for precipitation, the correlation coefficient was increased when previous 10-day periods were used in the analysis. For example, the r value was 0.31 for the relationship between NDVI and the first previous 10-day precipitation, and it was 0.33 when the second previous 10-day period precipitation was used in the analysis. When the analysis was performed for multiple time periods, the highest correlation for temperature was the mean temperature from the first two 10-day periods (r=0.69), while the highest correlation for precipitation occurred when two-month's total precipitation was used in the analysis (r=0.56).

When the dataset was stratified into ecoregions or land cover types, the r values were increased for most categories. The correlation between NDVI and temperature was 0.82 and the number was 0.32 for precipitation for Cropland Woodland land cover type, and 0.76 and 0.29 for temperature and precipitation respectively for Medium Biomass Cropland land cover

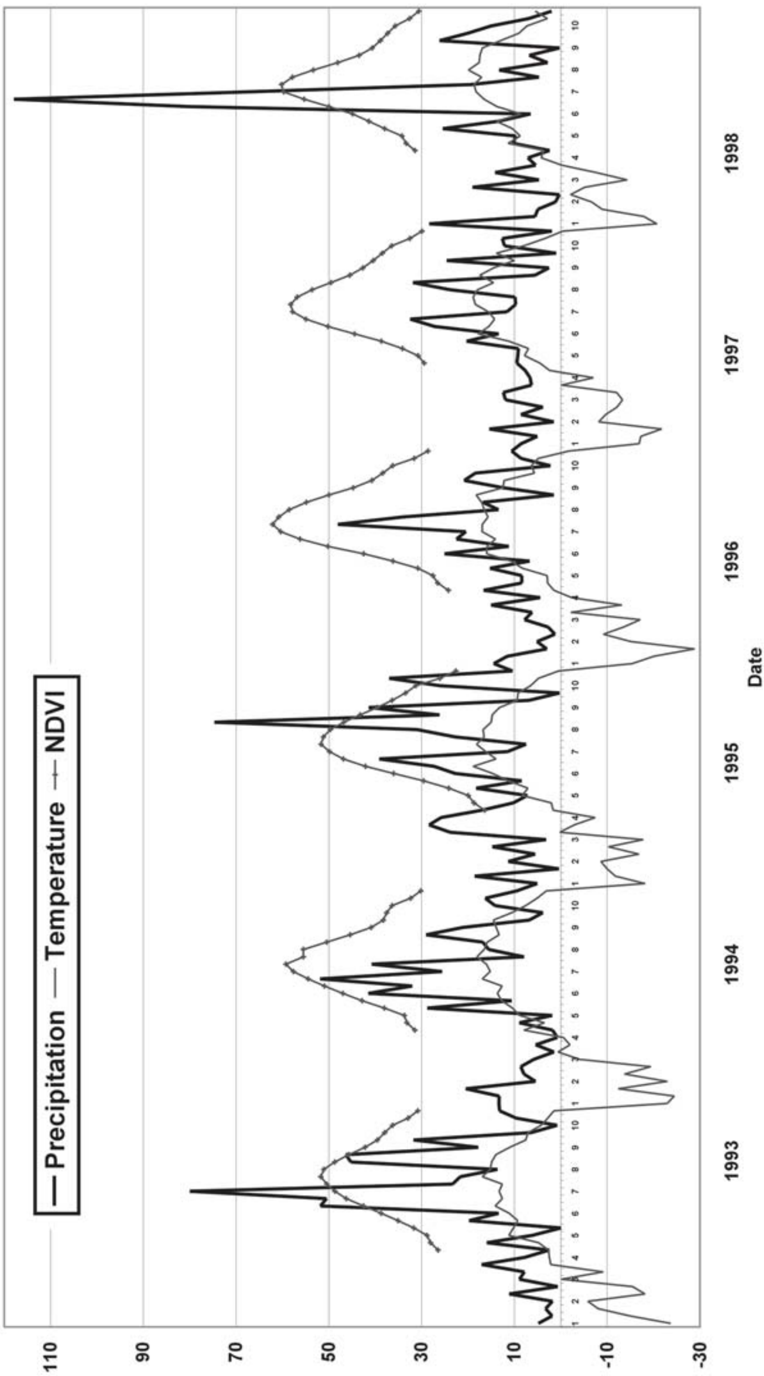

Figure 2: *Overall patterns of NDVI (after multiple 100), temperature (degree Celsius), and precipitation (mm) over six years (1993-1998).*

Table 1: *Correlation coefficient (r) values between NDVI and climate variables.*

Climate Variables		All Sites		Land Cover										Ecoregions					
				Grassland		Low Biomass Cropland		Medium Biomass Cropland		Woodland Cropland		Cropland Woodland		Mixed Grassland		Moist Mixed Grassland		Aspen Parkland	
		n	r	n	r	n	r	n	r	n	r	n	r	n	r	n	r	n	r
10-day precipitation	P1	9174	.263**	767	.220**	3716	.196**	3023	.291**	1320	.293**	348	.317**	3129	.181**	1708	.209**	3986	.300**
	P2	9163	.312**	766	.242**	3711	.273**	3021	.335**	1318	.340**	347	**.321****	3125	.246**	1705	.289**	3983	.342**
	P3	9146	**.330****	764	.237**	3706	.309**	3018	**.349****	1312	**.366****	346	.313**	3119	.270**	1702	.328**	3976	**.361****
	P4	9128	.323**	762	**.258****	3701	**.330****	3015	.322**	1305	.331**	345	.266**	3113	**.299****	1699	**.342****	3968	.326**
	P5	9110	.263**	760	.212**	3696	.276**	3012	.253**	1298	.255**	344	.195**	3107	.249**	1696	.289**	3960	.252**
	P6	9090	.193**	758	.212**	3689	.209**	3009	.168**	1291	.158**	343	.120*	3101	.201**	1692	.220**	3951	.156**
	P7	9070	.115**	756	.138**	3682	.139**	3006	.077**	1284	.066*	342	0.063	3095	.135**	1688	.133**	3942	.065**
Precipitation of longer periods	SP1	9163	.374**	766	.299**	3711	.311**	3021	.406**	1318	.412**	347	.393**	3125	.280**	1705	.336**	3983	.416**
	SP2	9146	.455**	764	.350**	3706	.399**	3018	.489**	1312	.502**	346	.451**	3119	.354**	1702	.435**	3976	.500**
	SP3	9128	.519**	762	.402**	3701	.478**	3015	.548**	1305	.564**	345	.486**	3113	.425**	1699	.520**	3968	.558**
	SP4	9110	.550**	760	.431**	3696	.518**	3012	**.577****	1298	**.589****	344	**.495****	3107	.462**	1696	.565**	3960	**.582****
	SP5	9090	**.556****	758	**.454****	3689	**.532****	3009	.574**	1291	.583**	343	.485**	3101	**.480****	1692	**.580****	3951	.574**
	SP6	9070	.539**	756	.454**	3682	.524**	3006	.545**	1284	.550**	342	.464**	3095	.477**	1688	.567**	3942	.540**
10-day temperature	T1	7431	**.651****	767	**.526****	3002	.684**	2351	.761**	963	.718**	348	**.820****	2534	**.632****	1470	**.717****	3076	.780**
	T2	7420	.650**	766	.495**	2997	.678**	2349	**.769****	961	**.726****	347	.809**	2530	.608**	1467	**.717****	3073	**.792****
	T3	7403	.575**	764	.407**	2992	.595**	2346	.690**	955	.652**	346	.714**	2524	.517**	1464	.635**	3066	.714**
	T4	7385	.482**	762	.309**	2987	.494**	2343	.594**	948	.554**	345	.598**	2518	.412**	1461	.534**	3058	.618**
	T5	7367	.411**	760	.245**	2982	.424**	2340	.509**	941	.469**	344	.513**	2512	.346**	1458	.457**	3050	.531**
Temperature of longer periods	MT1	7420	**.685****	766	**.537****	2997	**.716****	2349	**.808****	961	**.760****	347	**.857****	2530	**.652****	1467	**.754****	3073	**.829****
	MT2	7403	.678**	764	.515**	2992	.708**	2346	.804**	955	.758**	346	.844**	2524	.635**	1464	.748**	3066	.828**
	MT3	7385	.651**	762	.477**	2987	.678**	2343	.778**	948	.732**	345	.809**	2518	.601**	1461	.719**	3058	.803**
	MT4	7367	.611**	760	.432**	2982	.637**	2340	.734**	941	.690**	344	.757**	2512	.557**	1458	.675**	3050	.759**

Note: Numbers with ** are significant at 0.01 level; numbers with * are significant at 0.05 level.
Please refer to figure 1 for definitions of climate variables.
Numbers in bold showing the highest r value in each climate variable group.

type. For ecoregions, Aspen Parkland had the numbers of 0.78 and 0.30 for temperature and precipitation respectively . When the analysis was performed using individual 10-day period back to two months before the NDVI data, the highest correlation between NDVI and temperature was either for the same time period or 10 days earlier The highest correlation coefficient between NDVI and the first previous 10-day mean temperature was 0.79 for Aspen Parkland, and the highest number was 0.53 for grassland when the same time period was used. For precipitation variables, there was at least a 10-day lag for the highest relationship. NDVI was most highly correlated with the third previous 10-day precipitation with r of 0.34, and it was 0.32 between the NDVI and the first previous 10-day precipitation for Cropland Woodland land cover. The highest correlation (r=0.86) between NDVI and temperature was for the Cropland Woodland land cover when the mean temperature of the first two 10-day periods was used, and the highest correlation (r=0.59) for precipitation occurred when the 40-day total precipitation was included for the Woodland Cropland land cover.

Nevertheless, Table 1 shows a confusing result regarding the significance level and r values. Even though nearly all results were significant at the 0.01-level, r values were relatively low , ranging from 0.15 to 0.83. This is caused by a large sample size (Table 1). Significance and r value are two aspects of the correlation analysis. The significance shows a confidence level, while r value is a magnitude of the relationship. If two variables show a correlation significant at the 0.01 level, it means that the probability of the result by chance is lower than 1%. A stronger relationship between two variables will be indicated by a higher r value, however, both are influenced by sample size. As the number of samples increases, the significance of a result increases and the probability of the result being by chance decreases (Rummel 1976). Practically, the results of this study have high confidence, and the relationship revealed above caused by chance is very low.

Regression results:

Table 2 shows the regression analysis results between NDVI and climate variables when the stepwise multivariate regression method was used and only the first two entered variables were selected to develop the models. When all weather stations were used to build the model, the mean temperature (MT2) calculated from the same time period of NDVI and the first previous 10-day period temperature gave the highest ability to predict the NDVI variable (that is, it entered the model first). The next climate variable that showed a high ability to predict NDVI was the total precipitation, from the previous two months.These two variables explained

Table 2: *Regression analysis results between NDVI and climate variables.*

Land Cover category		Adjusted R^2	F	Predictors
All sites		0.55	4473.1	MT2, SP5
Land Cover	Grassland	0.33	189.6	MT2, SP6
	Low Biomass	0.58	2028.3	MT2, SP5
	Medium Biomass	0.7	2682	MT2, SP4
	Woodland Cropland	0.65	848.4	MT2, SP5
	Cropland Woodland	0.77	571.6	MT2, SP4
Ecoregion	Mixed Grassland	0.48	1160.8	MT2, SP5
	Moist Mixed Grassland	0.63	1215.7	MT2, SP5
	Aspen Parkland	0.73	4055.8	MT2, SP4

Note: Please refer to figure 1 for definitions of climate variables.

55% of the NDVI variance. When comparing the ecoregions, NDVI for the Aspen Parkland could be explained by the mean temperature combined with the first previous 10-day period value (MT2) and the total precipitation for 40 days (SP4) with R^2 of 73%, and the Mixed Grassland could only be explained by 20-day mean temperature (MT2) and 50-day total precipitation (SP5) with R^2 of 48%. For different land cover types, the adjusted R^2 values were not as high as for the ecoregions, but the trends were the same; the higher the NDVI number, the higher the adjusted R^2 value. The highest adjusted R^2 value was 0.77 for cropland woodland with 20-day mean temperature and 40-day total precipitation as independent variables, and the lowest 0.33 for grassland with 20-day mean temperature and 50-day total precipitation as predictors.

NDVI is affected by climate variability differently at different stages of the growing season (Table 3). Climate variability could explain about half of the NDVI variance in early spring (April). The adjusted R^2 are 0.57, 0.50, and 0.69 for the Mixed Grassland, Moist Mixed Grassland, and Aspen Parkland ecoregions respectively. For Aspen Parkland, climate variables were key factors of NDVI changes until June, while the climate influence was decreasing as the location moved south and the season changed to summer. Temperature was always the key factor, especially a 20-day mean temperature. Longer periods of precipitation could affect vegetation through soil moisture availability, especially in spring. With the fact that temperature has increased in spring, global warming may benefit vegetation on the prairies since temperature is a key factor for vegetation in this region. However, this conclusion should be treated with caution, as further study needs to be developed to investigate how precipitation will be changed as temperature increases and what the threshold will be for vegetation response to precipitation.

Table 3: *Regression analysis results showing monthly influence of climate variables on NDVI of three ecoregions of the prairie ecozone.*

Month	Model	Mixed Grassland Adjusted R^2	Moist Mixed Grassland Adjusted R^2	Aspen Parkland Adjusted R^2
April	1	0.51	0.42	0.54
	2	0.57	0.47	0.67
	3	0.57	0.50	0.68
	4			0.69
	5			0.69
	Variables entered	MT1,MT4,P6	MT1,MT4,P1	MT1,SP4,SP2,SP5,MT3
May	1	0.25	0.31	0.47
	2	0.29	0.34	0.57
	3	0.30	0.35	0.60
	4	0.31	0.37	0.61
	Variables entered	MT3,P5,P2,P6	MT3,P5,P2,P6	MT3,SP6,SP3,P3
June	1	0.11	0.33	0.44
	2	0.16	0.46	0.48
	3		0.48	0.53
	4			0.54
	5			0.55
	6			0.56
	Variables entered	MT4,SP5	SP4,MT4,MT1	MT4,SP1,P6,T3,SP6,T4
July	1	0.03	0.13	0.19
	2	0.05	0.21	0.20
	3		0.25	0.21
	4		0.28	0.22
	5		0.29	
	Variables entered	MT1,SP6	MT1,SP6,SP2,P6,MT3	T2,MT2,P5,P7
August	1	0.11	0.09	0.08
	2	0.14	0.25	0.12
	3	0.17	0.28	0.17
	4	0.18	0.30	0.19
	5	0.19	0.31	0.20
	6			0.20
	7			0.21
	Variables entered	T5,P4,MT1,T3,P5	SP1,SP5,T5,T1,T3	P7,T3,P3,MT1,P2
September	1	0.04	0.07	0.17
	2	0.05	0.12	0.23
	3	0.06	0.13	0.24
	4	0.07		0.25
	5	0.08		
	6	0.09		
	Variables entered	P7,P6,T1,T4,T5,T3	P7,SP2,SP6	T2,SP6,T5,T3
October	1	0.13	0.16	0.33
	2	0.14	0.19	0.39
	3		0.22	0.47
	4			0.49
	Variables entered	T1,T4	MT4,SP1,P3	MT4,SP1,SP3,MT2

Discussion and Conclusion

The study has shown that the NDVI values of vegetation varied over years. The NDVI was correlated with temperature and precipitation; however, temperature showed higher correlation with NDVI compared to precipitation. This results conflict with those obtained byWang *et al*. (2001) for the central Great Plains, which showed NDVI had higher correlation with precipitation. The reason for this may be that the present study area is further north then that used by Wang *et al*. and is more influenced by temperature. The results seem to conflict with another study by Mitchell and Csillag (2001). In their study, they concluded that precipitation was the critical variable for vegetation in the mixed prairie ecosystem. In this study, only the general correlation and regression between NDVI and climate variables were compared, and a more detailed study should be conducted to reveal how precipitation is critical, what time of year is more important for precipitation, as well as which vegetation type is more sensitive to precipitation.

This study's results also showed that the relationship between NDVI and precipitation became stronger when previous time periods were included in the model. The fact that there was a lag for the highest relationship between NDVI and precipitation means that current precipitation could influence vegetation two months later or that the influence only 'kicks in' after extended accumulation of precipitation. Two factors may contribute to this phenomenon, 1) there is a lag time from vegetation absorbing water to photosynthesis taking place, and 2) soil acts as a reservoir that regulates soil moisture content in a certain period.

Comparing ecoregions, climate variables were highly related with NDVI of the Aspen Parkland (r=0.83 and 0.58 for temperature and precipitation respectively), and NDVI from the Mixed Grassland showed the weakest relationships with climate variables (r=0.75 and 0.58 for temperature and precipitation respectively). Among land cover types, Cropland Woodland had the highest correlation coeficients between NDVI and climate variables (r=0.86 and 0.50 for temperature and precipitation respectively) and grassland had the lowest correlations between NDVI and climate variables (r=0.54 and 0.45 for temperature and precipitation respectively). This is because for land cover types with lower vegetation, especially grassland, other factors such as bare soil and dead grasses contribute to the signal intercepted by the satellite sensor, while the NDVI is an indicator of greenness.

Comparing two land cover classification systems, ecoregions showed better relationships between NDVI and climate variables compared to the relationships for land cover types. The weaker relationships with land cover types are probably caused by the fact that this is a nation-wide classification map and it was focused more on the boreal forest region, while the ecoregion classification was for Saskatchewan only , which promised a more accurate result regarding the consideration of vegetation, climate, and soil. Moreover, the ecoregion map does not account for current land use (e.g., grassland vs. cropland). The land classification derived by the Saskatchewan Research Council using Landsat in the late 90's should show better results because of its higher spatial resolution and more classes.

However, the more land cover types there are, the fewer weather stations there are in each category. Therefore, it may be less accurate.

Several limitations of this study restricted further explanation of the analysis results. First, only mean temperature and precipitation were considered in the data analysis. The maximum temperature, minimum temperature, and growing degree days may be more closely related with vegetation. Additionally, the Palmer Drought Severity Index and the ratio of precipitation to potential evapotranspiration, which combine temperature and precipitation, should be investigated, especially for the prairie region. Indeed, these variables are being processed and will be used in a study associated with the Moderate Resolution Imaging Spectroradiometer (MODIS) data. Second, the influence of climate variability on vegetation green-up and senescent stages couldn' t be investigated because of the dataset downloaded is only fromApril 11 to October 21. Instead, with the monthly regression analysis, the impact of climate data on dif ferent vegetation stages was investigated even though it is not specific on how climate affect the time of vegetation onset of greenness. Finallythe dataset is only for a six-year period, which is not long enough to detect climate change. In addition, the yearly climate variability is also influenced by El Niño events, which was not discussed in this paper while 1998 was an El Niño year. This paper revealed that vegetation is positively responsible with climate variability, and satellite, through vegetation indices (e.g., NDVI), could be used for climate change study.

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Development of a Landowner's Riparian Health Index (LORHI): a case study in the Broughtons Creek watershed

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Abstract: An index is a readily obtainable measurement that depicts a variable or process which itself is not easily measured.The Landowners' Riparian Health Index (LORHI) is founded on fundamental riparian parameters, is easily evaluated and cost eficient. The LORHI is calculated as the product of the riparian buffer width parameter and the vegetation diversity parameter within the riparian buffer zone. Landowners or tenants can evaluate the riparian buffer on their land by responding to a one-page questionnaire. Using the LO RHI, conservation district managers and landowners can identify problematic and unhealthy reaches and concentrate remedial actions in these areas. The Landowners Riparian Health Index was estimated for 22 reaches (44 banks) along the main stem of Broughtons Creek in the Little Saskatchewan River watershed. Results indicate that 50 percent of the channel length has a riparian health problem. Sixty-four percent of the problematic and unhealthy banks are unfenced pasturelands (classified as Unhealthy) that could be upgraded by the fencing out of livestock. Rehabilitation of the vegetal diversity (often, simply the seeding of bare ground) will result in an additional upgrading.

Introduction

A riparian zone is defined as the aquatic ecosystem and the portions of the adjacent terrestrial ecosystem that directly affect or are affected by the aquatic environment (Gregory and Ashkenas 1990). This includes streams, rivers, and lakes and their adjacent side channels, floodplains and wetlands. The riparian area also includes portions of hill slope that serve as streamside habitats for wildlife (Gregory and Ashkenas 1990).

Consequently, riparian areas are hosts to complex ecological units representing niche specific habitats of various avian, terrestrial and aquatic fauna. The vegetal growth in the riparian zone retards excessive erosion, traps sediment, adsorbs a variety of pollutants and attenuates floods.

There are many riparian classifications, most of which are prepared by and for government agencies. Riparian health classifications are applied to urban riparian zones, agricultural riparian environments or forest riparian areas. Generally, riparian classification systems, guidebooks and field notes are associated with a specific geographical area and are structured towards specific study requirements. For example, the field book "Caring for the Green Zone: Riparian Health Assessment for Small Streams and Small Rivers" (Fitch et al. 2001) has been published for an audience of livestock producers, landowners, and resource managers in southern Alberta. The "Alberta Lotic Wetland Health Assessment For Streams and Small Rivers" is designed to assist land managers in setting management priorities and stratifying riparian sites in Southern Alberta (Lotic Health 2001). Another riparian evaluation, the "Specification Riparian Forest Buffer," is used by the U.S. Forest Service to monitor riparian areas such as in the Willamette National Forest, Oregon. This classification system is concerned with landuse conflicts (Welsch 1991). Other classifications, such as the "Watershed Restoration Program" (Hogan et al. 1996) and the "Forest Practices Code of British Columbia" address the restoration, protection and maintenance of fish, aquatic and forest resources which have been negatively affected by forest harvesting practices (Oikos and Johnson 1996). However, there are few, if any, riparian health classifications that encourage the agricultural landowner to assess the riparian health of their stream frontage without requiring a minimal level of technical expertise.

Objective of the Study:

The objective of this study was to develop a landowners' riparian classification system that can be used by landowners and watershed managers to evaluate and monitor the health of riparian zones in prairie agricultural watersheds.

Riparian Health Assessment

Fitch et al. (2001) define riparian health as the ability of a reach, the entire stream or a watershed composed of many streams, to perform a number of key ecological functions. A healthy riparian ecosystem is characterized by natural processes such as flooding, erosion and deposition, vegetation succession, herb ivory and deciduous leaf fall interacting to create a dynamic system of exceptional natural diversity that is sustainable (Tighem 1995). The health of a riparian area can be assessed by the vitality and productivity of the vegetation in the buf fer zone, that area adjacent and including the stream channel (Fitch et al. 2001).

Riparian Buffer Width Assessment

Most riparian classification schemes acknowledge buf fer width, corridor width or leave strips as a critical parameter in assessing riparian health (Gregory and Ashkenas 1990, Chilibeck et al. 1993 and Castelle et al. 1994). Buffer width significantly impacts the effectiveness of sediment entrapment, erosion control, and habitat cover (Welsch 1991). Without a buffer, the vegetal diversity in the buffer zone need not be considered.

Most riparian classifications define buf fer width as the minimum distance measured normal (at right angles) to the stream from the water edge to the observed area of disturbed vegetation on either the right or left bank. Consequently, buffer width becomes a minimum value dependent upon the left or right bank conditions and riparian health parameters located on the opposite bank are ignored. Buf fer width will differ according to type of vegetation, slope, landuse, soil and hydrologic conditions.

Castelle et al. (1994) and O'Laughlin and Belt (1995) found that buffer width varied from 3 to 200 m, depending on the effectiveness for different functions. Peterjohn and Correll (1984) found that nitrogen and phosphorous nutrient concentrations in surface runoff in agricultural areas were reduced by 75 percent when passing through a 19 m agricultural-forest buffer. Welsch (1991) determined a minimum buf fer width in a forested environment by assessing the soil hydrologic groups, slope distance from the bank to the disturbed vegetation and soil capability class. Welsch (1991) recommends a minimum buffer width of 75 ft. (23 m) for the forested environment. The Department of Fisheries and Oceans (DFO 1996) suggest that the riparian buf fer width be a minimum of 15 m on both sides of the stream to protect fish and fish habitat and the Canadian Wildlife Service guideline (Environment Canada 2000), indicates that streams should have a 30 m wide naturally vegetated buffer on both sides. Both the Department of Fisheries and the Environment Canada buf fer width recommendations are incorporated in the Landowners' Riparian Health Index.

Vegetal Diversity Assessment

The diversity and distribution of vegetation in the riparian buffer is recognized as a significant parameter to the health of the riparian zone (Tighem 1996). The variety of species of trees, shrubs, and grasses is an indication of vegetal diversification. Percentage cover is indicative of abundance. Environment Canada (2000) recommends that a healthy riparian zone have a total buffer width of 60 m and that 75% of the stream length be naturally vegetated.

The Landowners' Riparian Health Index

An index is a readily obtainable measurement that depicts a variable or process which itself is not easily measured.The Landowners' Riparian Health Index (LORHI) is founded on fundamental riparian parameters, is easily evaluated and cost efficient. The LORHI is calculated as the product of the riparian buffer width parameter and the vegetal diversity parameter within the riparian buffer zone. The evaluation process can be initiated in the coffee shop or over the phone and ultimately gather information that is useful to the landowner , watershed manager and other researchers. Consequently the LOHRI is a subjective evaluation of riparian health based on informal observation of two fundamental riparian parameters.

Operational Definition of Riparian Buffer Width:

The operational definition of buffer width for the LORHI considers both the left and right banks of the stream. Consequently each sample reach will have a left and a right bank buffer width value. Buffer width (metres or feet) is measured or estimated normal to the stream, from the waters edge to an observed area of vegetation disturbance (i.e. the edge of the field or pasture). The minimum width is assigned a score according to the length (distance) measured. The optimum buffer width is greater than 30 metres or 100 feet (Environment Canada standard), which receives a ranked score of 5 out of 5. Other buffer widths are grouped as: 15 m to 29 m (the DFO recommendation for a healthy fishery), 10 m to 14 m (an intermediate width less than the DFO recommendation), 3 m to 9 m (a narrow buffer), and less than 3 m (effectively, no riparian buffer). The associated ranked scoring is 4, 3, 2, and 1 respectively.

Operational Definition of Vegetal Diversity in the Buffer Zone:

The operational definition of vegetal diversity in the riparian buffer considers grasses and emergent aquatic vegetation, trees and shrubs. The resulting parameter is the sum of the estimated frequency of trees, frequency of shrubs, and percentage of bare ground in the riparian buffer.

Grasses and emergent aquatic vegetation trap sediment and acquire nutrients, control erosion and provide faunal habitat. Rather than estimate percentage grass cover, the LOHRI assesses percentage bare ground present in a 20 m (65 feet) length of reach. Four subjective groupings are possible: no bare ground; the occasional small spot of bare ground (up to 5%); a few patches of bare ground (6%-20%); prominent large patches of unvegetated ground (over 20%). The associated ranked scores are 4, 3, 2 and 1, respectively.

In evaluating tree and shrub diversity, the actual species and percentage cover is not as important as the number of individual trees or shrubs. Therefore, identifying species and percentage cover is not required. The landowner need only identify individual trees and shrubs present in a 20 m (65 foot) length of the buffer width. Both the left and right bank is evaluated. Trees taller than the observer (greater than 1.78 m / 5' 10") within a 20 m (65 foot) length of riparian buffer are counted and placed into the following groups: zero trees; 1 or 2 trees (the occasional tree); 3 to 10 trees (some trees); and more than 10 trees (a wooded riparian buffer). These groups are given ranked scores of 1, 2, 3 and 4 respectively.

Shrubs and shrub elements (clusters) shorter than the observer (less than 1.78 m / 5' 10") are evaluated and grouped into the following categories: zero shrubs; 1 or 2 shrubs or clusters of shrubs (the occasional bush); 3 to 10 shrubs (some shrubs); and more than 10 shrubs or clusters of shrubs (a bushy riparian buffer). The respective ranked scores are 1, 2, 3 and 4.

The vegetal diversity score is the sum of the bare ground cover score, the trees score and the shrubs score. The maximum vegetal diversity score is 12 (4+4+4); the minimum value is 3 (1+1+1).

Calculation and the Evaluation of the LORHI:

The LORHI is defined as the product of the buffer width score and the vegetation diversity score. The highest possible score is 60 and the lowest is 3. Figure 1 summarizes the possible LORHI values and indicates five states of riparian health. The classification system is rationalized by the following.

An ideal riparian zone (index values of 41-60) must have the Environment Canada recommended buffer width of greater than 30 m (100 feet) and a minimum vegetal diversity score of 9. That is no bare ground, and some trees and shrubs. If the riparian zone displays ideal vegetal diversity (scores of 11 or 12), the Department of Fisheries 15-29

Buffer Width	> 30 m	29 - 15 m	14 - 10 m	9 - 3 m	< 3 m
Buffer Width Score	5	4	3	2	1
Vegetal Diversity Scores					
T + S + G = 3	15	12	9	6	3
T + S + G = 4	20	16	12	8	4
T + S + G = 5	25	20	15	10	5
T + S + G = 6	30	24	18	12	6
T + S + G = 7	35	28	21	14	7
T + S + G = 8	40	32	24	16	8
T + S + G = 9	45	36	27	18	9
T + S + G = 10	50	40	30	20	10
T + S + G = 11	55	44	33	22	11
T + S + G = 12	60	48	36	24	12

Ideal Riparian Zones
Healthy Riparian Zones
Adequate Riparian Zones
Problematic Riparian Zones
Unhealthy Riparian Zones

Figure 1: *Categorized Landowners' Riparian Health Index values.*

m buffer width can result in an ideal riparian zone classification (Figure 1).

The healthy riparian zone (index values of 31-40) will have a buffer width of at least 15 m (Department of Fisheries recommendation) and a vegetal diversity score of 8-10, indicating that at least two of the three vegetation categories score a 3 or better If the buffer width exceeds 30 m (100 feet) a vegetal diversity score of 7 can result in a healthy riparian zone. If the vegetal diversity is ideal (scores of 11 or 12) a narrower riparian buffer (10-14 m) can also result in a healthy classification (Figure 1).

The adequate riparian classification (index values of 21-30) combines a variety of buffer widths from 3-30 m (10-100 feet) with compensating vegetal diversity scores (Figure 1). That is, ideal vegetal diversity (11 or 12) with the narrower buffer widths and the moderate vegetal diversity (scores of 5 to 7) with significantly wider buffers.

Problematic riparian zones (index values of 13-20) display a poor combination of buffer width and vegetal diversity. For example, moderate vegetal diversity and narrow buffers or a wider buffer zone and poor vegetal diversity (Figure 1).

Riparian buffer widths less than 3 m (10 feet) represent unhealthy riparian environments regardless of vegetal diversity (Figure 1). Buffer widths less than 10 m (32 feet) with poor vegetal diversity (scores of 3 or 6) are classified as unhealthy as is the slightly wider buffer of 10-14 m (32-45 feet) combined with a vegetal diversity score of 3 or 4 (virtually no vegetation). The unhealthy riparian zone generally has an index value of 12 or less.

Case Study: Broughtons Creek Watershed

Study Area:

Broughtons Creek watershed is located in south-western Manitoba on the Assiniboine River Plain in the rural municipality of Blanshard (NTS 62/K1 and 62/K8) (Figure 2). Specifically, parts of Township13, Ranges 20 and 21, and parts of Townships 14 and 15, Ranges 21 and 22. The town of Cardale is centrally located in the watershed (Figure 3).

Broughtons Creek watershed covers an area of approximately 265 km^2 (102.6 mi.^{2}) (Figure 3). The drainage basin can be classified according to the Horton/Strahler system as a third order basin. The Shreve number (determined from the blue line data on the 1:50,000 topographic map) is calculated to be 27, indicating that Broughtons Creek has 27 tributaries, 14 source catchments and 13 interfluves.

The drainage basin extends from its headwaters located near the Blanschard/Strathclair municipal boundary, approximately 30 km (18.75 mi.) southeast to the Broughtons Creek outlet in Airplane Bay, Lake Wahtopanah (Rivers Reservoir) (Figure 3). The basin length, measured along a medial line extending from the mouth of Broughtons Creek northwest through the town of Cardale to a point located on the watershed divide approximately 2.6 km (1.0 mile) south of the southern extent of the rural municipality of Strathclair, is estimated to be 30 km (18.75 mi).The drainage basin is approximately 15.75 km (9.8 mi.) wide in the headwater region near the Blanschard/Strathclair municipal boundary and 11.2 km (7.0 mi.) wide at the mid-point along the basin length medial line (6.0 km (2.3 mi.) southeast of Cardale. The maximum elevation along the

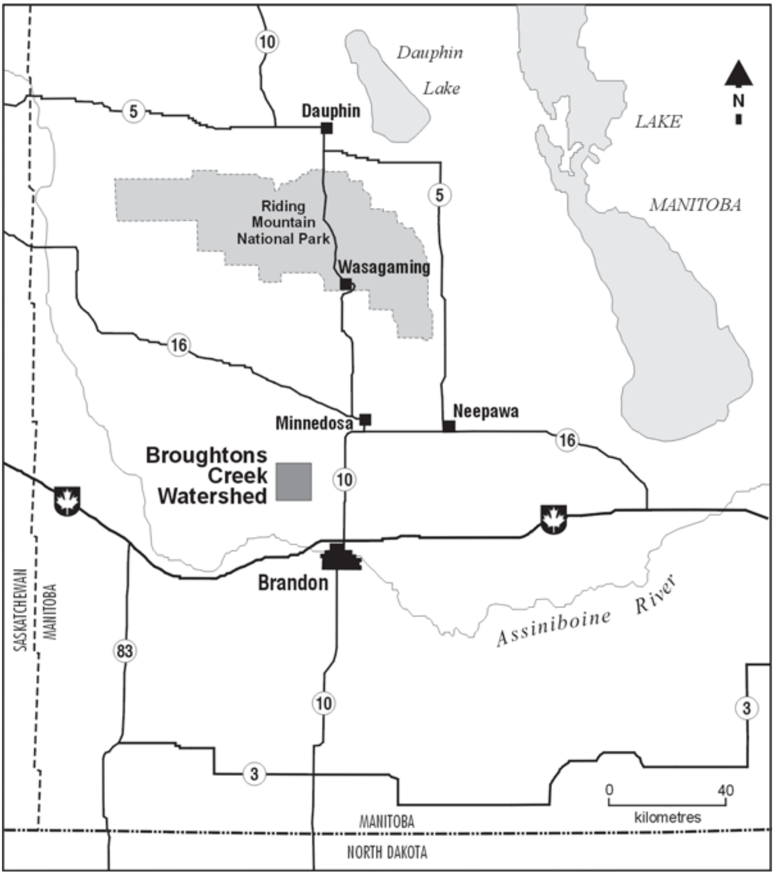

Figure 2: *General location of Broughtons Creek Watershed.*

watershed divide is estimated to be slightly greater than 600 m (1968 ft) and water levels on Lake Wahtopanah average 470 m (1541 ft.) a.s.l. Consequently, the relative relief for the watershed is calculated to be 135 m or 472 ft. The basin slope, defined as the ratio of basin relative relief to basin length, is calculated to be 0.0045, that is 4.5 m per kilometre (25 ft. per mi).

Broughtons Creek is an intermittent tributary stream of the Little Saskatchewan River that discharges into Lake Wahtopanah, a reservoir in the Little Saskatchewan River. The main stem of Broughtons Creek traverses a hummocky till plain with an average relief less than 3 m (10 feet). The area is predominately agricultural. Prairie sloughs appear to

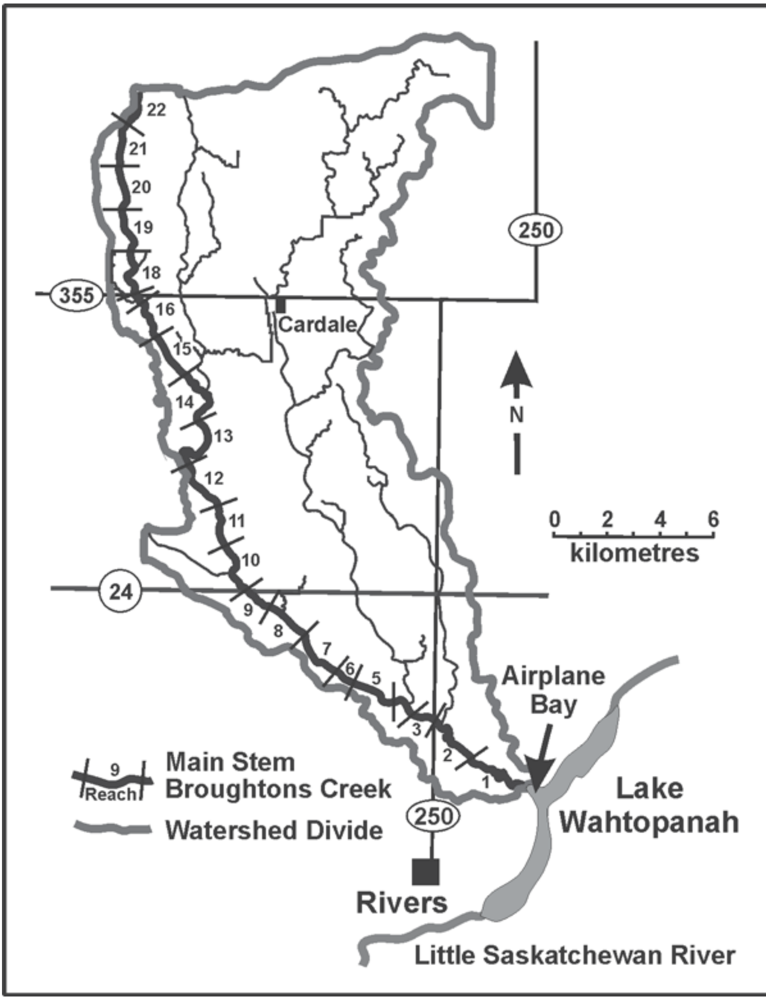

Figure 3: *Broughtons Creek Watershed.*

be relatively large, elongated, often oriented northwest to southeast, and shallow. There is a preponderance of permanent water bodies.

Broughtons Creek is located in theAspen Parkland ecoregion. Trees and shrubs surround water depressions and grass is dominant on the slopes and hillsides. Trees in the Broughtons Creek watershed are limited to a few species, mainly Trembling Aspen (*Populus tremuloides*) and Black Popular (*Populus balsamifera*). The most predominant shrubs are Peachleaved Willow (*Salix amygdaloides*), Snowberry (*Symphoricarpos occidentalis*), Wild Rose (*Rosa spp.*), and Chokecherry (*Prunus virginiana*).

The main tributary of Broughtons Creek was selected for evaluation of the LORHI (Figure 3). The stream channel is approximately 40 km in length, located in the sidehill position and entrenched 3-6 m below the local plain. The valley is flat-bottomed, U shaped in cross-section and 60-200 m wide. Significant deposits of sand and gravels cover the floor of the stream valley. Channel width ranged from 30 m in pooling areas to 0 m in areas of significant infiltration where the stream dif fuses through continuous vegetation.

Determination of LORHI:

The main stem of Broughtons Creek was divided into twenty-two reaches (Figure 3), defined and identified by section, township and range (Canada Land Survey). Reach 22 (26-15-22) included the headwater tributary, and Reach 1 (1-13-20) was located at the mouth of Broughtons Creek. Small grains or oil seed crops were found along 14 reaches (64% of the channel length). Five reaches flow through pastures (23%), natural vegetation was found along 2 reaches (9%), and there was 1 reach flowing through a hay field (2% of the channel length) (Table 1).

The riparian health of both the left and right bank of each reach was assessed. Buffer widths were recorded as the minimum measured distance in the observed reach (Table 1). The narrowest buffer width, other than those adjacent to pastures, was 5 meters (16.5 ft) and maximum buf fer widths were recorded to be 75 m (246 ft).

Figure 4 is a plot of the LOHRI calculated for 22 reaches of the main stem of Broughtons Creek from the mouth to the headwaters. Both the left and right banks were evaluated. The plot indicates that the riparian buffers for 14 banks out of the 44 were classified as unhealthy and 8 were considered problematic. That is approximately 50 percent of the channel length has a riparian health problem. All of the pastures were classified as Unhealthy (LORHI < 12) due to unfenced livestock. Consequently, the buffer width was considered less than 3 m and scored a value of 1. The vegetal diversity scores in the pastures averaged 7.2 indicating that there is potential for reestablishment once the riparian buf fer is fenced. Rehabilitation of the vegetal diversity, often simply the seeding of bare ground would result in a upgrading to Adequate.

The riparian buffer for 10 banks was classified as Adequate, 9 were considered Healthy, and 3 Ideal. In terms of channel length that is 23%, 20% and 7%, respectfully. It is estimated that the seeding of bare ground

Table 1: *Parameters and Calculation of LORHI, Broughtons Creek Main Stem.*

LOCATION		LANDUSE		BUFFER WIDTH					VEGETAL DIVERSITY								LORHI	
		Left Bank	Right Bank	Left Bank		Right Bank		Total WIDTH	Left Bank			Total Score	Right Bank			Total Score	Left Bank	Right Bank
Reach	Sec/Tp/Rg			Width (m)	Score	Width (m)	Score		Trees	Shrubs	Ground		Trees	Shrubs	Ground			
BC1	5-13-20	NAT	NAT	45	5	75	5	120	4	4	4	12	4	4	4	12	60	60
BC2	6-13-20	UFP	UFP	0	1	0	1	0	1	1	4	6	1	2	4	7	6	7
BC3	12-13-21	FOD	NAT	6	2	15	3	21	1	3	4	8	2	3	4	9	16	27
BC4	14-13-21	UFP	UFP	0	1	0	1	0	1	2	3	6	1	2	3	6	6	6
BC5	15-13-21	NAT	SG	12	3	34	5	46	3	4	4	11	1	2	3	6	33	30
BC6	16-13-21	NAT	NAT	46	5	55	5	101	2	2	2	6	1	2	3	6	30	30
BC7	21-13-21	UFP	NAT	0	1	0	1	0	3	2	4	9	2	2	4	8	9	8
BC8	20-13-21	NAT	SG	30	5	40	5	70	1	2	4	7	1	1	4	6	35	30
BC9	30-13-21	NAT	NAT	0	1	0	1	0	4	4	4	12	4	4	4	12	12	12
BC10	6-14-21	UFP	UFP	0	1	0	1	0	2	2	2	6	3	3	2	8	6	8
BC11	1-14-22	NAT	SG	9	2	14	3	23	4	2	4	10	4	3	4	11	20	33
BC12	13-14-22	NAT	SG	6	2	5	2	11	1	3	4	8	4	2	4	10	16	20
BC13	24-14-22	NAT	SG	14	3	24	4	38	4	2	4	10	4	2	4	10	30	40
BC14	25-14-22	NAT	NAT	20	4	12	3	32	1	2	4	7	3	2	4	9	28	27
BC15	26-14-22	NAT	SG	20	4	23	4	43	1	3	4	8	1	3	4	8	32	32
BC16	35-14-22	NAT	SG	14	3	12	3	26	1	1	4	6	4	3	4	11	18	33
BC17	34-14-22	NAT	SG	37	5	18	3	55	4	4	4	12	4	4	4	12	60	36
BC18	2-15-22	NAT	SG	5	2	8	2	13	4	4	4	12	1	3	4	8	24	16
BC19	11-15-22	NAT	SG	17	3	12	3	29	4	3	4	11	2	3	4	9	33	27
BC20	14-15-22	FOD	FOD	0	1	0	1	0	1	1	2	4	1	1	2	4	4	4
BC21	23-15-22	UFP	UFP	0	1	0	1	0	2	2	3	7	1	2	3	6	7	6
BC22	26-15-22	FOD	NAT	11	3	15	3	26	1	1	4	6	1	1	4	6	18	18

Landuse - SG - small grains; FOD - fodder; OS - oil seeds; FAL - fallow; UFP - unfenced pasture; NAT - natural vegetation; FP - fenced pasture

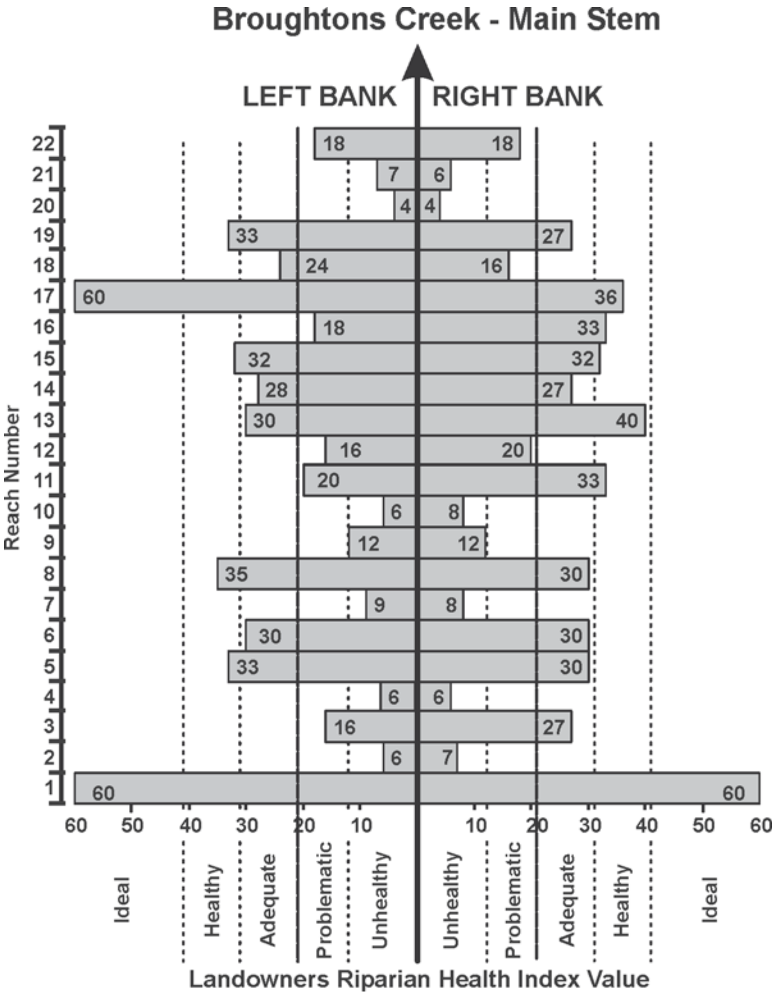

Figure 4: *Landowners' Riparian Health Index, Broughtons Creek - Main Stem.*

would result in a upgrading of three of the Adequate banks (33%) to a classification of Healthy.

Conclusions

An index is a readily obtainable measurement that depicts a variable or process which itself is not easily measured.The Landowners' Riparian

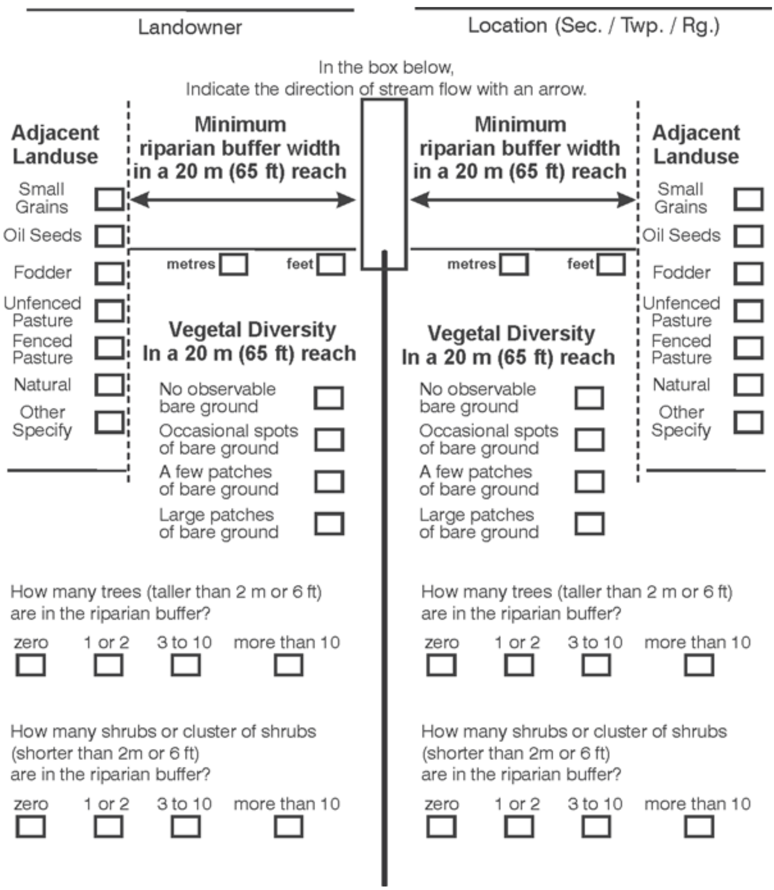

Figure 5: *Landowners' Riparian Health Assessment sheet.*

Health Index (LORHI) is founded on the principle that examining the vitality and productivity of the vegetation in a buffer zone can assess the health of a riparian area. Landowners or tenants can evaluate the riparian buffer on their land by responding to a one-page questionnaire (Figure 5). Due to the subjective nature of the riparian health index and the fact that most farmers have an intimate understanding of their land, respondents can complete the questionnaire in the field, over coffee or the telephone in just a few minutes. The LORHI can be easily calculated and classified into five health categories: Ideal, Healthy , Adequate, Problematic and Unhealthy. Problematic and Unhealthy classifications are generally associated with narrow buffer widths and poor vegetal diversity. Using the LOHRI, conservation district managers and landowners can identify problematic and unhealthy reaches and concentrate remedial actions in those areas.

The LORHI for the main stem of Broughtons Creek indicates that 50 percent of the channel length has a riparian health problem. Sixty-four percent of the problematic and unhealthy banks are unfenced pasturelands (classified as Unhealthy) that could be upgraded by fencing livestock. Rehabilitation of the vegetal diversity (often, simply the seeding of bare ground) will result in an additional upgrading.

The LORHI is an effective tool for assessing riparian health in small agricultural watersheds. It helps identify problematic and unhealthy reaches that require remedial actions. The LORHI will aid in allocating time and dollars into riparian areas that are in need of rehabilitation.

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Ordination of multispectral imagery for multitemporal change analysis using Principal Components Analysis

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Abstract: Early change analysis studies established the fundamental basis for applying the Principal Components Analysis (PCA) transformation to remote sensing images acquired on two dates.There are an increasing number of studies, however, which extend this basis to longer image time series with little concern for its appropriateness. In particular, when multispectral and multitemporal data are used in the same analysis, the components may be difficult to interpret since they would contain not only temporal variation, but spectral changes as well. In this paper we sought to establish an appropriate ordination technique to condense the multispectral information from each date prior to multitemporal PCA. Multispectral PCA and Normalized Difference Vegetation Index (NDVI) ordination approaches were applied to a series of four Landsat and SPOT multispectral images spanning a twelve year period. We found that the NDVI technique provides superior results because it produces annual composites with a strong physical basis.

Introduction

Remote sensing has a key role to play in environmental monitoring because it is the only source of data from which we can view the entire planet and monitor changes in the nature of the surface of the Earth through time in a consistent, integrated, synoptic and numerical manner (LeDrew 1992). As our concern for changes to the Earth's environment heightens we must begin to look for new analysis tools to help us identify where and when these changes are occurring. One such technique that has been used is Principal Components Analysis (PCA). Although the application of

PCA in change detection studies - analyses between *two* image dates - has been thoroughly examined (e.g., Fung and LeDrew, 1987), its use in multitemporal analyses - investigations between *many* image dates - has developed *ad hoc* without much attention paid to its appropriateness. In particular, when multispectral and multitemporal data are used in the same analysis, the components may be difficult to interpret since they would contain not only temporal variation, but spectral changes as well (Eastman and Fulk, 1993). The objective of this paper is to examine several options for addressing this potential for multispectral - multitemporal confusion.

Principal Components Analysis

Many remotely sensed images have significant inter-band correlation that, if not accounted for, can interfere with accurate and timely information extraction. For example, spectral response from a feature that is measured at green wavelengths is typically highly correlated to that features' response in the red spectral region. Similarly, since many Earth features do not move much there is significant spectral correlation between images acquired days, months, or even years apart. Principal Components Analysis is a mathematical transformation that can remove much of this redundancy (Jensen, 1996). Given a multi-band (multispectral or multitemporal) data set, a PCA will create a new image with fewer, uncorrelated bands, called *components*.

Although PCA will generate the same number of components as there are input variables, a key characteristic of the method is the concentration of the original data's variance into the first components. Thus, there should be a point at which it can be determined that most of the original scene variance has been accounted for, leaving only noise in the remaining components, which can subsequently be discarded. This "cut-off" point can be quite subjective and a variety of evaluation techniques have been devised to have it quantitatively determined (McGarigal *et al.*, 2000). In practical applications with remote sensing imagery, however, the statistical contributions from very small (relative to the entire remote sensing scene), but important, change regions do not typically pass most significance thresholds. We suggest that for multitemporal image analysis the utility of a component should be based more on the analyst's ability to ascribe meaning to the observed spatial and temporal patterns than on blanket statistical tests. This is the approach followed below.

Traditionally, PCA has been applied for image enhancement and to remove inter-channel redundancy (Singh and Harrison, 1985; Tangestani and Moore, 2001), however, it has also been effectively used in two-date change detection studies (e.g., Franklin *et al*., 2000; Li and Yeh, 2002). PCA can also be a powerful technique for information extraction across many dates (Eastman and Fulk, 1993; Piwowar and LeDrew, 1996; Young and Anyamba, 1999). When applied to multidate imagery, the PCA transformation should isolate the highest differences in image brightness in the first components and more statistically smaller changes in the lower components (Rundquist and Di, 1989).

Most sensor data shows wide differences in their dynamic range, even between simultaneously acquired spectral bands or between different dates. When used in a PCA, bands with higher data ranges tend to dominate the results. This is known as *non-standardized* PCA and can be useful for some applications where a particular band emphasis is desired. Alternatively, the original data can be normalized prior to PCA, thereby giving equal weighting to each input band. Such *standardized* PCAs have been shown to be effective at isolating variations in multitemporal analyses, so they were used throughout our analyses (Eastman and Fulk, 1993; Singh and Harrison, 1995; Fung and LeDrew, 1987; Young and Anyamba, 1999).

Imagery

We examined multispectral satellite imagery acquired of a rapidly urbanizing coastal city in Hainan Province, Southern China. In total, four images were obtained from three different satellite sensors to form a twelve-year chronology (Table 1). All of the imagery was acquired during the months of November and December to minimize the possibility of identifying changes that could be due to differences in the phenological stages of vegetation. To facilitate inter-annual comparisons, the images were co-registered to the 1991 SPOT image with a mean RMS error of

Table 1: *Optical satellite imagery analyzed.*

Year	Sensor	Bands Used
1987	Landsat 5 TM	2, 3, 4
1991	SPOT HRV	1, 2, 3
1997	SPOT HRV	1, 2, 3
1999	Landsat 7 ETM+	2, 3, 4

less than one pixel. Only the bands from similar spectral regions (i.e., green, red, and near-IR) were used to avoid biasing the PCA results from one year with spectral information that was not available from the other years' data.

Ordination Techniques

In order for any multitemporal image analysis to be effective: (a) precise co-registration of each image must be guaranteed; (b) the data must be univariate at each temporal instance; and (c) there must be some normalization of the data values between time slices (Piwowar and LeDrew, 1995). This paper is couched in an examination of the last two criteria. Specifically, given four multispectral images acquired over a twelve year period, we evaluated three *ordination* approaches - methods of reducing the spectral dimensionality of each image to render them univariate and normalized at each temporal instance.

We approached the ordination issue in three ways. For the first two methods, we reasoned that since PCA is a prime ordination technique in itself, it could be applied to the imagery for each year to condense the multispectral information independently (McGarigal *et al.*, 2000). That is, we determined if PCA could be used to address the multispectral - multitemporal confusion concerns by analyzing each year independently (to condense the multispectral information) and then input the resulting components into a second principal components analysis to highlight the multitemporal characteristics. For the third ordination technique, the normalized difference vegetation index (NDVI) was computed from the visible red and near-IR bands from each date before multitemporal PCA processing.

Technique 1: Split Annual PCA Ordination:

When applying PCA to multispectral optical imagery of a typical vegetated terrestrial landscape the first two components will highlight the differences between the visible and near-IR spectral regions (Byrne *et al.*, 1980; Rundquist and Di, 1989). The analysis of our imagery followed this pattern: the first component was consistently highly correlated with the visible bands and the second PC loaded heavily on the near-IR channel. Thus we were able to use PC 1 as an ordination for the first two bands and PC 2 as a representative of the third band. We then used the four PC 1 images (one from each year) in a second principal components analysis to highlight the multitemporal characteristics evident in the visible spectral

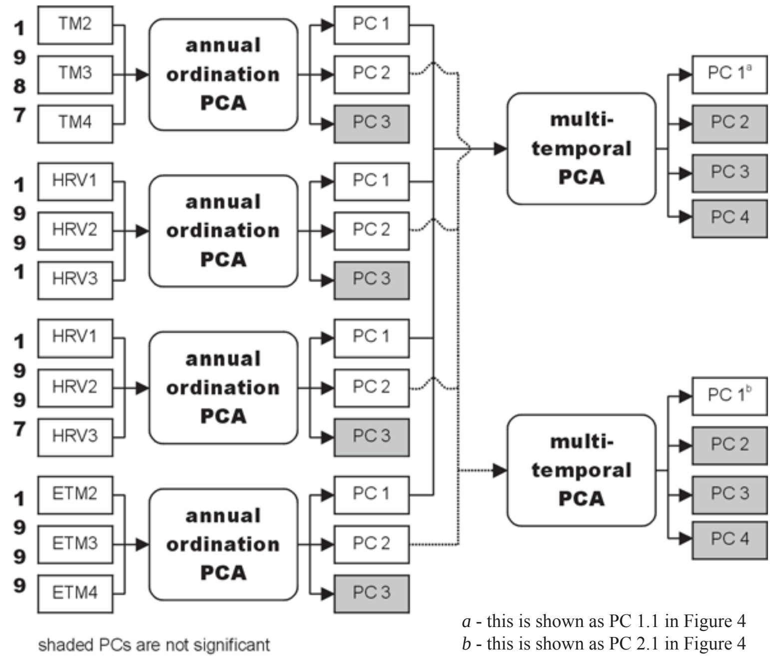

Figure 1: *Multitemporal PCA from Split Annual Ordination PCA Flowchart.*

data (Figure 1). Similarly, the temporal changes in the near-IR imagery were isolated with a multitemporal PCA of the four annual PC 2 images.

Technique 2: Joint Annual PCA Ordination:

Instead of examining PC 1 (representing primarily the visible spectral region) and PC 2 (representing the near-IR) separately, for Technique 2 we analyzed the first and second components from each year together (8 input bands in total) in a multitemporal PCA (Figure 2).

Technique 3: NDVI Ordination:

The spectral reflectance from typical terrestrial landscapes is dominated by the characteristics of the vegetated land cover . The normalized difference vegetation index (NDVI) is a mathematical combination of the visible red and near-IR bands that has been found to be a sensitive indicator of the presence and condition of green vegetation (Townshend, 1994) and is potentially an effective ordination technique. For multitemporal analysis, the NDVI also has the advantage of helping

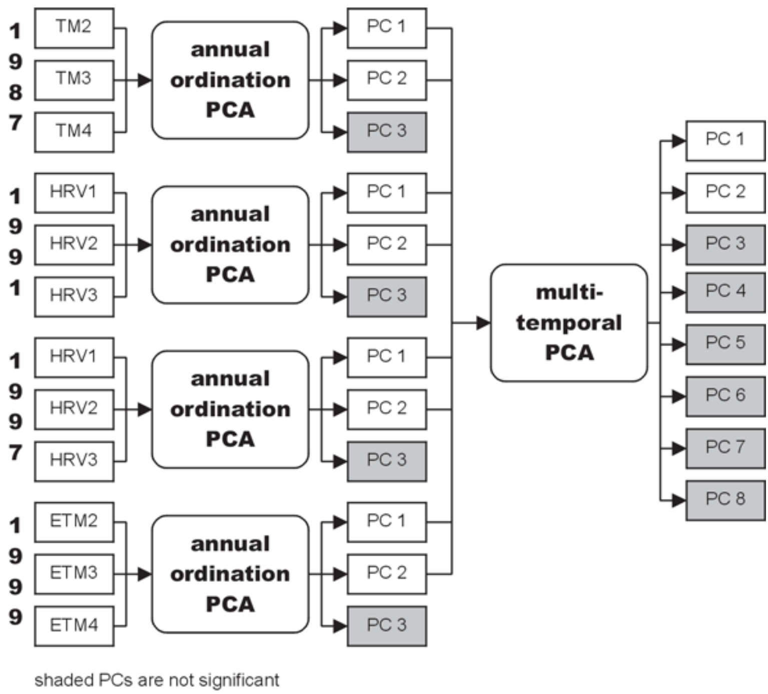

Figure 2: *Multitemporal PCA from Joint Annual Ordination PCA Fowchart.*

to compensate for extraneous factors such as differences in scene illumination and atmospheric conditions. In Technique 3, we used the four NDVI images (one computed from each year) in a second principal components analysis to highlight multitemporal changes (Figure 3).

Results

The results presented below are interpreted through an examination of the principal component images and their associated loadings plots. Whereas the component images identify the *spatial* arrangement of the change patterns, the loadings plots indicate their *temporal* domains. That is, the images show us *where* strong spatial patterns were occurring while the plots report *when* these patterns were strongest.

Multitemporal PCA from Split Annual Ordination:

Standardized principal components were calculated from the individual years' PC 1 data.[1] The first two components created from the

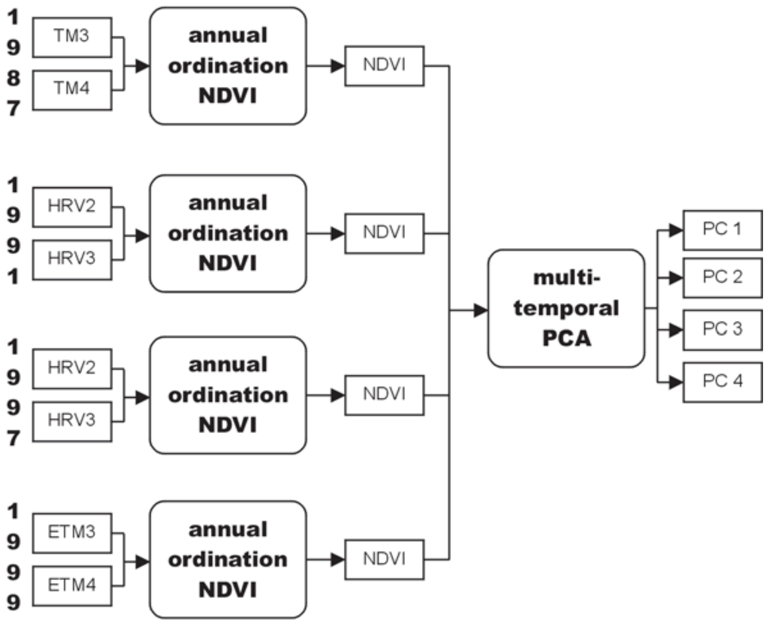

Figure 3: *Multitemporal PCA from NDVI Ordination Flowchart.*

PCA of the multitemporal analysis are shown in Figure 4 as PC 1.1 and PC 1.2. The loadings plot for PC 1.1 shows strong positive correlation between this component and the first components from all years except 1991. Thus, this component can be considered as the integrated average of the source data and any real change information is lost in the transformation. Since these data are drawn primarily from the visible bands of the original imagery, the tonal ranges in the PC 1.1 image follow the typical patterns evident in visible imagery: urbanized areas have strong reflectance; vegetated regions exhibit moderate reflectance; and generally low reflectance from water bodies. There is little detail in any of these areas, however.

From the loadings for PC 1.2 we see that this component is strongly correlated only with 1991. However, the correlation is *negative*, suggesting that this component shows typical image detail that was *not* evident in 1991. This is borne out in a comparison of the PC 1.2 and 1991 images (not included here) that show the extensive road network developed in the latter half of the 1990s and clearly shown in the PC 1.2 image was absent in 1991.

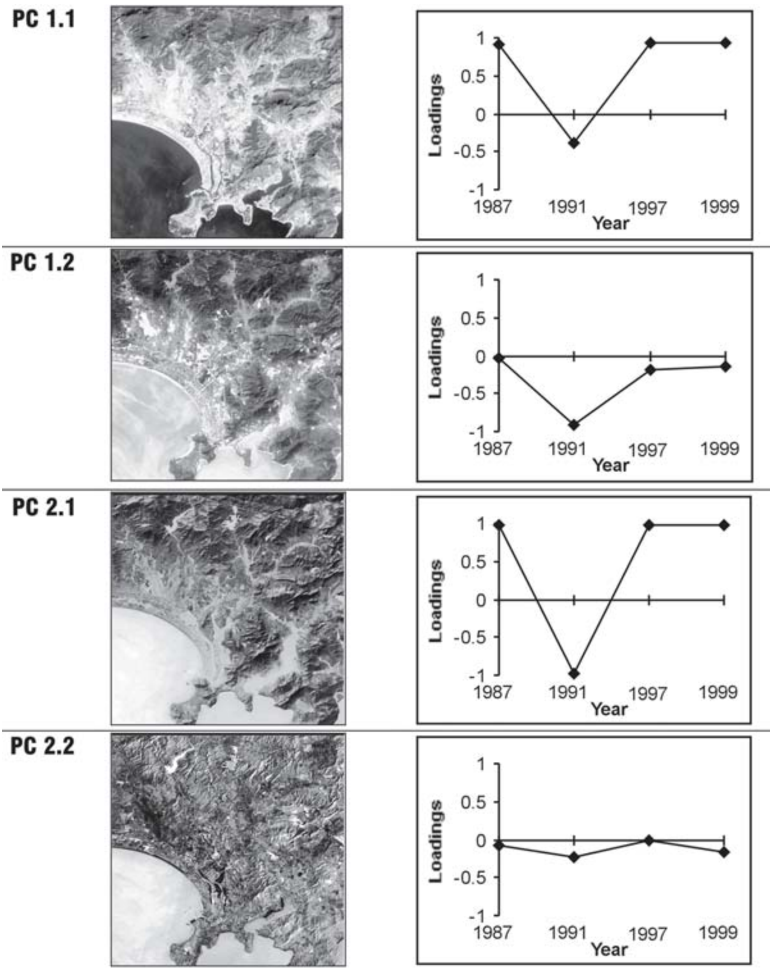

Figure 4: *Multitemporal Principal Components from Split Annual Ordination PCA.*

Figure 4 also shows the first two components calculated from the individual years' PC 2 data, labelled as PC 2.1 and PC 2.2The associated loadings plots show that PC 2.1 is strongly positively correlated with 1987, 1997 and 1999, and strongly negatively correlated with 1991.The PC 2.1 image highlights the land-water dichotomy evident in near -IR imagery. PC 2.2 is not significantly correlated at any year . The PC 2.2 image highlights localized differences in land development between the first two and last two dates.

The strength of the apparent anomaly in 1991 remains a mystery and we are continuing our attempts to arrive at a suitable explanation.

Multitemporal PCA from Joint Annual Ordination PCA:

Instead of splitting the individual years' PC 1 and PC 2 results into separate multitemporal analyses (as was done in the previous section) we repeated the multitemporal PCA including both the individual years' PC 1 and PC 2 data jointly. The first four components thus derived are shown in Figure 5. The first component loads strongly positive with the near-IR data (PC 2s) from the individual years, with 1997 as the lone anomaly, and moderately negative with the visible imagery (PC 1s). The PC 1 image is thus an integrated average of the diferences between the visible and near-IR data and consequently shows poor contrast and detail. The second component loads strongly with the visible band (PC 1) from 1997 and produces a striking contrast between vegetated uplands and non-vegetated valleys and coastal areas. The third and fourth components are not strongly correlated with any year and progressively show more localized changes. For example, PC 3 appears to highlight major land development changes occurring between 1991 and 1997, while variations in scene illumination dominate PC 4.

Multitemporal PCA from NDVI Ordination:

Recall that the first component derived during PCA is typically an integrated average of the input data. Although this trait has been shown during some of the analyses above, the results have not been consistent or conclusive. The first component derived from a multitemporal PCA of the NDVI calculated for each of the four data years, however, has strong loadings across all years (Figure 6). This is the hallmark of an integrated average and is exemplified in the PC 1 image.This scene shows, in detail, the average vegetation characteristics in the temporal sequence. Little detail is allocated to areas of consistently low NDVI for each year.

The loadings from the second component clarify the interpretation of an otherwise obscure pattern in the PC 2 image. The plotted loadings identify this component as the declining trend in NDVI across the four dates. The brighter areas in the PC 2 image are associated with higher loadings, hence more vegetative greenness in 1987 than in 1999. Conversely, the darker regions are areas where there has been a vegetative increase between these years.

The loadings for PC 3 show a slight increase from 1997 to 1999. This is reflected in the PC 3 image with brighter tones in areas of higher NDVI in 1999 and darker tones where there was more green vegetation in 1997.

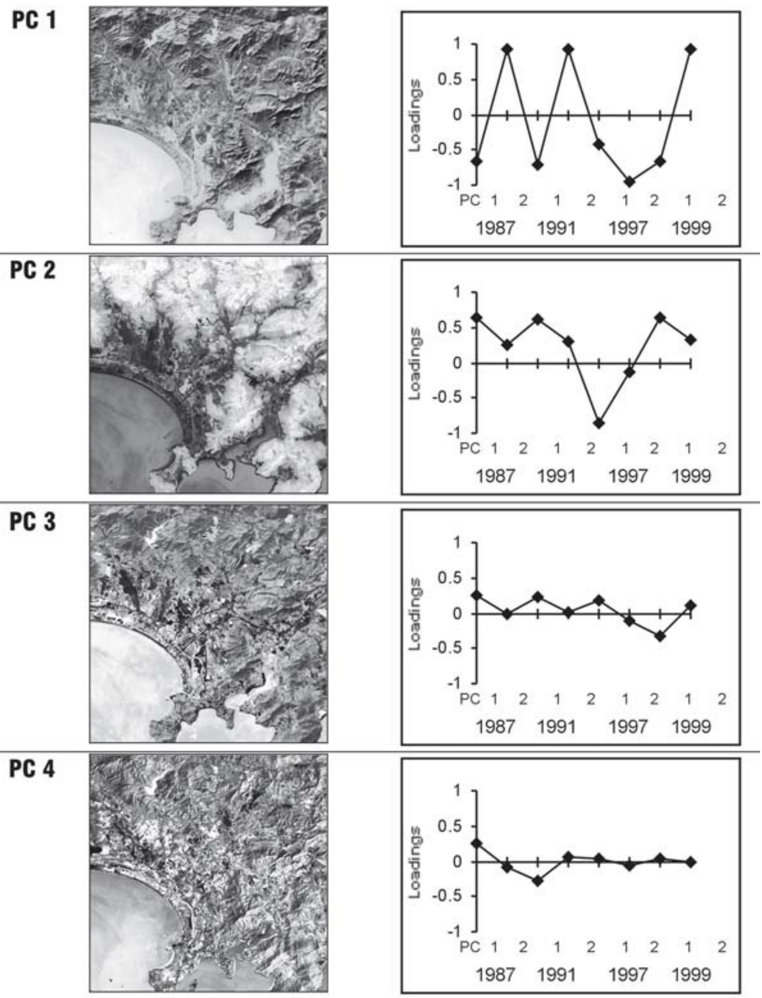

Figure 5: *Multitemporal Principal Components from Joint Annual Ordination PCA.*

Discussion

Principal components do not tell us about the possible mechanisms that are creating the observed patterns; they simply describe the major spatial relationships in the data. Thus, they do not tell us what the relationships mean or what is causing them. To take the analysis to the

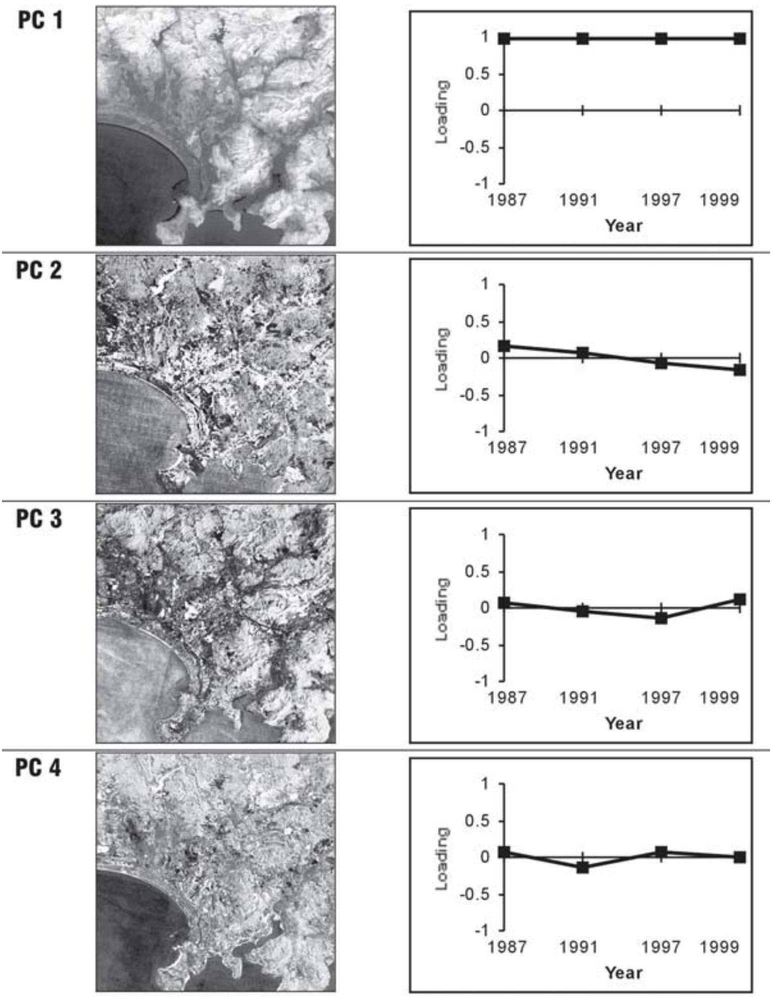

Figure 6: *Multitemporal Principal Components from Annual NDVI Ordination.*

next stage we must try to associate the observed patterns with other factors to interpret their meaning.

In the first technique discussed above, multitemporal components were derived separately from the first and second components of annual ordination PCAs. In both cases (shown in Figure 4), the first multitemporal component was identified as an integrated average while PC 2 isolated changes between 1987-1991 and 1997-1999. The third and fourth components (not shown in this report) isolated more localized changes.

Although this method was effective, interpretation of the components was hampered by the need to examine two different result sets and by apparently conflicting component loadings and images (e.g., PC 1.2).

The first component derived from the multitemporal PCA of joint annual ordination PCA (PC 1 in Figure 5) is a clear case of the potential problems arising from mixed spectral-temporal analysis that Eastman and Fulk (1993) warned about. This component loads highly positive with most of the annual PC 2s and moderately negative with all of the annual PC 1s. The accompanying component image, however, is representative of neither extreme: it is an average of the two, conveying little useful information. Similar difficulties arose when attempting to interpret the later components.

The first two techniques are plagued with a lack of a strong physical basis: we cannot say what the first component from the annual ordination actually represents. In a typical change analysis exercise we want to be able to relate our analysis findings with ground-based observations. For example, we know that the first component is supposed to be an integrated average, but what does an integrated average look like if you were standing on the ground? The multitemporal PCA from NDVI does have a strong physical basis, on the other hand. We know, for example, that higher NDVI values in the imagery are directly related to increased green vegetation vigour on the ground. In the present study, we saw an overall decrease in NDVI through the twelve year study period, presumably as a result of increased urbanization in the region. Thus, the interpretation of the multitemporal components of annual NDVI images was clear and concise.

Conclusions

In this paper we have examined three ordination techniques for the reduction of the dimensionality of multispectral remote sensing imagery prior to their inclusion in multitemporal principal components analysis. In the first two approaches, PCA was applied to the spectral bands from each date individually. This was based on the principle that, by definition, PCA has the potential to be an excellent ordination technique. We found that the subsequent components created from the multitemporal PCA were difficult to interpret, however, because the annual ordination components did not have a strong physical basis. Using the NDVI transformation on the individual images, on the other hand, produced consistent and easily interpreted results because the NDVI is not an abstract value. Further, the NDVI accounts for interscene illumination and atmospheric differences that are frequent obstacles in inter-scene comparisons. Thus we find that performing a PCA with the NDVI temporal bands is simpler to use and produces more robust results than the annual ordination PCA.

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Growth form adaptations by conifers in an anthropogenically stressed environment, Flin Flon, Manitoba - preliminary observations

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Abstract: Growth form adaptations by conifers to harsh climates are the norm in such places as the alpine treeline and the forest-tundra/tundra transition. Here, various shapes of krummholz, such as mats, basal skirts (rosettes), and flag development, together with vegetative propagation by way of layering, are typical adaptations to low temperatures, desiccating winds, and ice-crystal blasting.This study reports preliminary data and analysis of similar adaptations by black spruce and jack pine in a climatically less stressed mid-boreal ridge-crest environment near the Hudson Bay Mining and Smelting Co. smelter in Flin Flon, a region now severely impacted by air pollution. Undisturbed shield ridge-crest ecosystems some distance from Flin Flon consist of somewhat open jack pine and black spruce stands with cryptogam (lichen-moss) ground cover . Near the smelter SO_2 and metal particulate have severely impacted ridge-crests to the point that their cryptogam cover has died and their thin oganic-cryptogam soils have been badly eroded. This has exposed bedrock and caused most of the ridge-crest conifer tree cover within three km of the smelter to die of f. Pollution-induced thinning of ridge-crest ecosystems decreases progressively away from this zone. Surviving conifers close to the smelter are exposed to the ef fects of reduced volumes of sustaining soil, soil pollutants, exposure to greater wind speeds, and supranival exposure to winter fumigation. For black spruce this has induced krummholz forms such as mats, development of basal skirts, and often signs of supranival flagging and deformation similar to those characteristic of the alpine treeline and the forest-tundra/tundra transition. Many jack pine exhibit basal skirt formation, with some surviving only as mat krummholz, as is the case for many pine species along the alpine treeline in western North America.

Key words: pollution, ridge-crests, cryptogams, growth forms, black spruce, jackpine

Introduction

Growth-form adaptations by conifers to stress are particularly evident in the forest-tundra/tundra transition of the high subarctic, and along the transition between the alpine treeline and alpine tundra. At both locations spruce growth-form adaptations are attributed to the extreme climate and impacts of desiccating winds, while ice-crystal abrasion and damage of needles is also a major contributing factor in the high subarctic. Along the forest-tundra/tundra transition white and black spruce (*Picea glauca* and *P. mariana*) and tamarack (*Larix laricina*) show modifications to these extreme conditions (Scott, 1995). At alpine treeline in the western cordillera species such as Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), limber pine (*Pinus flexilis*) and lodgepole pine (*P. contorta*) are affected (Weisberg and Baker, 1995). For both regions the classic physiognomic conifer growth form often becomes modified to form krummholz ('crooked wood') shapes. Typical modifications include mat krummholz, basal skirts (rosettes), and 'flag' forms. Basal skirts (rosettes) develop and survive because branches close to ground level are better protected within the winter snow (infranivally). Stems projecting above snow level (supranival) are exposed to wind and ice-crystal blasting and can develop flagged or otherwise deformed krummholz shapes, or die-back leaving only infranival krummholz forms. Figure 1 illustrates typical growth form adaptations for white spruce (*Picea glauca*) near Churchill (Scott *et al.*, 1987) and by black spruce (*Picea mariana*) in northern Quebec (Lavoie and Payette, 1992).

In 1989 field studies on severely impacted ridge-crest ecosystems near the point-pollution source of the Hudson Bay Mining and Smelting Co. (HBMS) smelter in Flin Flon revealed somewhat similar adaptations by black spruce, and jack pine *(Pinus banksiana*). This was considered anomalous because here the natural vegetation cover is characteristic of the mixed-woods section of the boreal forest, and bio-climatically as part of the 'sub-humid mid-boreal ecoclimatic region' (Scott, 1995). Typical tree species include such hardwoods as trembling aspen (*Populus tremuloides*), black poplar *(P. balsamifera*), and paper birch (*Betula glandulosa*), together with softwoods such as white and black spruce and jack pine. Rowe (1972) describes this mixture of hardwoods and softwoods as the 'mixed-woods' section of the boreal forest, and attributes the mix to frequent fires that are encouraged by the sub-humid forest climate. For Flin Flon the mean annual temperature is 0.6 °C with seven months averaging above zero, and mean annual precipitation is 463.1 mm (Environment Canada, 2002). Mean annual snowfall is 140 cm, and dominant winter winds are towards the southeast (Franzin, *et al.* 1979).

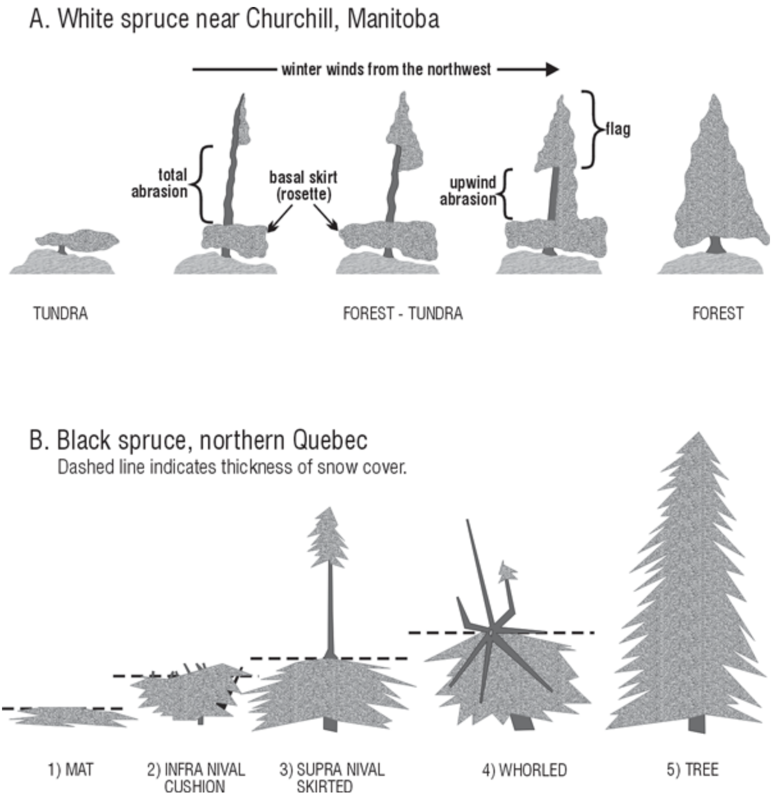

Figure 1: *Spruce growth forms across the forest-tundra/tundra transition. A. White spruce near Churchill (adapted from Scott* et al.*, 1987). B. Black spruce, northern Quebec (adapted from Lavoie and Payette, 1992).*

Objectives

In 1995 new field studies were initiated to determine the types of growth form modifications present in the heavily polluted zone close to Flin Flon. In addition, a preliminary investigation was initiated to see if those conditions which promote such modifications in the climatically more extreme high subarctic and alpine treeline also give rise to growth form modifications near Flin Flon.

The Study Region

Flin Flon is located on a portion of the PreCambrian Shield containing orebodies rich in non-ferrous metals (Figure 2A). Shield outcrops form low rolling hills with glacially scoured crests that have been scraped relatively clean of regolith (Figure 3). HBMS began smelting for zinc and copper in 1930. Emissions were released to the atmosphere from a single 30 m tall stack. This stack was replaced in 1974 by one 251 m tall. Emissions include sulfur dioxide, zinc, cadmium, copper, arsenic, and other base metals, with dry and wet base metal fallout taking the form of metal particulate, and metal oxides and metal sulfates (Franzin *et al.* 1979). The dominant winds have given rise to an oval pattern of decreasing base-metal contaminated soil centered on Flin Flon, with a northwest to southeast axis (Zoltai 1988). These pollutants have lead to tree and groundcover mortality on ridges, and to epiphytic and terricolous cryptogam cover in the lowland depressions. For more detailed information on both pollution loads and impacts to vegetation near Flin Flon see, Hogan and Wotton (1984), and Scott (2000).

Undisturbed ridge crests some distance from Flin Flon include soil-free areas (but with terricolous cryptogam cover) and thin Folisol-like organic profiles developed from dead cryptogams, and conifer and herbaceous plant residues. These Folisols are protected from erosion by the living cryptogam and vascular plant cover and provide an acidic substrate sufficient to support scattered jack pine. Where Folisols are underlain by a thin veneer of mineral soil, black spruce have become established. Consequently, undisturbed ridge-crests often contain a mix of both jack pine and black spruce. Closer to the smelter these plant communities are missing or are damaged as cryptogam death leads to the dessication and erosion of the thin Folisols and mineral soil veneers. Cryptogam regeneration seldom occurs, and the surface is essentially a sterile grey-black colour with only the occasional vascular species such as blueberry (*Vaccinium angustifolium*), colonial bentgrass (*Agrostis capillaris*), and willow (*Salix* sp.) showing any signs of vigor (Figure 3).

Methods and Materials

Study site selection:

In 1989 and 1995 fourteen ridge-crest study sites were selected throughout the region to study the impacts of atmospheric pollution on ridge crest ecosystems (Figure 2). Sites #1-10 follow a southeast transect of decreasing pollution load downwind of the smelter to Cranberry Portage.

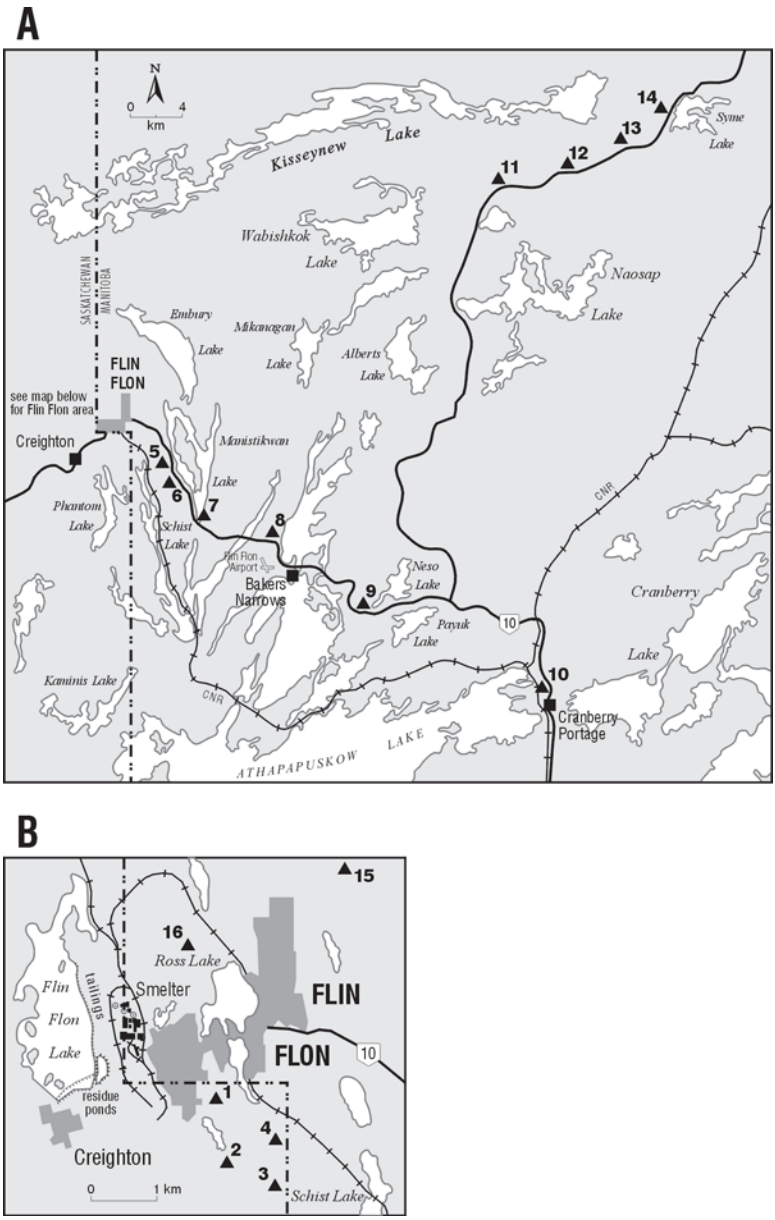

Figure 2: *The Flin Flon, Manitoba, study region. A. Study Sites more than 4 km from the HBMS smelter. B. Study sites within 4 km of the HBMS smelter.*

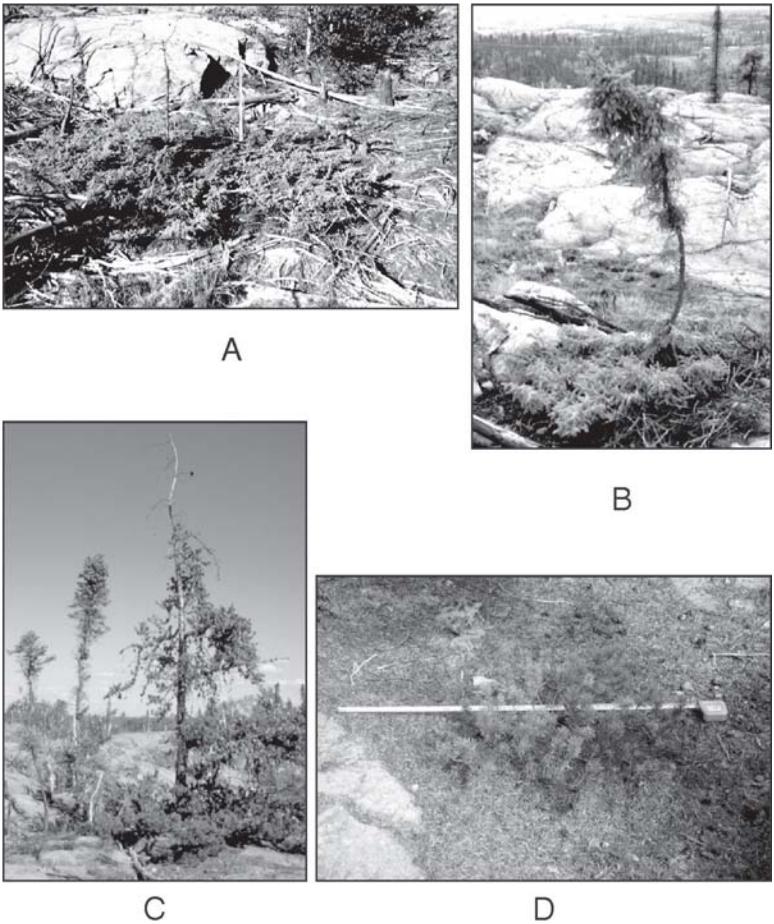

Figure 3: *Growth form adaptations by black spruce and jack pine close to Flin Flon. Note the lack of ground cover. A = mat krummholz black spruce; B = supranival skirted black spruce; C = supranival skirted jack pine; D = mat krummholz jack pine.*

As suitable study sites could not be selected southeast of Cranberry Portage, due to the fact that here carbonate bedrock replaces igneous and metavolcanic bedrock, four control sites (1 1 - 14) were selected to the northeast along the Sherridon road where no visible air pollution impacts were observed, and where soil base-metal contents approach background levels (Zoltai, 1988). In addition, in 2002 two additional sites (15 and 16) were selected just north and northeast of the smelter , because at these sites jack pine showed well developed growth form adaptations. Specific field studies to characterize these adaptations were carried out at selected study sites in the summers of 1995, 1996 and 2002, and in the winter of 1996. For specific details on pollution-induced thinning of ridge-crest ecosystems along the transect from Cranberry Portage to Flin Flon (Study Sites 1 - 10) see Scott and Orlandini (2002).

Growth form sampling:

Due to the preliminary nature of this study only some of the non-impacted control sites, and most severely impacted sites were sampled. At vegetated ridge-crest control Study Sites 12 and 14, quadrats of 20 x 20 m were established to sample black spruce and jack pine. Closer to the smelter, severely impacted Sites (2 and 3) were also sampled for black spruce using 50 x 50 m quadrats to allow for sufficient living trees to be studied. Sampling was not possible at Study Site 1 as no living conifers remained there. Jack pine were sampled at Study Sites 15 and 16 using 50 x 50 m quadrats. In addition, pine were sampled in Study Site areas 2 and 3, but because there were so few surviving pine here the quadrat combined both site regions and covered 1.75 km^2. All black spruce and jack pine trees within a quadrat were measured for height, and where living branches exited trunks close to ground level and above basal skirts, flagging characteristics and aspects of supranival die-back. For basal skirts, both skirt depth, and skirt branch length from stem along the eight cardinal compass directions were measured. In addition, mat krummholz forms were documented, and any vertical stems growing from windthrow or from basal skirt branches (*i.e.* layering) were noted.

Results

1. Black Spruce:

While no living conifers remain on the sterile rock outcrops at Study Site 1, the most severely impacted study site, an important observation is that tall, healthy white spruce, showing no signs of flagging or basal skirt development, are present in Flin Flon ridge-crest gardens several hundreds of metres away. In these gardens the soil is anthropogenic and well maintained, and other garden trees afford some protection from the wind. In addition, both black and white spruce survive with few growth form modifications on the deep mineral and organic soils of lower slopes and lowlands below the study sites. Study Sites 2 and 3 are severely impacted sites which support some scattered living spruce and the occasional pine. At these two sites, black spruce average 5.9 m tall, and individuals are rarely clumped so branch die-back due to shading is not expected (Table 1). Mat krummholz and basal skirt forms hug the ground closely, are typically no more than 35 cm thick, have irregular margins, and do not show the oval pattern so characteristic of spruce skirts in the high subarctic (Table 2, Figure 3A and 3B). Occasionally layered branches have new vertical stems rising from them, and basal skirts often have more living needles than on the few remaining supranival branches above. In addition, flag forms are fewer and less symmetrical than the classic forms illustrated in Figure 1, yet often the northwest side facing the smelter exhibits less vigorous growth and fewer living branches.The branchless zone between basal skirts and the first living supranival branch averages about 2 m (Table 3). Winter snow depths at these two sites averaged 30 cm in February, 1996. Consequently, skirts were well protected during winter inversion/fumigation episodes. Equivalent 1996 snow depths around the more closely spaced trees at Sites 8 - 10 were 90 - 95 cm, and although some individuals had branches hugging the ground, there was no branchless zone separating these from supranival branches above. Observations on needles in these

Table 1: *Black spruce stem/branch characteristics close to Flin Flon.*

study site[1] #	# of living trees used	mean tree height (m)	trees with basal skirts	# of mat krummholz spruce	new stems from skirt	mean skirt thickness (cm)	mean[2] skirt branch length (cm)
2	19	5.7	16	2	4	34.3	94.3
3	9	6.4	7	0	1	33.9	73.4

1. Quadrats = 50 X 50 m.
2. Mean of basal skirt branch lengths measured along eight cardinal compass directions.

Table 2: *Black spruce mean basal-skirt branch length (cm) and branch orientation close to Flin Flon. Smelter is to the NW of both sites.*

study site[1] #	# with basal skirts	N	NE	E	SE	S	SW	W	NW	mean branch length (cm)
2	16	98.3	91	100	99.4	94.7	82.9	91.3	96.6	94.3
3	7	75.8	53	66	83.4	90.4	88.3	73.4	57	73.4

1. Quadrats = 50x50 m.

Table 3: *Supranival characteristics of black spruce close to Flin Flon.*

Study site[1] #	# of living trees	# with a branchless zone[2]	length of branchless zone (m)	# of flagged trees	# with branch thinning[3]	relative % of branch thinning[4]
2	20	12	1.87	3	7	28
3	7	7	2.85	4	2	25

1. Quadrats = 50 X 50 m.
2. A branchless zone between ground or basal skirt (if present) and the first supranival living branch.
3. One side of tree (not necessarily flagged) but with fewer and shorter living branches, and oriented towards smelter.
4. Relative percentage of branch thinning for trees in note # 3.

lower zones showed little indication of cuticle rupture from ice-crystal blasting. Tree cores revealed that most black spruce colonized these sites since the smelter became operational in 1930. Figure 4A summarizes black spruce growth forms found present in the heavily impacted zone close to Flin Flon.

2. Jack pine:

Although jack pine close to the smelter usually have basal skirts, these are not always as dense and as symmetrically disposed abound the tree base as with black spruce, having only 2 - 6 basal branches. Although mean skirt branch length is approximately 1 m, some regularly exceed 2 m (Figure 3C), with one at Study Site 16 reaching 4.5 m. Jack pine trunks are shorter than for remnant black spruce, averaging only 4.65 m, and with branchless zones between skirts and the first supranival living branch of about 1 m (Table 4). Basal skirt shapes shows little symmetry and any geographic orientation seems influenced more by nearby rocks and outcrops than by prevailing winds. Flagging rarely seemed to be a significant modification to jack pine near Flin Flon.

At control Study Sites 12 and 14, few basal branches are found. Individual trees are much taller, closely spaced, and possess some dead lower branches typically associated with shading. Layering is uncommon, except for surviving windthrow. There is little evidence of needle cuticle damage from ice-crystal blasting. Figure 4 B summarizes jack pine growth forms found close to the smelter.

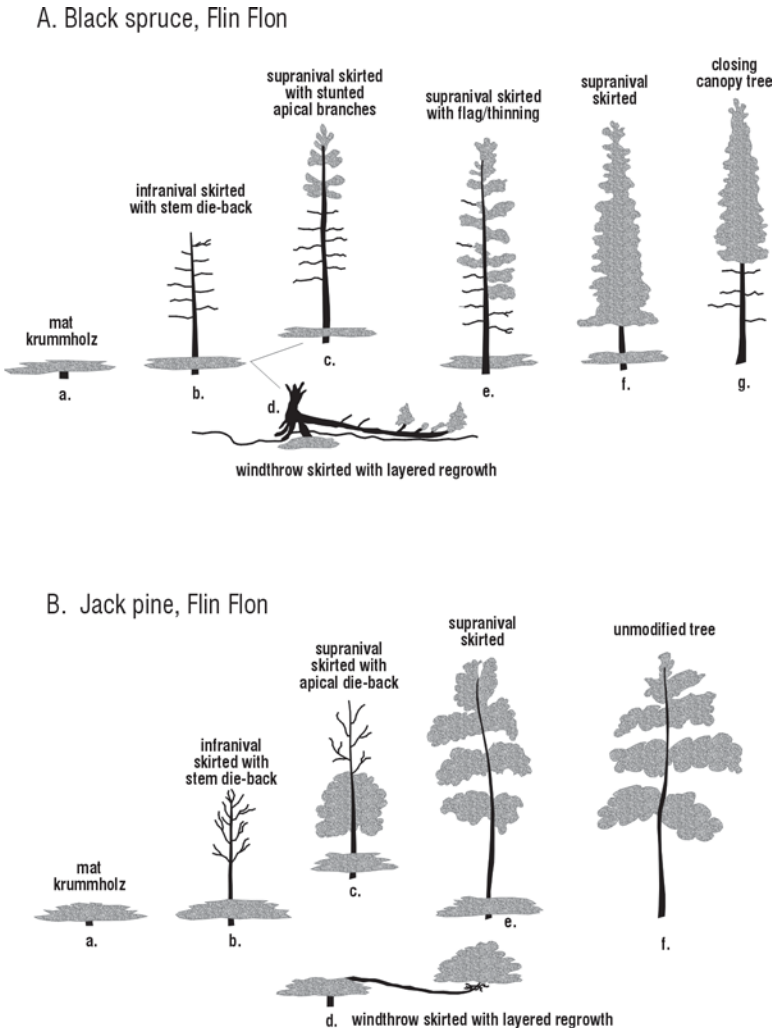

Figure 4: *Typical growth-form adaptations by black spruce and jack pine on ridge crests close to the Flin Flon smelter.*

Discussion

Growth form adaptations by black spruce and jack pine are important survival strategies for isolated individuals surviving on ridge crests near Flin Flon. It would appear from this preliminary study that black spruce adaptations result primarily from the impact that air pollution has in opening

Table 4: *Selected Jack pine characteristics at four sampling sites close to Flin Flon.*

Study site[1] #	# of trees used	mean height (m)	# of krumm-holz	# with basal skirts	mean skirt thickness (cm)	length[3] of branchless zone (m)	# of trees with apical stem dieback	# of trees with skirt verticals
2+3	5[2]	8.5	0	2	32	2.7	2	0
15(a)	18	3.35	0	17	25	0.85	0	0
15(b)	27	5.03	5	16	28	0.98	2	1
16	11	4.12	1	10	33	0	0	1

1. Only five jack pine exceeding 1 m in height were found in an area of 1.75 km^2 combining sites 2 and 3, while quadrat size for sites 15(a), 15(b), and 16 is 50 X 50 m.

2. Two of these five had apical-stem dieback of 2.0 and 2.5 m above living supranival branches.

3. A zone above ground or basal skirt (if present) before the next living branch.

up these ridge-crest ecosystems to greater dessication by winter winds and perhaps some ice crystal blasting. Increased spring/summer moisture stress as the moisture storage capacity of soil pockets continues to be reduced may also be a factor. Individual trees become isolated as die-off follows the loss of cryptogam cover and associated Folisols. Surviving or germinating ridge-crest black spruce are now confined to small patches of remnant soil, and any attempt to colonize the intervening exposed bedrock areas which would lead to reduced dessication, is impossible. In addition, stronger ground-level winter winds due to tree isolation leads to a much thinner winter snow pack and therefore a potentially reduced spring soil moisture supply. The trapping of winter snow by basal branches favors basal skirt development, while supranival stems/trunks experience damage that is partially the result of desiccating winds and dessication in general as continued erosion causes soil volume to decrease. Needle cuticle damage, which is considered a major aid to dessication in the high subarctic, is less evident here. While the dramatically-flagged spruce form so common along the forest-tundra/tundra transition and subalpine treeline is less frequently encountered here, the unequal development of branches on the side of trunks facing the smelter is similar to the characteristics of less damaged spruce in the high subarctic.

It is not possible to compare adaptations by jack pine to pine in the forest-tundra/tundra transition zone, because none are found there. Comparisons, however, can be made with pine along the alpine treeline areas of western North America where such species as, whitebark (*Pinus albicaulis*), limber (*P. flexilis*), bristlecone *(P. artistata*), and lodgepole pine (*P. contorta*), are common as krummholz and deformed and flag types (Tranquillini, 1979; Weisberg and Baker, 1995). The various jack pine growth forms found near Flin Flon are illustrated in Figure 4B, and their development not only reflects many of the same ecosystem disturbance factors noted above for black spruce around Flin Flon, but also the winter moisture stress conditions so prevalent along the alpine treeline (Tranquillini, 1979). This moisture stress southeast of Flin Flon is so profound that few pine survive, and it is noted that of the five remaining jack pine examined around Study Sites 2 and 3 (Table 4), all have overcome some of this moisture stress by having roots extend downslope to nearby semi-permanent wet depressions.

Conclusion

Atmospheric pollutants indirectly set the stage for growth form adaptation by ridge-crest black spruce and jack pine near Flin Flon (Figure 4). By damaging and destroying the ridge-crest cryptogam cover, soils are then partially or wholly eroded, mineral cycling regimes are altered, and the sustaining soil medium for trees and most plant species is severely compromised. This results in the almost total demise of cryptogams and vascular species in these ecosystems. While surviving and germinating conifers in the most heavily polluted zone must now contend with these indirect consequences of air pollution, a possible, but unknown role may also be played by air pollutants impacting directly on conifer needles, branches, and roots. One avenue for further research in this regard could be a study of possible damage to conifer-root symbiotic ectotrophic mychorriza. Given that well maintained ridge-crest garden spruce throughout Flin Flon do not exhibit these modifications, a second avenue for research could examine supranival stem and branch die-back on exposed ridge-crest spruce as related to winter-time air pollution acting preferentially on already highly stressed trees. In terms of growth form change with distance from the smelter any future study could also sample conifers at all study sites between Flin Flon and Cranberry Portage.

It is evident that indirect and possibly direct impacts of air pollutants in effect superimpose forest-tundra/tundra, and alpine treeline like conditions on black spruce surviving on these highly disturbed mid-boreal ridge crests near Flin Flon. These same impacts also impose essentially alpine treeline conditions on ridge-crest jack pine. While Tranquillini (1979) and others attribute conifer growth form modifications along the alpine treeline almost entirely to winter climate conditions, it is clear that other factors must be considered in explaining conifer growth form modifications near Flin Flon.

Acknowledgements

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Exploring geographic knowledge throughm apping

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Abstract: Knowledge about the world is expressed in many ways. Sketch mapping has been a dominant method used by researchers in a variety of disciplines to indicate both spatial and geographic knowledge. Unfortunately, sketch mapping tasks have the potential to be confounded by drawing ability and non-spatial recall ability, among other variables. By using three types of sketch mapping tasks, student knowledge of world geography was assessed. Knowledge of world geography was assessed by the rate of accurate inclusion of individual countries. Comparing student map production to their individual performance on two spatial figures drawing tasks (the complex figures test) allowed for a comparison of geographic knowledge and both drawing and visuo-spatial ability . Students in two geography classes participated, one a first year cultural geography class the other a senior technical geography class. Results indicate that drawing ability can be controlled for in sketch mapping tasks and that the relationships among geographic knowledge, spatial ability, and drawing skill can be understood, and that this understanding can be used to increase the validity of sketch mapping tasks.

Introduction

In late November 2002 geographic knowledge and literacy became a front page item across both Canada and the United States. The National Geographic Society (NGS) presented the results of the National Geographic-Roper 2002 Global Geographic Literacy survey. The survey showed that globally geographic knowledge is surprisingly poor and that such knowledge is particularly low in North America (Canada, the USA, and Mexico). While the headlines focused on the dramatic lack of knowledge among survey participants, there were several positive outcomes. Over the past several years the numbers of students in North

America exposed to geographic curriculum in their formal education increased (as did geographic literacy, although not as much as many had hoped it would).

The NGS survey illustrated two relevant issues related to the current study. The relative impact of, and relationship between, geographic instruction and geographic knowledge must be better understood and the methodology for evaluating geographic literacy and knowledge must be evaluated. A traditional method for evaluating geographic knowledge of the world is by having people (participants) complete a sketch mapping exercise (Blades 1990, Pinheiro 1998, Taketa 1996, Saarinen 1999). Sketch mapping methodologies have proven reliable (Blades 1990), have produced a better understanding of how people around the world understand global geography (Saarinen 1999, Stea, Elguea and Blaut 1997, Stea, Blaut and Stephens 1996, Saarinen 1973), and have been used in several educational and research based applications (Pinheiro 1998, Golledge 1985, Kitchin 1997). What has been explored less thoroughly is the extent to which the sketch mapping paradigm is evaluating the intended independent variable(s); in most cases the independent variables are related to the geographic or spatial knowledge of the individual completing the sketch map. As most sketch mapping tasks involve some component of drawing ability and spatial memory it seems reasonable to determine the extent to which these two variables play a role in the sketch mapping process.

Sketch mapping and related drawing and mapping tasks have been used in a variety of ways to examine spatial and geographic knowledge as well as provide additional evidence for spatial reasoning abilities of different types. As suggested above the most common sketch mapping task is to have participants free draw a map of the world (or some subset) labeling and drawing countries and other geographic features (Saarinen 1999, 1973). The only limitations these types of techniques present the individual producing the sketch map is the size of the paper on which the map is drawn and the specific instructions that are delivered by the researcher. In order to examine different constructs, such as how spatial information is processed during wayfinding and navigation, how scale affects knowledge representation, knowledge of different types (country capitals, physical features within larger spaces, etc.), among many others, the sketch mapping technique has been modified with reliable, and important results (Blades 1990). For all of these techniques some aspect of the mapping process is limited so the result is a task that is more likely to produce data that tests the research hypothesis (hypotheses). In most cases this approach is adopted to focus on a specific type of knowledge or to eliminate the role that drawing ability might play in the quality of sketch map produced by an individual. An individual with drawing skills may be able to produce a more well balanced drawing that better supports the inclusion of geographic features. Poor drawing ability is more likely to result in a map that does not use space in an efficient manner and will create a situation in which some feature cannot be included, labeled, or properly identified.

These types of "modified" mapping tasks can take many forms. In a task presented to blind participants in a navigation experiment, Jacobson (1998) provided individual pieces that were to be used to build a model of the space they had recently learned. As with most modified mapping tasks at least one variable in the mapping process is limited in such a way that the participants do not have complete freedom in how a map is drawn, a model built, or features labeled. There have been several mapping tasks that have not been as abstract as the Jacobson example, in which participants are provided with map elements (symbols, labels, objects, and other features) which are in turn placed on the map to indicate the correct location of each map element (Ferguson and Hegarty 1994, Tversky and Taylor 1998). Instead of providing the elements that will be added to the map, the research can also limit the space being mapped, or provide some other frame of reference within which the map will be completed. These "frames" can take the form of a traditional neat line, but can also include an arrangement of predetermined features, continental or national boundaries, or other well known geographic information. Each of the above mentioned techniques can facilitate the collection of valid and more focused data.

While a variety of sketch mapping techniques have been used to study a broad range of topics in geography and cognate disciplines there has been relatively little research examining the relationship between different sketch mapping tasks and the constructs they are intended to measure (a sketch mapping task's external validity). This research takes a systematic look at three derivations of a common sketch mapping task and compares performance (as measured by geographic knowledge communicated through the sketch mapping task) among the sketching tasks as well as to a non-geographic spatial drawing and spatial memory task. By using a task that can measure both drawing ability and spatial memory independently from geographic knowledge we can examine the extent to which drawing ability and non-geographic spatial memory play in performance on sketch mapping tasks that rely on drawing ability to varying degrees. Specifically, the object is to determine the role that drawing ability and spatial memory play in sketch map performance. The hypothesis is that drawing ability will play a role in the ability to complete a sketch mapping task that relies to some extent on the ability to draw an accurate (proportional, complete) image of the area being mapped, even if the relative accuracy of the map is not evaluated and the only measure is the number of countries labeled.

Methods

Participants:

Thirty participants from two separate geography classes took part in the study: seven participants from an upper year geography course (all female), and twenty-three participants from an introductory human geography course (seventeen females and six males). The mean age of the participants from both courses was twenty-two years. All subjects provided informed consent and completed the survey on a voluntary basis. While this sample is relatively small in comparison to other larger sketch mapping projects (Saarinen 1999) it is not out of the range of experimental behavioral projects examining spatial cognition in a controlled setting. Furthermore, the use of a repeated measures design in which within participant variation is measured the validity of a smaller sample size is increased.

Materials:

All of the survey materials were presented in one test packet per participant. A random code number was assigned to each packet. The test packet consisted of six tasks. First, there was a background questionnaire that asked the participants to identify their age, sex, birthplace, education and travel history. The background questionnaire was followed by five drawing and mapping tasks: a complex figure drawing task; a world sketch map task; two different world map labeling tasks; and finally a complex figure memory task. Also, all participants were provided with consent and debriefing forms.

Procedures:

The testing was done during class time in a mass testing format. The participants were instructed to work individually on each task, to not look forward or backward through the test packet during the test (except where indicated below, and only during the completion of an individual task), and to proceed to the next task only when instructed to do so. Each task was timed and accompanied by written and verbal instructions to ensure that the participants understood each component of the experiment. Time to complete each task was based on a pilot study completed by a small sample of students and staff.

TASK 1: Complex Figure Drawing

After completing the background questionnaire participants were instructed to begin the first task, which was a complex figure-copying task in which the participants were instructed to copy a figure drawing as accurately as possible (Figure 1).The participant's reproduction was scored based on the individual elements it included that were identical to that of the original; a perfect score is 36.This task was used as an index of drawing ability that did not include any world geography component. Participants were allowed three minutes for this task.

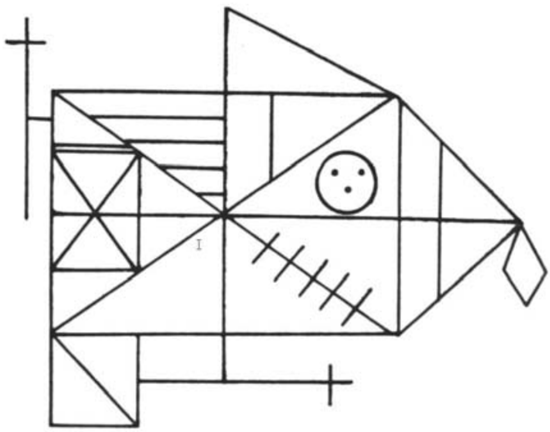

Figure 1: *Complex Figures Test used in both copying task and drawing from memory task.*

TASK 2: Free hand World Sketch Map

The second task required the subjects to draw a sketch map of the world and accurately label as many countries as possible, given the following instructions:

> "Draw a sketch map of the world. Label all the countries and any other features you think are of interest. Do not worry if your map is not perfect. Just do the best you can.We are sure you will find this an interesting experience once you get started." (Saarinen 1999)

This task was completed on a blank 8 ½ by 1 1-inch sheet of paper. The intent of this task was to measure participants' knowledge of world geography (as indicated by the number of countries correctly labeled). The only dependent measure for this task is the number of country names placed on the map associated with a drawn area.There was no evaluation of whether countries or any other subset of the world (physical or social) were accurately drawn, as this would be difficult to determine given the range of drawing ability that is usually expressed on sketch maps. Likewise any list of country names was ignored when maps were being scored.This task allows for a comparison of other sketch map techniques that rely less on drawing ability and more on knowledge of the countries of the world, to a task that relies on drawing ability . If one cannot draw a well proportioned map that includes space for all of the (known) countries, then it will difficult to label all of those known countries. Participants were given twelve minutes to complete this task.

TASK 3: World Map Labeling

Participants were then given a map labeling task.This task consisted of three regional outline maps covering the entire world and included the outlines of 193 countries, the maps were: 1.The Americas; 2. Europe and Africa; 3. Asia. Participants were instructed to accurately label as many countries on the maps as possible. Participants were allowed to label countries in any order and were, therefore, allowed to move back and forth among the three maps. The intent of this task was to measure participants' knowledge of world geography (as indicated by the number of countries correctly labeled) in a setting that does not rely on drawing ability. For this task participant scores were based on the number of countries that were accurately labeled, country names did not have to be placed within or completely within the boundaries of that country but there did need to be a clear association between the country label and that country's outline on the appropriate map. This task allowed for the measurement of participants' memory for and knowledge of world countries and their locations independent of drawing ability . Participants were allowed ten minutes for this task.

TASK 4: World Map Labeling with Country List

The final mapping task was a modified map labeling exercise. Participants were provided an unlabeled outline map of the world (single sheet, same countries as the maps in task three) and a separate list of countries numbered in alphabetical order. The participants were asked to indicate, as accurately as possible, the locations of countries by writing the number corresponding to each country (from the alphabetical list) in the correct location on the map. As a modification of the preceding labeling task, the intent of this task was to eliminate the participants' need to remember the names of countries for which they might have geographic (locational) knowledge. This task was scored based on the total number of countries accurately labeled (numbers are clearly associated with the correct country outline). This task allowed for the measurement of participants' knowledge of world countries and their locations and was independent of drawing ability. The participants were given twelve minutes for this task.

TASK 5: Complex Figure from Memory

For the final task participants drew the complex figure (from task #1) from memory on a blank sheet of paper. Drawings were scored in the same manner as the copying task and were used to measure spatial memory and as a second drawing ability index. They were given five minutes to complete this task.

The total time to complete the entire test packet was forty-two minutes. At the end of the experiment any further questions were answered and participants were given debriefing forms upon completion of the test packet.

Results

Preliminary Results:

One participant was eliminated as an outlier (more than three standard deviations from the mean of number of countries recalled on all three map tasks). Preliminary analysis of participant performance indicates that geographic knowledge was easier to express in the two labeling tasks (labeling and labeling with country list) than in the free sketch map task. The mean number of countries labeled on the free sketch map was 19 (total number of countries labeled, with no evaluation of whether labels were attached to correct countries), while on the labeling and labeling from country list means were 26 and 25 countries accurately labeled (labels attached to correct country outlines), respectively. For the entire participant pool, collapsing across sex, geography courses taken, and course in which participants were enrolled at the time of testing, the difference between the free sketch task and the map labeling from memory task was significant, while the difference between the free sketch task and the map labeling from list task was approaching significance. A repeated measures Analysis of Variance model indicated a difference between at least two of the three tasks, $F(2, 26) = 4.563$, $p=0.015$. Pairwise comparisons indicated a significant difference between each of the map labeling tasks and the free sketch map tasks, (free sketch vs. labeling, $t(28) = 2.468$, $p=.02$; free sketch vs. labeling from list, $t(28) = 2.011$, $p=.054$).

It was hoped that comparisons based on the course of enrolment (introductory geography vs. senior geography), the number of geography courses taken, and sex would provide interesting results related to how we express geographic knowledge and role that different types of geographic training plays in the development of geographic knowledge. Unfortunately the rate of participation by students in the two geography classes made this impossible. Of the thirty participants only seven came from the senior geography class, furthermore, of the total sample twenty-four were females. Comparisons between groups of such different sizes can affect the validity of statistical analysis; therefore, these comparisons will be tabled, at least until a larger sample is collected. One interesting implication of these differences is the relative likelihood of participants volunteering for the study and group membership. That more student participants came from the introductory class is not surprising; there were 153 students enrolled at the time of testing, compared to fifty-six in the senior class. On the other hand the number of males and females in each was approximately the same, indicating that female participation in the study was much more likely than male participation.

While the above pattern of participation was disappointing further evaluation of the relationships among the tasks for the entire participant sample was pursued. That differences exist between the individual tasks was a first step; a comparison of these results with performance on the drawing and spatial memory tasks was next. Performance on the copying and spatial memory tasks indicated that the two were measuring different abilities. The mean score on the copying tasks was 29.4 (out of a total possible of 36), while mean for the memory task was 19.6. Using a repeated measures test this difference was significant, $F(2, 26) = 59.257$, $p=0.000$. As the scale of measurement for the three mapping tasks and the copying and drawing tasks was different, correlation analysis was used to examine the relationships among the various tasks.

Correlation Results:

Using the Pearson Product Moment correlation coef ficient, performance on both the drawing and memory tasks were positively and significant correlated with the free sketch mapping task, r(29)=.393, p=.043 and r(29)=.385, p=.039, respectively (see Table 1 for complete table of correlation results). Neither the drawing nor the spatial memory task was correlated with either the map labeling or map labeling from list task. This suggests a relationship between the non-geographic abilities represented by the drawing and drawing from memory tasks and the free sketch map task. In order to examine the potential diference between the mapping task that included some drawing ability and those mapping tasks relying less heavily on drawing ability correlations were calculated between the three mapping tasks. Unfortunately these results were not as clear as was hoped. While the two labeling tasks were strongly positively correlated, r(29)=.919, p=.000, the labeling from memory (no country list) was also positively correlated with the free sketch mapping task, r(29)=.525, p=.003.

Table 1: *Correlation results. Bold indicates significant Pearson correlation.*

	Free Sketch	List Labeling	Memory Labeling	Copying	Memory
Free Sketch P	1	**0.525** 0.003	0.35 0.063	**0.385** 0.039	**0.393** 0.043
List Labeling P	0.525 0.003	1	**0.919** 0	0.272 0.153	0.244 0.221
Memory Labeling P	0.35 0.063	**0.919** 0	1	0.297 0.117	0.22 0.269
Copying P	**0.385** 0.039	0.272 0.153	0.297 0.117	1	0.36 0.65
Memory P	**0.393** 0.043	0.244 0.221	0.22 0.269	0.36 0.65	1

Discussion

The results of student performance on these relatively straightforward sketch mapping tasks and two more abstract drawing tasks (copying and memory) provide interesting insight into the validity of sketch mapping tasks for evaluating geographic knowledge. In the past researchers have evaluated sketch map output based on both geographic content and drawing ability, but have had difficulty differentiating between the two (Saarinen 1999, 1973). While using drawing ability to measure geographic knowledge (accuracy of country or continental outlines) has been critiqued in the past (Golledge 1987), there have been few attempts to examine the role that drawing ability has on sketch map performance as a measure of geographic knowledge. The current study controlled the dependent variables to those related strictly to geographic knowledge (country names), in an attempt to eliminate, as much as possible, the role that drawing ability played in performance. Even with this control, differences in geographic knowledge as expressed in different sketch mapping tasks occurred.

The first important result of this study was the relationship between the two drawing specific tasks (non-geographic) and the geographic sketch map task that included the strongest drawing component. This result indicated that there was a relationship among drawing, copying, and geographic knowledge as expressed in a free sketch mapping task. Interestingly, there was no correlation between the two non-geographic sketching tasks (complex figure, copying and memory), yet both were related to the number of countries labeled on the free sketch map. This implies that while drawing accuracy (as measured by the copying task) and memory of spatial relationships (as measured by the final memory task) are not correlated, each is related to performance on the free sketch task. This might have been affected by the way each map was scored, the free sketch map scoring did not measure the correct placement of country names, just the inclusion of a countries name on the sketched map. This ability seems related to one's ability to draw complex figures (e.g. country and continental outlines) and remember the complex spatial relationships between shapes and objects (e.g. the relative position of countries, continents, and oceans). The author sees no way to escape this situation as the free sketch maps cover a wide range of drawing ability Furthermore, the labeling task allowed for the inclusion of correct country labels and it seems reasonable to use this information, even to the point of being unavoidable.

Additionally, the relationships among the mapping tasks themselves seem to provide evidence for the complicated processes at work when trying to recall spatial and geographic knowledge.The final mapping task (map labeling from a list) was a purely spatial (geographic location) task, participants did not have to remember country names, they had to relate each country name to the correct outline on the world map. The second map task (labeling from memory) shared components of both the free sketch map and map labeling from list tasks. Participants had to recall country names from memory (as in the free sketch map task), but were provided the spatial cue of world location and country shape (as in the map labeling from memory task). Based on the correlation analysis this task may have more in common with the map labeling from list task than the free sketch mapping task, although it clearly has ties to each.That the final mapping task was only correlated with the labeling from memory task indicates that relating country name (not from memory) to its correct shape and geographic location has more to with spatial, or geographic, knowledge than to drawing ability or ability to draw geographic phenomena (e.g. countries, continents, and oceans).

Conclusions

Sketch maps have a long history as a technique for eliciting both spatial and geographic knowledge (Saarinen 1973, Ladd 1970, Moore 1974). They have been used in a variety of disciplines and have been used as principal and contributing measurement devices in a range of experimental studies (Blades 1990, Saarinen 1999). Many researchers, several of them avid users of sketch mapping devices, have commented on and questioned the validity of sketch mapping and the complicity of drawing ability and other potential confounding variables in the process of producing sketch maps and other spatial diagrams (Golledge 1987, Siegel and Cousins 1985).The current study exposes more explicitly some of the advantages and disadvantages of general styles of sketch mapping and the relationship each has to geographic/spatial knowledge and drawing ability (copying and spatial relation recall). Free sketch mapping tasks that require the expression of spatial components and relationships require greater drawing ability than those tasks that rely less on these non-geographic (in this case) drawing abilities. Future work can build on this understanding and develop more thorough models of the relationship between the non-geographic abilities that inhibit sketch mapping from revealing more truly the nature of geographic knowledge.

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The (in)authenticity of the Prairie: elsewhereness and insideness in Margaret Laurence's Manawaka series

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Abstract: This paper addresses the reinvention of Prairie space and place through the development of Mar garet Laurence's Manawaka series. In her attempt to create the quintessential Prairie town, the 'insideness' of the place she understood as the Neepawa of her childhood permeated the 'elsewhereness' of the fictional town of Manawaka – and, thus, she has forever changed the literary record of the Prairie and our perceptions of that space. Through literary place reconstruction and cognitive mapping, it is shown how the 'elsewhere' landscape of Laurence's fictional Manawaka space is encroaching upon and imbuing its sense of place and its inauthenticity on the actual town of Neepawa.

Contextualization of the Prairie in the Manawaka Series

Margaret Laurence's Manawaka world was *created* as the quintessential Prairie town for 'every man and every woman' with particularities that are emphatically Canadian (Thomas 1975; Payne 1998; Payne 2001). Laurence envisioned a fictional town that could represent any Prairie town in Canada, with qualities and characteristics that typified Prairie living – the rail lines, grain elevators, socio-cultural divisions, a strong work ethic, and a 'traditional' Prairie landscape. In what has been called "the most extensively and consistently developed town in Canadian literature" (Thomas 1975, 174), Laurence has developed a literary record of Prairie life through the creation of the Manawaka series – five books (*The Stone Angel, A Jest of God, The Fire-Dwellers, A Bird in the House*, and *The Diviners*) about the lives and events of the people in the fictional Manitoba town of Manawaka.

The fictional/literary world of Manawaka was highly grounded in contextual space, so much so that one may place the literary world of Laurence's creation in the context of actual location. It is through Laurence's deep understanding of 'place' and her 'insideness' with respect to that place that allows the reader of the Manawaka series to experience, in a literary context, the representative Prairie town she hoped to convey (see Figure 1).

The combination of actual location and the fictionalization of location are oft referred to as 'elsewhereness' (Relph 1976; Tuan 1961; Tuan 1974). Elsewhereness is the re-invention of place where the sources of meaning, essence of place, and/or specific reference to actual location are fictionalized or modified through a lens of artificiality or inauthenticity. In essence, it is the process of making 'some place' some 'other place.' Within the context of literary tourism, it is the traveling to a location to "experience the history and culture" of that location as depicted in literary works (Fawcett and Cormack 2001, 687). It is the process of looking for the inauthentic (the literary world) within the authentic (reality). For the purposes of brevity and space limitations, authenticity and the inauthentic will be treated as noted above, with the researchers' cognizance of the social and value laden nature of authenticity For a more complete treatment of authenticity as implied herein, please see Trilling (1972), Cohen (1979) and Redfoot (1984).

This transformation of space and place "in relation to its opposite" (Urry 1990, 1) has been a prominent theme within the literary tourism literature with respect to the authentic/inauthentic dichotomy (Cohen 1988; Hughes 1995; MacCannell 1973; Moscadero and Pearce 1981; Pearce and Moscadero 1986; Redfoot 1984; Squire 1994). As Hughes notes, the literary tourist makes representations about space based on the literary record. The more detailed the description of the location, the more 'framed' (Hughes 1995) the touristic experience – the greater the expectation that the authentic will represent the literary (inauthentic). Within the context of Laurence's Manawaka series and the actual town of Neepawa there is a complex interplay between the inauthentic and the authentic. The interplay manifests itself in Neepawa where the literary tourism of the town is based on "the intersection of [Laurence] (biographical facts and real places associated with the author) and fiction (settings and characters [of her books])" (Fawcett and Cormack 2001, 687). This complexity arises from the fact that it was through Laurence' s detailed understanding of place based on her 'insideness' that she was able to provide such a detailed fictional town-space that the degree of spatial similarity between the authentic (reality) and the 'elsewhere' (literary) is noteworthy, as this paper will show.

Figure 1: *Mountain Ave., Neepawa (River Street, Manawaka), 1906.*

To explore more fully how Laurence's 'insideness' of the place she understood as the Neepawa of her childhood permeated the 'elsewhereness' of the fictional town of Manawaka, let us begin by developing a shared understanding of 'place' and 'insideness' in order to better identify how fictional space is modifying actual space on the Manitoba Prairie.

The Essence of Place

Places are those constructs of both human and natural orders that are the centres of our existence. Place is not concerned with the geographic location of activity (a grassy field, a city, a fictional landscape – these are the purview of 'space'), but rather place is intent on the experience and meaning of a particular setting. Place has as its basic constructs the objects of space as they are experienced, imbued with meaning, and rooted in activities centred about those experiences and meanings (Tuan 1974). Places are "sources of individual and communal identity, and are often profound centres of human existence to which people have deep emotional and psychological ties" (Relph 1976, 141).

Those deep emotional and psychological ties instil place with the memories of the meaningful events, experiences, and ongoing actions of our existence. As Relph indicates, without 'place,' our lives are devoid of meaning in the world, for "a deep relationship with place is as necessary and perhaps as unavoidable, as close relationships with people; without such relationships human existence, while possible, is bereft of much of its significance" (Relph 1976, 41). The significance to which Relph refers is the broader understanding of our identity - our awareness and consciousness of place is a vital source of both individual and cultural identity and security, a point of understanding from which we orient ourselves in the world.

Place is that memory laden centre of our lives where we develop our sense of being and understanding of the unfolding of life events, grounded against the meanings such events hold for our lives, contextualized by the memories (events, experiences, and their emotional attachments) developed from our place in the world.

Insideness and Outsideness

One of the constructs used to better understand and develop the notion of place is insideness. Insideness, or being inside, is fundamental to the place concept, such that "to be inside a place is to belong to it and to identify with it" (Relph 1976, 49). Such identification is paramount to place, for our identification with a place is more than just the site and situation of a setting, but more importantly it is the entirety of the experience at that setting that gives it meaning, and such meaning becomes part of our memory to identify like places. Insideness is that deep level of understanding about a place that can only be developed through experiences at that place. The more profoundly inside one is, the stronger ones' identity with the place (Relph 1976).

Insideness is developed through the collection of life experiences, where those experiences are contextualized at the individual/personal level. Insideness provides one the ability to place the significance of events in life into the context of time and space. Insideness is that degree of understanding about a place that can only be realized through direct experiential contact and embeddedness of a person in that place.

Outsideness is the opposite construct in this dualistic expression of place and personal identity with space. If one is not inside, by definition, one must be outside. Insideness is an intimate knowledge of place based on the existential phenomena associated with the places, while outsideness is a passivity of experiential connectedness to place. Outsideness to place (therefore, location or space) is as if one is looking at a setting without feeling, meaning, or the ability to truly understand the context of the activities occurring at that location. It is a disconnectedness with the events of the location, and a lack of experiences (memories/local knowledge) in order to contextualize and 'place' that event that gives rise to being 'outside.' Insideness versus outsideness is akin to being an active participant versus being a passive spectator.

Various Degrees of Insideness

As readers of the lives and events that Laurence has created in the town of Manawaka, we experience what is termed 'vicarious insideness' (Relph 1976) – that degree of understanding about a location that gives the reader a sense of what it is like to live at that place. It is the intent of literary writers/authors to provide as detailed a vicarious experience of the place as possible in order for the reader to identify with the characters and to be able to relate "the depiction of a specific place…with our experiences of familiar places" (Relph 1976, 53). It is through this engagement that the reader develops a sense of deeply felt emotional attachment and involvement to the location as it is being described, to the extent that the elements of space and context provide a degree of 'place' for the reader within the context of the literary world.

The extension of vicarious insideness, carried to the next echelon of attachment to 'place,' is 'empathic insideness.' This degree of insideness,

> demands a willingness to be open to significances of a place, to feel it, to know and respect its symbols….To be inside a place empathically is to understand that place as rich in meaning, and hence to identify with it, for those meanings are not only linked to the experiences and symbols of those whose place it is, but also stem from one's own experiences. (Relph 1976, 54-55)

Laurence's works provide readers with the vicarious insideness of her knowledge of the 'place' she understood as the Neepawa of her youth, placed into the context of a lifetime of experiences. It is that lifetime of experiences, both Laurence's and the reader's, that offers a connection with the author's work that transcends mere words and becomes a deeper, richer experience where the essence of 'place' becomes part of the cultural and place-based Canadian Prairie identity.

A Few Questions

Some questions thus arise from the constructs above: Has Margaret Laurence created a true 'elsewhereness' in the fictional town of Manawaka? Further, is it only through the skilful wordsmithing of the author that we develop a sense of 'place' that we, as readers, have been known to associate with the actual town of Neepawa; or has Laurence's understanding of the place and her insideness to Neepawa simply been reconstructed and documented as part of the Prairie literary record under a new/fictional place-name?

Methodology

Throughout the Manawaka series, there are references to places, both proximate and immediate, that when taken in the context of all five books of the series, allow the reader to develop a detailed understanding of the site and situation of the fictional town of Manawaka.The extent to which Manawaka can be 'placed' and situated 'inside' Neepawa can be observed through literary place reconstruction - the ability to accurately recreate space created in prose due to sufficiently detailed descriptions of the location (Pocock 1982; Ferguson 2002). Key to employing literary place reconstruction is, as a reader, to experience the text (a vicariously inside experience) in order to develop a 'sense of place' with the fictional location such that the broader understanding of the locations within all the texts, when taken into collective consideration, allow one to recreate (map) that space as if one had lived, as a member of the community (empathic insideness), in the fictional town of Manawaka.

To reconstruct the literary world of Manawaka, each of the books of the series needed to be considered. The process of literary place reconstruction itself is rather elementary – record each place or locational reference in the text(s), and then site those places/locations *vis-à-vis* their situation, in the context of the fictional town. Once mapped (which is the second phase of the methodology – that of cognitive mapping), the degree of similarity between the maps (reality vs. literary) is evaluated.Typically, cognitive maps are drawn by various readers, and their degree of similarity is assessed. In this instance, since fictional Manawaka is believed to be the actual town of Neepawa, the cognitive map was compared to the actual locations of places in Neepawa.

In order to reduce bias in the interpretation of literary versus actual space, all locational references were recorded by one researcher and those locational cues provided to the other researcher for the cognitive mapping exercise to be conducted without having first visited the town of Neepawa. Once the cognitive map was completed, only then was a street level base map of the town of Neepawa consulted in order to site the places of fictional space relative to actual space – if in fact Neepawa was the construct for Manawaka.

The Findings

Beginning with a street level base map of Neepawa, it was evident that some literary license was taken by Laurence with respect to street names. After correcting for her differing street names (only two corrections were required for the two major arteries running through Neepawa – Mountain Avenue was called River Street in the texts, and Hamilton Street was known as Main Street) all the reconstructed sites fell readily into place. Laurence's attention to detail and the extent to which she described the site and situation of the buildings and landmarks within her fictional world were so specific (when placed within the context of all five books of the series) that the similarity between the locations (Manawaka and Neepawa) is exceptionally noteworthy. Using the 31 specific references made to locations in the 5 books of the Manawaka series, those same locations were sought in Neepawa. If the elsewhereness of the literary world (Manawaka) was grounded in the actual location of Laurence's youth (Neepawa), there would be a high degree of correlation between the maps of these two realms. Table 1 indicates the degree of similarity between fictional and actual space.

Table 1 indicates a high level of correspondence between the settings, to the extent that virtually every locational reference in Manawaka (fictional space) can be linked with an actual location in Neepawa (actual space). Had Laurence simply attempted to construct a generic Prairie town, one with quintessentially Prairie characteristics, the elsewhereness of such a place should have *some* degree of similarity to Neepawa, but for there to be such a high degree of spatial similarity from the fictional world to the real world leaves little room for misinterpretation – Manawaka and Neepawa, Manitoba are one and the same place.

If these two worlds have indeed collided, and their spaces are being shared in the same location, then the cognitive map of Manawaka should serve as a map for Neepawa. To test this statement, a driving tour of Neepawa was conducted using the cognitive map of Manawaka, recording the similarity of locations (as described through the series) photographically and cartographically. Once again, correcting for literary license with the street names (Mountain Ave vs. River St., and Hamilton St. vs. Main St.), every location from the series was referenced back to a location in actual space. Those locations as defined by the cognitive map of Manawaka are identified by the push-pin symbols on Map 1.The map details the sites of locations in Neepawa that match the sites of locations in Manawaka – those sites including identically titled businesses, house names, important buildings, and places identified by the Margaret Laurence Museum as 'important places' to Laurence, her readers, or those on literary tours (see Figures 2, 3 and 4). (As an anecdotal aside, this referential tour spanned a total of 3 ½ hours, both driving and walking about the town of Neepawa, where on more than one occasion the researchers caught themselves referring to places, street names, and businesses not by their names as they appeared before them, but by their names as known in the Manawaka

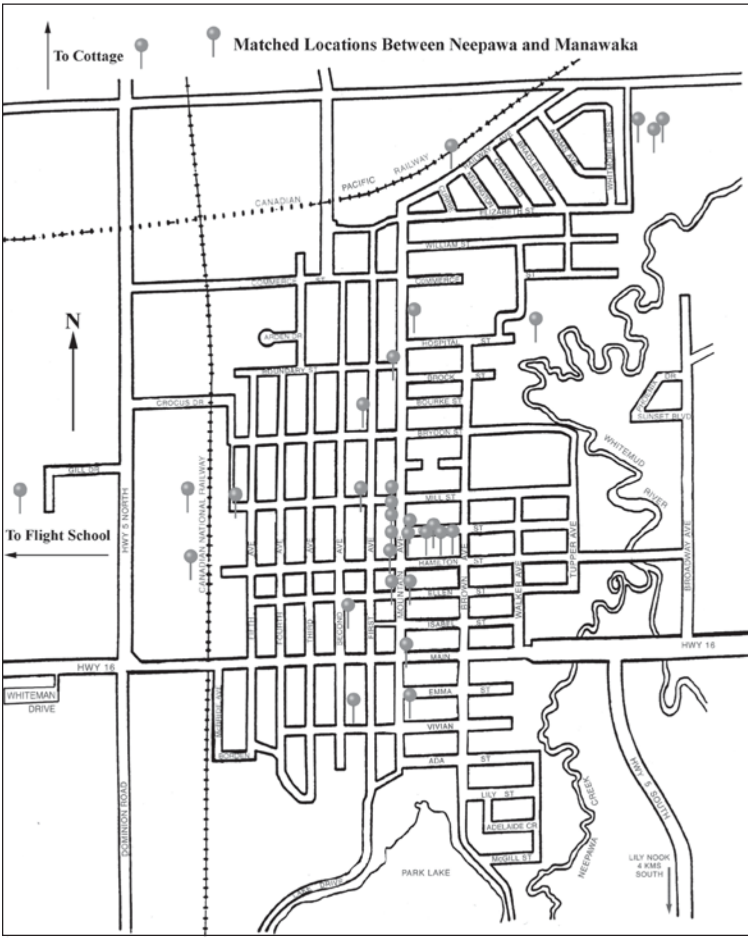
Table 1: *Manawaka locations versus Neepawa locations.*

Manawaka Locations	Neepawa Locations	Book References*
Near Winnipeg	Near Winnipeg	SA, JG, FD,BH, D
Diamond Lake	Clear Lake	FD, BH, D
Galloping Mountain	Riding Mountain	SA, JG, BH, D
RCAF Base	Flight School	FD, BH, D
Wachakwa River	Whitemud River	SA, JG, FD,BH, D
Grain Elevators	Grain Elevators	BH, D
Train Station	Beautiful Plains Museum	SA, FD, BH, D
Manawaka Creamery	Neepawa Creamery	SA
Shacks/Shanties	Small houses near tracks	SA, JG, FD,BH, D
The Dump/Nuisance Grounds	Composting Site	SA, D
Cemetery	1 Smith Drive (Cemetery)	SA, JG, BH, D
Stone Angel	Davidson Memorial	SA
Peonies, Crocuses on Graves	Petunias on Graves	SA, JG, D
Grandfather's House	312 First Ave.	BH
Presbyterian Church	Knox Presbyterian	SA
MacLeod Residence	483 Second Ave.	BH
Public School	Former location of School	SA, JG, FD,BH, D
Christie & Prin's House	265 Vivian St.	D
Cameron's/Japonica Funeral Parlor	580 First Ave.	SA, JG, FD,BH, D
Regal Café	Lee's Restaurant	JG, BH, D
Queen Victoria Hotel	King Edward Hotel	SA, JG, BH
Simlow's Ladies Wear	Myra's Ladies/Men's Wear	SA, JG, BH, D
Bank of Montreal	Bank of Montreal	SA, JG, BH
United Church	United Church	SA, JG, BH, D
Anglican Church	Anglican Church	SA
Manawaka Hospital	Neepawa Health Centre	SA, JG, FD,BH, D
Roxy	Roxy Theater	JG
Court House	County Court Building	BH, D
MacLeod & Cameron Cottages	Family Cottage	BH, FD
Manawaka Banner	Neepawa Press	SA, FD, D
Granite Works	Guinn Bros	D

* *WHERE:*
SA = The Stone Angel, JG = A Jest of God, FD = The Fire Dwellers
BH = A Bird in the House, D = The Diviners

series. Even here, care had to be taken to refer to the factual and fictional places carefully.)

Given the exceptionally high level of correspondence between the settings, the elsewhereness of the fictional space Lawrence attempted to create has been replaced with her insideness of place, based on actual location. Laurence's insideness (her understanding) of Neepawa provided the only Prairie context from which she could write about such places. The highly emotionally charged and memory-laden 'place' of her youth became the point for all spatial and locational references to what she deemed as Prairie.



Map 1: *Cognitive Map of Manawaka Cross-referencing Sites from Table 1*

As one of the most detailed and extensively developed literary place constructions of the Prairie, it is Laurence's very insideness to the place that allows the reader to vicariously experience Prairie life - at least as Laurence defined it. Her perspective, accurate or otherwise, has defined and documented a collage of Prairie existence that is now part of the Canadian, and Prairie, literary record. That record of Prairie living as seen through Laurence's eyes and characterized through the town of Manawaka, has come to be understood as Neepawa, Manitoba, as the literary place reconstruction readily attests.

Figure 2: *312 First Ave. – Grandfather's House.*

Figure 3: *580 First Ave. – Japonica Funeral Parlor.*

Figure 4: *The Stone Angel – The Davidson Memorial.*

For those individuals who, after reading the series, have developed a sense of empathic insideness – that deep degree of connection with the characters and places developed in fiction – and feel the need to experience the 'place' of Manawaka as Laurence has developed it through her experiences and her life in Neepawa, they rely on literary tourism to more fully develop their empathic and vicarious insideness (BTA 1983; Curtis 1985; Pocock 1987; Squire 1988; Squire 1992). Literary tourism is that experience whereby visitors attempt to connect with the cultural heritage of the author through guided or self-guided tours of places of importance to the author. Typically, these places of importance are buildings, streetscapes, or a childhood home. These tours have an interesting effect on 'place'; as Urry (1990) indicates, the literary tourist, instead of seeking actual sites, looks for 'the opposite' on these tours, attempting to find identifiers, traits or characteristics depicted in the 'elsewhereness' of the literature.

Extending Urry's (1990) and Hughes'(1995) constructs into a spatial application of the authentic/inauthentic duality of literary tourism, a question comes to the fore: Does literary tourism in the Town of Neepawa take an authentic location and, through the eyes of the tourist, render it Manawaka (inauthentic) as tourists seek to find visual cues from Laurence's' works? In other words, does literary tourism, then, take 'elsewhere' and make that place 'here,' and if so, what does that do to the identity of the place?

Spatial Identity Implications for the Town of Neepawa

Irrespective of the degree to which the literary tourist believes his or her 'insideness' extends into the community of Neepawa/Manawaka, that insideness fails to fully capture the insideness to which Margaret Laurence developed her sense of place in this Prairie town. These empathic/vicarious insiders re-live Laurence's fictional and factual worlds, her life, and her works, but may never perceive them in *exactly* the same way as Laurence sensed her place in this Prairie landscape. The result is one of 'outsideness' for the literary tourist, for no two people can perceive space in *exactly* the same manner (Tuan 1974).

The tourist, however, has commodified the fictional world of Manawaka in the attempt to see elements of that fictional elsewhereness in the (f)actual town of Neepawa. Imparting such elsewhereness upon actual space fails to capture Laurence's insideness of Neepawa. The very process of commodification of place changes the essence of that place, replacing the insideness that imbued the site with such strong symbolism and character as found in the literary record of Laurence's Manawaka with 'outsideness'. In the case of Neepawa, Manitoba, the 'outsideness' is expressed subtly through elements of the elsewhereness of Manawaka permeating, encroaching upon and imbuing its sense of place and its inauthenticity on the actual Town of Neepawa. This 'emergent authenticity' (Cohen 1988) has resulted in the 'real' being substituted with the inauthentic and fictional. For example, the local art gallery bears the title Manawaka Gallery, even though the community is not called Manawaka (see Figure 5); the Margaret Laurence museum is part of her childhood home, but the museum office (at the back of the house) has been completely remodeled and does not represent the original kitchen and back-room of the house Laurence once knew; and the United church, which was so important to Lawrence, was completely rebuilt after a fire rendering that site no longer an authentic link to Lawrence's Neepawa/Manawaka. The result is an "inauthenticity" of the very environment the 'outsiders' are there to see and experience as literary tourists.

Figure 5: *Manawaka superimposing itself upon Neepawa.*

Conclusion

The 'quintessential Prairie town' as understood and depicted through Margaret Laurence's insideness and sense of place with the Neepawa of her childhood is changing to reflect the elsewhereness of the fictional space she has created. The literary record that Laurence created through inauthentic Manawaka has taken on qualities of what Cohen (1988) termed 'emergent authenticity' as Neepawa's townscape is transforming to explicitly exhibit traits of Manawaka for the literary tourist, as Figure 5 attests.

The findings indicate that of the 31 identified place locations from the Manawaka series, all 31 sites could be situated within Neepawa and its surrounding area through literary place reconstruction and cognitive mapping. This degree of correspondence between the authentic and the inauthentic can readily lead to a misinterpretation of Laurence's intent to create a quintessential Prairie town for all her readers to understand Prairie life. As more of the artificiality of Manawaka emerges into Neepawa, the commodification of the town serves to promote literary tourism based on Laurence's works and her life. The record of Prairie life she attempted to preserve in such socio-cultural and spatial detail is forever being changed from the authentic to the inauthentic.

Laurence's deep understanding of 'place'and her 'insideness'to that place are not fully captured by literary tourists, irrespective of how deep their sense of connection to her works (Redfoot 1984; Tuan 1974). The lens of artificiality through which the readers of the Manawaka series vicariously and/or empathically experience Laurence's interpretation of life in the Prairie town of Neepawa, Manitoba, is acting both as an optic to let 'outsiders' 'into' Laurence's 'place,' and as an instrument that is now letting her world 'out', transforming it, and rendering it inauthentic.

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Inuit housing needs: a Coral Harbour, Nunavut case study

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Abstract: The settlement of Coral Harbour, Nunavut, is characterized by geographic isolation, high rates of population growth and high levels of poverty. This case study, employing a review of relevant literature, analysis of available statistics and key informant interviews, focuses on the housing needs and circumstances of the resident population. Demographic trends and social housing waiting lists illustrate a significant demand for new housing and the young population with high rates of household formation means continued housing demand for many more years. The high cost of housing characteristic of such northern communities as Coral Harbour, when combined with the poverty so prevalent in the centre means, however, that few households can afford housing without public support. Without improved economic development opportunities providing more full time, better paying jobs for local people, public support for new housing will continue to be a high priority for the community. This case study, as well as highlighting housing, demographic and economic circumstances in Coral Harbour, illustrates many of the issues and problems facing Inuit communities in the North.

Key words: northern communities, housing needs, poverty

Introduction

Located on Southampton Island, Nunavut, at the north end of Hudson Bay, the hamlet of Coral Harbour (so named because coral is present in the harbour) is situated at approximately 65 degrees north latitude and 85 degrees west longitude. The community has no road access and is only accessible by plane in winter with the addition of water access (boat and barge) during the short late July to mid October shipping season. The centre is located approximately 500 kilometres (by air) from Rankin Inlet, 825 kilometres from Iqaluit and 275 kilometres from Repulse Bay (Figure

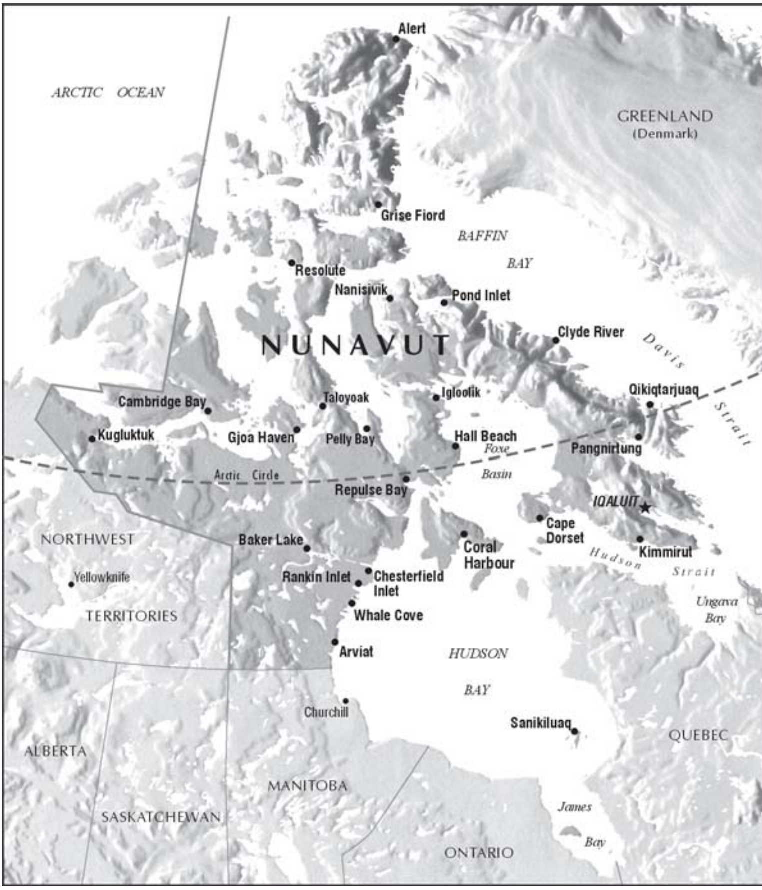

Figure 1: *Location of Coral Harbour.*

1). This paper focuses on the housing needs and circumstances of the community.

The objectives of this paper include: documenting the housing needs and circumstances of the resident population; illustrating how housing has been used to generate employment opportunities; and, highlighting the fact that other economic development initiatives are necessary if the community hopes to address the deep levels of poverty experienced by the population. Although the focus of the paper is Coral Harbour , the issues and problems highlighted by this case study are typical of many northern Inuit communities.

History and Past Development Trends

European settlement in the Coral Harbour area dates from the late 19th century when European and American whalers arrived to exploit the rich bowhead whaling grounds off the coast. In 1899 the Scots established a permanent whaling station on the southern tip of the island (Marketing-ology 2002a).

Early contact with the Inuit proved disastrous as the Europeans brought previously unknown diseases into the region. In the winter of 1902 the Inuit contracted a virulent gastrointestinal disease that wiped out all but one woman and four children who were adopted by other Inuit from the west coast of Hudson Bay. By 1915 the whaling industry in the area had collapsed because of over killing. In 1924, Inuit again began to settle in significant numbers in Coral Harbour as a local hunter had convinced the Hudson Bay Company to establish a trading post on Southampton Island (Struzik 1988). In the 1950s and '60s federal government presence in the centre increased with the building of a school in 1950 and a nursing station in 1963. The government encouraged Inuit to move from their camps to the community to receive health care, social services and education and began building public housing during this period to accommodate families moving to the community. During the same period the Anglican and Roman Catholic Churches established missions in the community The community has continued to grow and today, in addition to being a service centre for the local population, it attracts some tourists because of the rich wildlife in the area as well as the skills of its local carvers, painters and those producing crafts from seal, caribou and other local furs (Marketing-ology 2002b, 2002c).

Methodology

Three approaches were employed to complete the analysis provided in this case study: a review of literature on Coral Harbour and other Inuit communities in the North; a statistical review of data from Statistics Canada, the hamlet office, the housing authority office and the Government of Nunavut; and, interviews with key informants in the community

Key informant interviews were held in May 2002 with sixteen individuals with a good knowledge of the housing, economic development, social, cultural and historical circumstances of Coral Harbour. These individuals included hamlet staff, councillors and the Mayor, the social worker, economic development officer, health care workers, the housing authority manager and tenant relations officer, the school principal, law enforcement officers and administrators of key businesses in the community. In addition to these key informant interviews in the community discussions were held with staff of the Government of Nunavut. Questions during the interviews focused on housing conditions, housing needs, the housing market and housing programs supported by public funds, demographic trends, employment opportunities and issues associated with poverty.

Demographic Trends

The 2001 population of Coral Harbour was 712, up 6.4% since 1996 (Table 1). In the census period 1991 to 1996, the population grew by 15.7% from 578 to 669. The 6.4% growth rate in Coral Harbour in the 1996 to 2001 period is slightly lower than the rate for Nunavut as a whole, which increased 8.1%. Other centres in the area are growing at similar or slightly higher rates: Repulse Bay at 9.5%, Rankin Inlet at 6.4% and Baker Lake at 8.8% (Statistics Canada 2001).

Growth rates in Coral Harbour are much higher than most small communities in the south because of higher birth rates and falling mortality rates, hence high rates of natural increase. Consequently the population of the community is very young. Approximately 53% of the population was 19 years of age and younger (Figure 2). In 2001 approximately 17% of the population was between the ages of 0 and 4; 12% between 5 and 9; and another 15% between 10 and 14. The school principal reported that there would be approximately thirty students going into kindergarten in Fall 2002 and there were between 35 and 40 children born in the community in 2001. Less than 3% of the population is 65 years of age or older (Table

Table 1: Coral Harbour Population Profile - 2001

Total Population (1996)	669
Total Population (2001)	712
% Population Change 1996-2001	6.43
% 65 years + (2001)	2.8
% Lone Parent Families	20.69
% Living Alone	14.71
% Two Parent Families	79.31
% Family Households	76.47
% Non-Family Households	23.53

Source: Statistics Canada, 1996 and 2001 Census of Canada

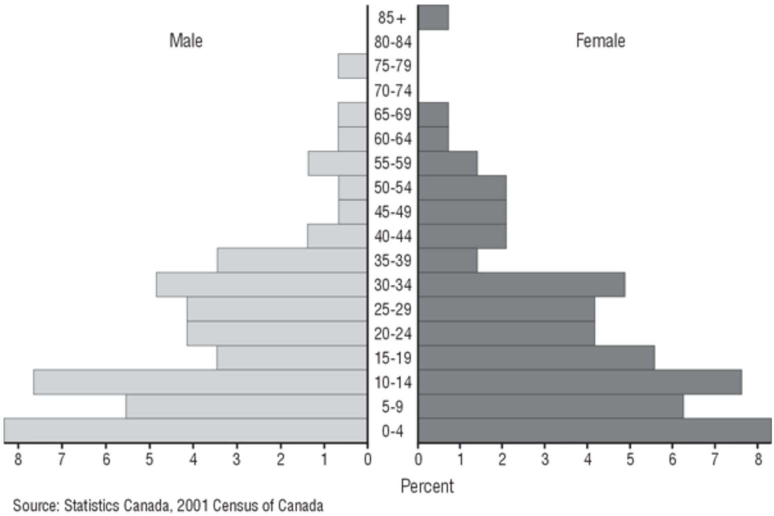

Figure 2: *Coral Harbour population pyramid, 2001.*

2). Although there will be some growth in the number of elderly over the next decade, less than 5% of the population is between 55 and 64 years of age (Figure 2). Some people interviewed suggested that the birth rates are starting to fall modestly as people are beginning to recognize the economic and social advantages of smaller families. However, the young population profile illustrates that housing demand will certainly be strong for the next fifteen to twenty years, as household formation will be high, at least for another generation.

Household size is also worth noting as one-third of the households contain four or five persons and another one-third contain six or more persons. Only 13% are one person households and another 10% are two person households. Average household size, which stood at 4.1 persons

Table 2: Private Households by Household Size - 2001

	Coral Harbour	Canada
1 person households	14.7%	25.9%
2 person households	8.8%	32.6%
3 person households	11.8%	16.3%
4-5 person households	41.2%	22.3%
6 or more person households	26.5%	3.1%
Average number of persons	4.1	2.6

Source: Statistics Canada, 2001 Census of Canada per household in 2001 (Table 2), down from 4.5 in 1996, may continue to fall in the future, but will be larger than the Canadian average (2.6) for many years to come. Falling household size, however, will also increase the number of households and therefore housing demand in the community. Coral Harbour can obviously look forward to robust housing demand for many years.

Household structure in the community illustrates a high proportion of family households. Many are young couples under 20, or 20-24 years of age. In 2001 there were a total of 175 households (Table 3), of which 76% were family households (Table 1). The number of lone parent families (both male and female led) has been increasing and in 2001 comprised 21% of total families (Table 1), up from 15% in 1996. People marry at a relatively young age, according to informants in the community, but with such a young population there are also many single individuals in their late teens and early twenties. Although most of them still live in the family home, persons living alone constituted 15% of all households in 2001 (Table 1). Some of these single households, it was pointed out, were people who had moved into the community from the south to take jobs as school teachers, nurses and RCMP officers. Living alone is not a prominent characteristic of the local population for a number of reasons. Many people interviewed suggested there is a shortage of housing (apartments or units other than single family homes) for single individuals; many local single

Table 3: Coral Harbour Housing Stock Profile - 2001

% Homeowners	31.4
% Renters	65.7
Average Value of Owned Dwelling*	$146,273
Average Monthly Payment (Owner Occupied)	$675
Average Gross Rent	$271
Total Dwellings	175
% Built Prior to 1946	0
% Built Between 1991 and 1995	22.9
% Built Between 1996 and 2001	14.3
% in Need of Major Repairs	8.6
% in Need of Minor Repairs	28.6
% Single Detached Dwellings	70.6

Source: Statistics Canada, 2001 Census of Canada

* Value of dwelling based on owner's estimate of what it cost to build the dwelling. So few private sales occur in Coral Harbour that people do not provide value estimates based on sales or market value.

people cannot afford housing on their own; and, the importance of family and the preference to live with family is strong both until one is married, and later when people become seniors.

Informants suggested that very few people leave the community. Some move to take advantage of employment opportunities elsewhere, generally in other nearby northern communities such as Rankin Inlet or Iqaluit. A few move to further their education. In 2002 four grade twelve graduates left the community. This is the highest number of graduates ever to leave the community in any one year. Usually it is one or two - often none at all. Family is very important, as it is in nearly all Inuit communities. People are reluctant to leave home, and when they do they often return because of family ties. It was the consensus that growth in the community is mainly the result of natural increase as opposed to movement of people into the centre. The high number of births and large family size support this. Very few people move to Coral Harbour to take advantage of jobs because there are generally few jobs not filled by local people, with a few exceptions in education, health care and some government positions.

Economic Characteristics and Major Employers

Coral Harbour is primarily a service centre for the resident population. There is virtually no trade area as the remainder of the island is uninhabited. Major employers in the community include the Hamlet that employs approximately forty people who provide garbage pick-up, road repairs, water and sewer services and maintenance of town buildings, and staff the power corporation and the hamlet office. Other major employers include the school (which provides K-12 for approximately 270 students), with seventeen teachers and four support staff; the Health Centre with six to eight employees; the Northern Store with approximately sixteen employees; the Co-op Store with slightly fewer employees; the RCMP office with four employees; and the Territorial Government with a modest number of employees in Natural Resources, Social Services, Economic Development and Transportation. The Housing Association is also a major employer with seven full time and four part time employees who are involved in functions ranging from tenant relations, administration and accounting to maintenance, repair and construction.

Other sources of employment are related to the natural resources in the area. One of the largest caribou hunts in the North takes place on Southampton Island with hunters from the United States, Mexico, and European countries participating. The hunt can last for up to two months, and employs up to forty local people in a variety of positions, including guides. Informants indicated that if more guides were available the hunt could actually be expanded. The meat is consumed locally or taken to Rankin Inlet where it is prepared for southern markets while antlers and heads are taken out by hunters as trophies or used in local crafts. Coral Harbour would like to develop its own meat processing plant so that it could create more jobs locally.

Guiding and outfitting provide a significant number of seasonal jobs. Tourist attractions include three to six day guided tours to nearby Coats, Bencas and Walrus Islands for watching walrus, birds and polar bears along the coastline. Fishing is also pursued locally for commercial sale and local consumption and fishermen act as guides for tourists. Other local activities that produce jobs and income include carving (soapstone, white limestone which is unique to the area, antlers, walrus ivory and whalebone), beadwork, art, and crafts and clothing from fur Products of the artisans are sold locally to tourists and business people visiting the community or to the Northern and Co-op stores who, in turn, market the products in southern locations. Some of the better artists have agents working on their behalf in the south.

An important characteristic of employment in northern communities is the division of the labour force into two components: positions held by local people and positions held by those from outside the community (outsiders), often from the south (Bone 1992; Carter 1994). The local/outsider distinction generally means an Inuit/White distinction as well. Frequently the division is based on skills and expertise, with outsiders holding the professional and managerial jobs and local labour relegated to less skilled positions. Although this division is certainly evident in Coral Harbour it does not seem as pronounced as in some northern communities. Management at the Co-op and the Northern Store, some of the school teachers and health care workers, the RCMP officers and some government officials are 'outsiders'. However, there is a very strong local contingent in many of the professional positions. For example, nine of the seventeen teachers are local individuals and the Hamlet employs local people in professional and semi-professional/management positions. This is also true of government departments and the health centre. All employees of the Housing Association are local individuals. This helps to address the deep poverty that many households in the community face as most of these jobs are permanent and pay average or better wages for the community.

Overall, however, the basic problem Coral Harbour is faced with is too few jobs. Even some of the jobs that do exist are seasonal and/or part time. The serious nature of the problem is highlighted by the fact that informants, when asked what percentage of the households were on social assistance, provided estimates that ranged from 50 to 80%, depending on the time of the year. The case load is generally much higher in the winter months.

The lack of jobs is closely linked to housing problems in Coral Harbour. People do not have sufficient income to adequately address their housing needs. Governments provide housing in non-market communities like Coral Harbour, but generally never enough to meet the demand. Long-term sustainable jobs that pay a decent wage would provide more households with the income necessary to address their own housing problems or, alternatively, participate in publicly sponsored self-help initiatives that have been effective in providing housing in non-market centres (see "The Housing Market and Housing Options" below). Self-help initiatives, through participant labour, and sometimes cash contributions, reduce the level of public assistance required so more units can be built. Just as important, however, is the fact that without jobs with reasonable incomes, households do not have sufficient income to cover the cost of home operation and maintenance that is so important in preventing rapid deterioration in the housing stock.

Characteristics of Low Income Households

Incomes in Coral Harbour illustrate the bi-modal distribution common in many northern centres (Bone 1992) with those dependant on social assistance and low paying unskilled positions concentrated in the lower income brackets and those in professional positions concentrated in higher income brackets (Table 4). When income is compared to living costs, poverty is pervasive in the community, but it is most severe for young households and individuals. The community is characterized by welfare dependency. In the month of May 2002 approximately 49% of the households were dependent on social assistance (Table 5). It was acknowledged by informants, however, that this proportion was much higher in mid-winter and would fall lower than this in mid-summer

In addition to people on social assistance, there are people who are working part or full time whose income may fall below a certain level, making them eligible for an income supplement: their incomes are 'topped up'. Informants noted that people working as clerks in the Northern and Co-op Stores were often being paid as little as $8.00 per hour and rarely more than $11 per hour. Eligibility for the supplement depends on factors such as monthly income, household size and the age of the children. A few households receive employment insurance and a small number are on

Table 4: Coral Harbour Income* Breakdown for Private Households - 1996	
Under $10,000	6.60%
$10,000 - $19,999	16.60%
$20,000 - $29,999	10.00%
$30,000 - $39,999	10.00%
$40,000 - $49,999	10.00%
$50,000 - $59,999	6.60%
$60,000 - $69,999	13.30%
$70,000 - $79,999	6.60%
$80,000 - $89,999	10.00%
$90,000 - $99,999	0.00%
$100,000 and over	10.00%
Average household income	$51,248
Median household income	$45,696

Source: Statistics Canada, 1996 Census of Canada

*Household income is the combined income of all household members from all sources before income taxes are deducted. Income includes wages and salaries, net income from self-emplyment, investment income, retirement pensions, other monetary income and all government transfer income.

Table 5: Coral Harbour Social Assistance Caseload - May 2002

Household Size	Caseload
Single individual	44
2 people	8
3 people	6
4 - 5 people	21
6 or more people	7
Total Assisted Households	86
Total Households	175
% Households on Social Assistance	49.14

Source: Social Services Department, Coral Harbour disability pensions, but because there are relatively few seniors, old age pensions are not a significant generator of income.

Low incomes, when combined with the high living costs in the community, create significant poverty problems. The high consumption of 'country food' (fish, caribou, etc.) helps lower the cost of living for many but high housing operating costs are an important factor in the poverty equation. Table 6 provides costs for fuel, electricity, sewer and water and garbage pick up for one, two, three and four bedroom units. These costs do not include taxes and maintenance. Although there will always be variations in costs related to life-style factors which can affect water, sewer and power usage, and costs will also vary depending on the age of the unit and the number of persons in a home, these figures do illustrate that operating a home in Coral Harbour is expensive. The depth of poverty is further illustrated by the living allowances for people on social assistance who do not receive high monthly payments, despite the cost of living in the north. A single person on social assistance receives approximately $300 per month; a couple with two children $700 to $800 per month. The depth of poverty is ameliorated to a certain extent by the fact that people in public housing and those on social assistance (generally those with the most severe poverty problems) have very low housing costs. Some, or all, of the operating costs are paid and those in public housing pay rent on the basis of their income. A household earning less than $500 gross income per month would pay a basic rent of $32; a household earning $1,000 gross income a month would pay a basic rent of $192. However, for people in other units, whose utilities are not subsidized, housing represents a significant drain on their income. Housing costs certainly contribute to the level of poverty in the community. Viewed from the other side of the equation, significant public subsidies are required to make housing affordable. Coral Harbour is a community with significant poverty problems that will only be addressed by economic development that generates stable long term jobs that pay a reasonable wage.

Table 6: Housing Operating Costs

Size of Unit	$
1 Bedroom	9,903.28
2 Bedroom	11,483.00
3 Bedroom	11,957.36
4 Bedroom	15,885.84

Source: Coral Harbour Housing Association, 2002

The Housing Market And Housing Options In The Community

Coral Harbour can be characterized as a 'non-market' community. Nearly all housing is provided with the support of public funding. With the low incomes and low or no profit margin (because of low incomes) the private sector is generally not active in the provision of housing. The stock is relatively new with no occupied dwellings left in the community that were built prior to 1946 (Table 3). The housing stock can be divided into four major components (Nunavut Department of Community Government, Housing and Transportation 2002).

1. Public Housing: Built by the federal and territorial governments, public housing units (currently 117 two to five bedroom units) provide rental accommodation for low income families. Rents are based on income and for people on social assistance can be as low as $32.00 per month. The cost of utilities (sewer, water, power, garbage removal, etc.) is included in the rent.

2. Homeowner Assistance Program (HAP): Units built under this program (no longer active) were targeted at those able to afford the costs of home operation and maintenance. The units were provided mortgage free but families had to provide most of the labour to build the home. In addition to providing shelter, the program operated as a training vehicle in home construction, maintenance and operation. The program is credited with generating a great deal of construction expertise in the community that is still there today and utilized extensively in the renovation and maintenance of the existing stock and the construction of new units as well as non-residential structures. All informants spoke very positively about this program.

3. The Access Program: This is a modified version of the Homeowner Assistance Program. People no longer have to build their units, which are generally built by private contractors, but they are no longer mortgage free, although mortgage subsidies lower payments to 30% of the household's gross income. After fifteen years households receive title to the unit.

   Under the two homeownership programs mentioned above, residents are responsible for all utilities, home insurance and maintenance. They are also responsible for local property taxes, which are about $250 per year Responsibility for operating costs represents the most significant difference between the ownership and rental stock in terms of costs. Sixty-two units have been built under the HAP and ACCESS programs.

4. Staff Housing: The community contains some staff housing for RCMP, nursing staff, some teachers and government workers. Rents on these units may be subsidized, depending on contractual arrangements, or people may have to pay rent plus utilities which can be as much as $1,500 month for a two bedroom unit. Some people coming in from the south to work get a northern living allowance ($13,000 per annum) to help cover the high cost of living.

There are only five or six units in the community that were privately built: not enough to constitute a 'private' market. A few HAP homes are starting to change hands but the market is limited because there are only a few households that can afford the cost of these homes (often more than $150,000). The average value of units in the community was estimated at $146,273 in the 2001 census (Table 3). The 2001 census indicates that only 9% of units are in need of major repair and housing as a whole is considered to be in good condition.

Building Capacity, Land and Infrastructure

Despite the limited housing activity in the community, according to key informants there is considerable construction expertise locally. For most activities, such as general construction and renovations, there is an adequate supply of local skilled labour As noted previously, much of this expertise was developed during the delivery of the HAP Program. There is a shortage of skilled sub-trades (plumbers and electricians, for example). Such workers have to be brought in from places such as Rankin Inlet, Winnipeg or centres in Newfoundland. There are contractors locally who often bid on projects but they do not have the necessary pricing and administrative skills to compete with general contractors from these larger centres. However, outside contractors are hiring local labour much more often than they did five or ten years ago because of the improved construction skills of local people.

Land supply is not a problem in Coral Harbour Information from the Hamlet Office indicates approximately 30 building lots are available and there is room for expansion. However, construction has to deal with both permafrost and bed rock, which increases the cost. Nearly all houses are built on piles and do not have basements. Many of the units built are single detached, the housing option preferred by most people. However, more and more of the Housing Association units are duplex, triplex or fourplex as building at higher densities reduces both construction and operating costs.

In addition to the higher costs associated with building in permafrost and bedrock areas, construction costs are also increased by the transportation costs necessary to bring the units, and most material required for renovations and repair, to Coral Harbour by barge (Canada Mortgage and Housing Corporation 2002). This also increases the planning time to build new units. Decisions to build have to be made a year to eighteen months in advance. The building season is also very short. Material does not arrive by barge until mid to late August and houses have to be enclosed by early October if they are to be built in one season. Occasionally material arriving by barge sits until the following year before the home is constructed. This can also increase costs.

There are no underground sewer and water systems or above ground utilidors. All water is hauled in to home storage tanks and sewage is pumped out of holding tanks and hauled to the waste disposal area. Current water capacity (from a well near the town) is adequate to support growth for many years. Sewage disposal capacity is currently adequate but will have to be expanded before too many years to support new growth. Currently sewage is untreated but treatment facilities will have to be introduced within a few years. Electricity is diesel generated and the cost of fuel and transportation (barged in) have increased so electricity costs are high and increasing.

Overall, construction labour and skills and the supply of land do not represent a barrier to the provision of housing. Like most northern communities, however, the cost of dealing with environmental characteristics and transportation costs to bring in construction material makes the building of homes very expensive (key informant interviews; Carter 1993; Canada Mortgage and Housing Corporation 1999; Yukon Housing Corporation 2001). The Mayor pointed out that a family home (three bedroom) that costs $67,000 in centres in southern Quebec will cost about $192,000 in northern centres such as Coral Harbour.

Housing Needs in The Community

Nearly all northern communities are characterized by high levels of housing need (Institute of Urban Studies 1986; Canada Mortgage and Housing Corporation 1999). Coral Harbour is no exception. The waiting list in Coral Harbour currently contains 23 households (Table 7). There

Table 7: Coral Harbour Social Housing Waiting List - February 2002	
1 Bedroom	12
2 Bedroom	6
3 Bedroom	4
4 Bedroom	1
5 Bedroom	0
Sub total	23
Potential applicants	10
Grand total	33
Applications for transfer/trade	5

Source: Nunavut Housing Corporation, 2002

are also ten households that have not yet been of ficially approved but have asked to be rated for waiting list allocation. In addition to these 33 households there are five households waiting for transfers to lar ger or smaller units because of changing household circumstances (family additions, death of a spouse, etc.). Seven new units built in 2002 will reduce the number on the list but with high rates of family formation in the community because of the very young population it is certain that new names will be added. Informants indicated that some people would have to wait two to three years before they received a unit and they did not expect the waiting list to be significantly reduced for many years to come, unless the number of units built was increased significantly

Nearly all the people on the waiting list were young families or individuals so the greatest demand at this point is for one and two bedroom units. Although it is not evident from the population profile, informants also suggested there was a modest demand for accommodation for seniors (55 plus), particularly housing that incorporates services such as meals, housekeeping, social and medical support services and a 24 hour resident supervisor with healthcare/nursing experience (also noted by Canada Housing and Mortgage Corporation 1991 and Carter 1994). A home care program introduced in 2002, may help address some seniors' needs.

Overall, however, the need is predominantly for housing for young families and individuals as is the case with many northern communities (Canada Mortgage and Housing Corporation 1999). People were quick to point out that these people are not currently on the street and do have shelter. Only one person, currently living in a fishing shack outside the community, could be considered homeless. The people who need housing are living with relatives or friends, or are doubled up with other families.

There are many situations where young couples are married and have children but have to live with their parents. There are also single mothers and single fathers living in the same situation. Many young single individuals (late teens or early 20s) also live with friends or relatives, often moving from one relative or friend to the next.

The situation described above means that many of the units are crowded. One instance of fourteen people in a three bedroom unit was mentioned, although this is the extreme. There are also examples of extended family situations that include three generations. In addition to crowding, these circumstances often lead to tension and loss of privacy in the household. Some concern was expressed by many of those interviewed that grandparents, although not victims of physical abuse, were often taken advantage of in such situations as they were left with too much responsibility for child care and money they received from pensions or other sources of income was often used to support other family members.

The crowded circumstances also have implications for health and education. Informants, particularly the school principal and health care workers, indicated that the prevalence of communicable diseases was enhanced because of the crowding circumstances. Health care officials noted that lung diseases, particularly tuberculosis, were problems in the community. From an educational perspective, crowding in the home inhibits a child's ability to find the space and privacy required to do homework and study.

Opinion on the need for an emergency shelter was mixed. Several informants stated that instances of domestic abuse were not common, and people had plenty of friends and family they could turn to for shelter and protection from abusive situations. Others felt that family abuse was a problem for wives and for some elders that live in extended family situations. In the case of the elders, the abuse is generally not physical as has already been pointed out, so short term emergency shelters were not the answer. What is required for people in this situation is long term seniors housing.

Although there is a shortage of housing and some of the units are certainly crowded, the stock in general is in good physical condition. The Housing Association has an extensive renovation and maintenance program and repairs on their inventory are addressed promptly. HAP homes and homes built under the Access program are relatively new. Some staff housing, it was suggested, was in need of repair, particularly the older units. The most notable problem with the housing stock, particularly the older units, is energy efficiency. Newer units in the community have been built to much higher standards.

When discussing the housing problems in general, informants did not describe the situation as a 'housing crisis'. Everyone agreed that more units were needed, particularly for young families and individuals. Everyone agreed that crowding was a problem in some of the units and that the older units in particular were not as energy efficient as they should be, given the cost of utilities in the community . There were also many who noted that some units with support services were required for the elderly (55+). However, without exception, informants indicated that there had been tremendous improvements in the housing circumstances over the last couple of decades. The school principal, who has been in the community for fifteen years, indicated he has seen tremendous improvement in the housing stock since he arrived.With his close contact with students and families over the fifteen years he could also attest to the differences this has made for health and education. Although he thought there was certainly room for additional improvement and more units were needed, he felt it was important to acknowledge the work that had been done in the community. He went on to point out that improvements in the housing stock had also been accompanied by changes in lifestyle: cleanliness as there were improved facilities for washing clothes and improving personal hygiene, for example. He also noted that in the last few years people who smoke have tended to smoke outside the home and this had made a tremendous difference for the children.

Conclusions and Looking to the Future

There is definitely a shortage of adequate and affordable housing in Coral Harbour. More housing is needed for young single individuals and young families, and there is a modest demand for seniors housing with support services. Although seven new units were built in the 2002 construction season, this will not satisfy the need as there are at least 23 households waiting for units. It is unlikely that the need will be addressed in the immediate future without a much more extensive building program, particularly with such a young population and high rates of household formation. Doubling up with family and living with friends and relatives will continue to be the situation for many households for some time. Some units will continue to be crowded.

Despite the need for more units none of the informants interviewed characterized the situation as a 'housing crisis'. They also stressed the significant improvement in housing conditions over the last ten to fifteen years. Nevertheless an expanded building program is necessary and this program should provide a higher proportion of one and two bedroom units.

Given the costs of providing housing in a community such as Coral Harbour there are few options beyond publicly sponsored programs. Although many people in Coral Harbour have the skills to contribute to construction of their own units or units for other people, there are few local resources or agencies that can be drawn upon to provide support for the development of housing units for the poor, and most households fall into this category in Coral Harbour The centre is a non-market community and a high percentage of the households are dependent on government transfer payments. In such circumstances provision of adequate, affordable housing for most households will remain largely a public responsibility.

Although most informants acknowledged that Coral Harbour is not facing a 'housing crisis', without exception there was agreement that the community faced an 'economic development crisis'. Coral Harbour has limited economic options which reduces the potential residents have to obtain year round employment and adequate incomes. Therefore, as the job situation documented here suggests, it is critical that housing development strategies be linked to broader economic development approaches to help create jobs and income for low income people (Canada Mortgage and Housing Corporation 2003). In particular, what are needed most in Coral Harbour are economic initiatives that provide more long term sustainable jobs that pay a decent wage. Until these economic initiatives are in place, the community will remain largely dependent on social assistance and short term seasonal employment. Long-term employment providing reasonable incomes will provide more people with the opportunity to participate in addressing their own housing needs, either by financing the construction of their own homes or, more likely, through participation in publicly sponsored self-help initiatives. Improved incomes also help households cover the cost of home operation and on-going maintenance requirements, helping to prevent the rapid deterioration of homes that is so common in northern communities. Although the construction and maintenance of housing provides jobs, the housing problems Coral Harbour faces cannot be considered in isolation from the need for economic development in other sectors of the economy.

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A home away from home at Grand Beach, Manitoba

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Abstract: From its inception, Grand Beach, Manitoba, quickly became one of Western Canada's foremost recreational, cottage resort localities and it has regained that position despite many years of neglect and abuse. Dominion government surveyors were the first to recognize the recreational possibilities of the beach, but this potential was not realized until the Canadian Northern Railway extended a line up the eastern side of Lake Winnipeg. Under a leasing arrangement with the provincial government, the railway company developed Grand Beach peninsula into an extremely popular lakeside resort and camping area, which during its heyday, was visited by countless thousands of excursionists and longer-term vacationers. This paper focuses on the development of the 'Campsite', an area initially created for temporary summer campers, but which was soon converted to leasehold lots available for long-term cottage development. Although the area is now part of Grand Beach Provincial Park, the cottages built in the old campground still remain. However, they are now being progressively upgraded, converted into more permanent fixtures, and many adapted for year-round use. Surveys of cottagers identify some interesting ownership patterns and reveal the strength of attachment that many of the predominantly urban residents have for their cottages or second homes, as they are commonly referred to in the academic literature.

Introduction

Although it is best known as a popular day resort area, Grand Beach is also one of Manitoba's more important areas of cottage development, having been developed nearly a century ago during the First World War. The cottages at Grand Beach were a significant factor in the creation of the province's first series of Provincial Parks, dating back to 1961 (Lehr 2001). Some of the story of Grand Beach has already been told (Lemoine and Barnfather 1978; Lehr, Selwood and Badiuk 1991): Grand Beach resort was established by the Canadian Northern Railway to complement

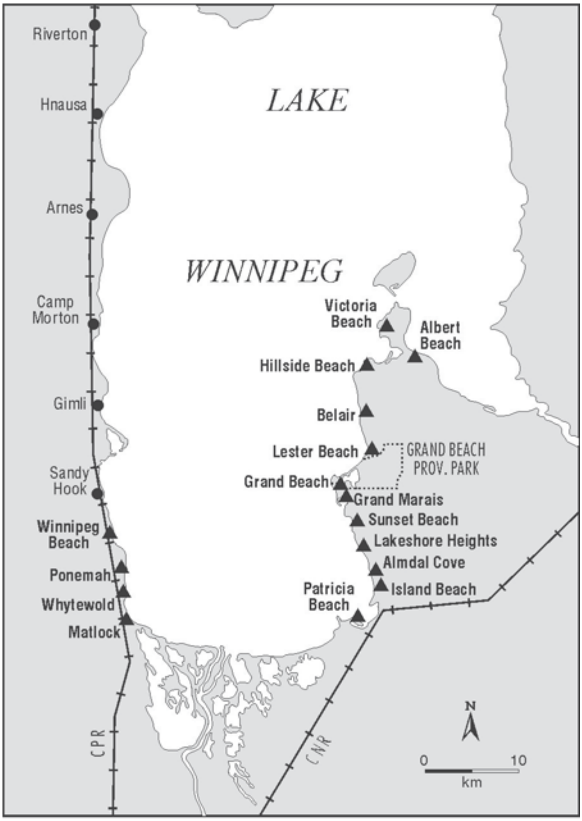

Figure 1: *Southern Lake Winnipeg Resorts.*

its interests at the relatively exclusive Victoria Beach some 25 kilometres to the north (Selwood, Badiuk and Lehr 1983) and to compete with Winnipeg Beach, the Canadian Pacific Railway's popular resort on the west side of Lake Winnipeg. Grand Beach thus became one of a number of similar purpose-built cottage communities ringing the southern end of the lake, serving a population drawn largely from metropolitan Winnipeg located some 90 kilometres to the south (Figure 1) (Lehr, Selwood and Badiuk 1991). In many ways, Grand Beach is typical of the many cottage communities described in the growing literature on second homes in Canadian cottage country (Wolfe 1951; Lehr, Selwood and Goatcher 1984; Jaakson 1986; Stadel and Selwood 1996; Halseth 1998). There are also many parallels that can be drawn from the international literature (Coppock

1977; Selwood, Curry and Koczberski 1995; Galent and Tewdwr-Jones 2000).

This paper has two primary objectives. The first is to examine the history of Grand Beach, filling in hitherto missing details of how its distinctive cottage landscape has emerged. The second objective is to capture the strong sense of attachment, or sense of place, cottagers have developed for their community through the more relaxed nature of cottage life and through reinforcement of kinship and friendship ties. Previous work (Boholm 1983; Selwood, Curry and Kozberski 1995: Russell 2000) has indicated that cottagers can develop extremely strong ties with their vacation property that are reflected in length of residence, kinship ties, and potential conversion of the vacation home into the principal residence. As Jaakson (1986, 371) states: "There is a culture centred on the cottage. The cottage has a deep, almost mystical meaning to many Canadians". However, these aspects of cottage life are relatively overlooked topics in the academic literature on second homes. Archival research into newspapers and corporate records, supplemented by informal interviews with long-term cottage residents, reveals much of the development history; whereas the informal interviews and a structured survey of the cottagers at Grand Beach investigates their feelings about life at the cottage and the importance of the second home in fostering kinship ties.

Beginnings

As soon as it became accessible by rail, Grand Beach, at the northernmost end of Grand Marais (Figure 2), quickly developed into one of the earliest and most popular summer vacation spots in Manitoba. (Stadel and Selwood 1996). Grand Marais (Big Marsh) was named by La Verendrye in 1783 (Lemoine and Barnfather 1978) and Mills (1997) indicates that the critical areas of the wooded headland in the eastern half of Section 24, Township 18 Range 6E, now generally known as Grand Beach, were homesteaded at the beginning of the twentieth century, with one Gilbert Dennett receiving his patent for the southern portion in 1901 and Charles Henry Powell obtaining his patent for the northern portion in 1911. By 1909, dominion government surveyors had targeted the sandy beach enclosing the lagoon in Section 19 to the east of the headlands as a potential vacation spot and they subdivided the area into villa lots. However, a plan of subdivision was never registered at the Provincial Land Titles Office. Just how the area came to the attention of William Mackenzie and Donald Mann, principal owners of the Canadian Northern Railway, is not known, but in 1912, the government withdrew its plan for the beach in

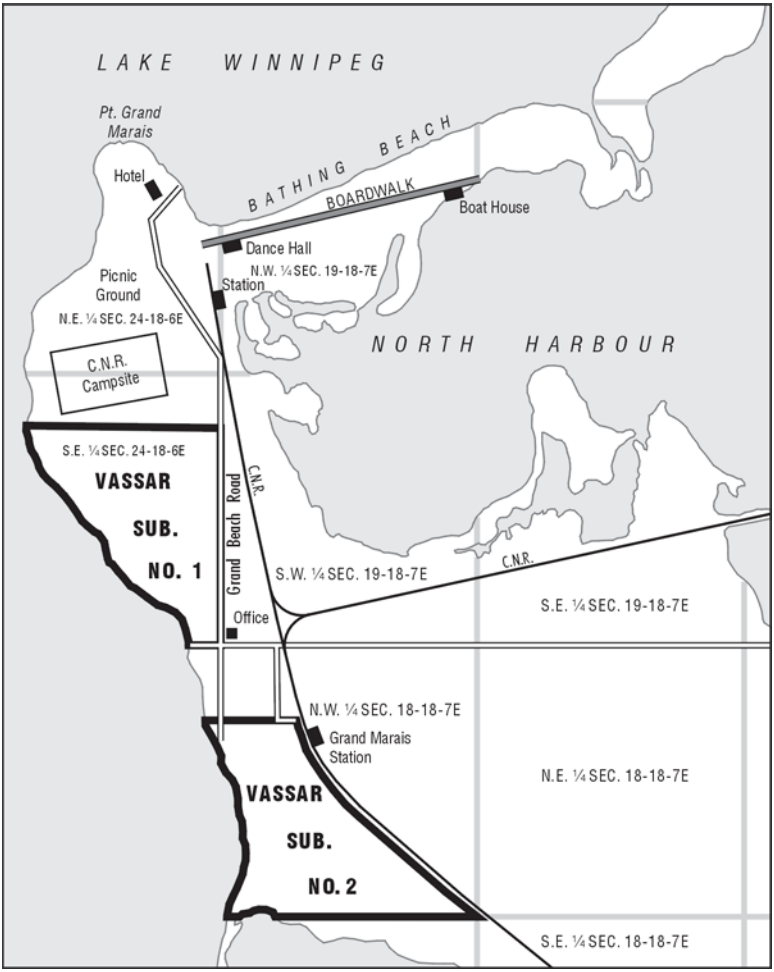

Figure 2: *J. Vassar's subdivisions at Grand Marais.*

response to the railway company's proposal to develop the area as a major summer resort. Through their company, Mackenzie, Mann & Co., the partners secured control over all of the property in the area, leasing the land in the more immediate vicinity of the fine, sandy shoreline at Grand Beach from the government (Mackenzie, Mann & Co. 1915; Lynch, 1919).

Even before its line from Winnipeg to Grand Beach officially opened on 17 June 1916, the Canadian Northern Railway began to hold picnics there for its employees (*Manitoba Free Press* 17 June 1916; Lemoine and

Barnfather 1978) and during the height of the first official operating season, excursion trains were already taking up to 4,000 people a day up to the beach. Since there was no built accommodation, the railway had to return them to Winnipeg on the same day, except for the few diehards who camped in the sand dunes. However, shortly thereafter, the company installed a couple of sleeping cars, with berths available at $1.00 per night, along with a dining car supplying food for 50 cents a meal. A tenting area was also prepared for campers and they were informed that: "Pending the completion of plotting the land, campers will be allowed to pitch their tents free of charge on sites of their own choosing" (*Manitoba Free Press* 19 June 1916, 4).

These temporary arrangements provided the railway company's executives with time to clarify the land ownership situation and to prepare development plans for the property. The company had been involved in a complex series of dealings in gaining control of their landholdings. Their interests in the land had been accumulated over a period of years and, by 1918, extended as far south as Balsam Bay, some four miles to the south of Grand Beach. In July 1916, R.G. Mackenzie, William Mackenzie's son, General Manager of the Canadian Northern Railway, who had been delegated the responsibility for developing the area, visited the site with the company's architect, Charles W. Leavitt of New York. In instructing his architect, Mackenzie argued that the land sales be restricted to a subdivision in the neighbourhood of Balsam Bay, where there was a fine, sandy beach. The rocky sections were to be cleared of stones and these used to build cottages of quality. According to Leavitt, Mackenzie's position was that the headland at Grand Beach should not be sold. Instead, his vision was:

> For a huge picnic ground with a hotel on the northmost point and perhaps a row of cottages along the western part of the land overlooking Lake Winnipeg. He then wished to carry out our scheme for a boardwalk, fakir shows, bathing pavilions, baseball, boating, etc., etc., on the sand beach running out to the east from the land which is now owned by the railroad and he is endeavoring to make a lease of this land from the Government. (Leavitt 1916a)

After going over the ground with Mackenzie, Leavitt was assigned to draft up a plan of the proposed layout for the area, produce a concept plan for the hotel and its associated cottages, and provide detailed plans for the boardwalk, which Mackenzie saw as the top priority. Leavitt (1916b) sent his plans to R.J. Mackenzie in December 1916. By mid-1917, the company had secured its lease with the government, had assumed control over all the lands at Grand Beach, and was in possession of the transfer documents (Mitchell 1921).

The development plans proceeded, although complications arose over issues of land ownership and control, the complexities of which are unclear. The parent company retained its controlling interest. However, the southern portion of the landholding had been acquired partly in R. J. Mackenzie's name, partly in the name of the Canadian Northern Railway and partly by the Grand Marais Development Company, controlled by J. S. Vassar, a realtor who appears to have acted on behalf of the railway company (Mills 1997; Coyle 1917; Mackenzie 1917). The southern portions of the property, identified as Grand Marais, were subdivided and developed by the Grand Beach and Balsam Bay Summer Resorts Limited, and marketed as the Vassar Properties, with J.S. Vassar as the principal agent (Figure 2) (Vassar 1922). These subdivisions were laid out in conventional suburban form, containing larger, freehold lots, unlike the adjacent significantly smaller, leasehold lots designed for tenting that were laid out on the Grand Beach promontory by the Canadian Northern Railway. The latter subdivision was commonly referred to as the Campsite, denoting its original purpose (Figure 2). There were brief delays in the expansion program caused by the bankruptcy of the Canadian Northern Railway, its takeover by the Canadian government in 1916 and the transfer of its properties to the Canadian National Railway (CNR) in 1918 (Fleming 1991). Some controversy also arose between the partners over building agreements. For a short while, the campground improvements were jeopardized because Vassar insisted that his arrangement with the Canadian Northern Railway had been that no campsites would be leased once the Vassar property had been readied for market. In return, he had committed to selling lots only for residential and not commercial purposes (Warren 1920). Vassar's objections were obviously over-ruled and the Campsite stayed.

Grand Beach developed rapidly during 1918, beginning with the season's opening on Arbor Day (4 May). The beachfront was improved, with bath houses provided for rental. The railway company also built a modest "sleeping house" and made significant improvements to the Campsite. Special trains to the lake were dubbed "Greater Production" trains in expectation of "hundreds of campers [fixing] up the gardens and potato patches at their summer cottages" (*Winnipeg Tribune* 4 May 1918, 8). Already, by 1918, many of the campers were holding on to lots that they had leased in the previous year. By that time, all the camping sites had been pegged with white markers, with avenues and blocks signposted. Electric lighting had also been installed, adding to "comfort of the campers, as well as adding beauty to the scene." (*Manitoba Free Press* 17 June 1918, 4). Walter Pratt, General Superintendent of the Canadian Northern

Railway's Sleeping, Dining and Parlor Car, Hotel and News Department, in reviewing the year's operations at Grand Beach, noted that the excursion traffic had been very profitable, urging that future expenditures be directed towards developing that market. Significantly, he recommended against construction of the grand hotel, arguing that the weekend holidaymakers would not warrant the expenditure. However, he stressed that the campsites had been most popular, with the 300 sites the railway had made available all being rented or sub-let. He therefore suggested that weekenders should "look for their accommodation as guests of the campers, or … experiment with a few camp cottages which would be partly furnished and which we could rent for periods during the summer months" (Pratt 1918).

The Campsite's immediate acceptance can be inferred from the veritable absence of space devoted to its promotion in Winnipeg's newspapers. A detailed search revealed only a small, single column advertisement in the *Winnipeg Tribune* (31 May 1919, 2) as follows:

> GRAND BEACH IDEAL FOR CAMPERS
>
> Beautifully treed, high and dry camp sites may be secured at this popular summer resort on application to Tourist and Travel Bureau, Canadian National Railways, corner Portage and Main. There are a few left at $5.00 per month, $10 per season. They are electric lighted. Water supply. Groceries supplied at standard prices. Ice free. Fruit at reasonable prices. –Advt

Evidently, campers and the tens of thousands of excursionists provided a ready market for the campsites

The Grand Beach Campsite subdivision was located on the promontory west of the railway station and divided into a series of rectangular blocks that eventually contained five hundred or so lots in total (Figure 3). The lots were small, most of them only 35 feet wide by 75 feet (10.686 X 22.872 metres) deep because of their originally intended use as temporary, seasonal tenting sites. However, more permanent structures were quickly erected. An interim structure was the 'Donaldo', basically a tent on a wooden platform, with a timber frame and partial cladding on the sides (Figure 4). Leases were for the summer season, generally running from May to September, although due to the War and civil unrest, the season varied. The Winnipeg General Strike, for example, severely disrupted the opening in 1919 (*Manitoba Free Press* 29 May 1919). Because leases became renewable annually, the temporary structures were soon replaced with more substantial, but still modest timber framed structures, a few of which survive, although they are now fast disappearing (Figure 5).

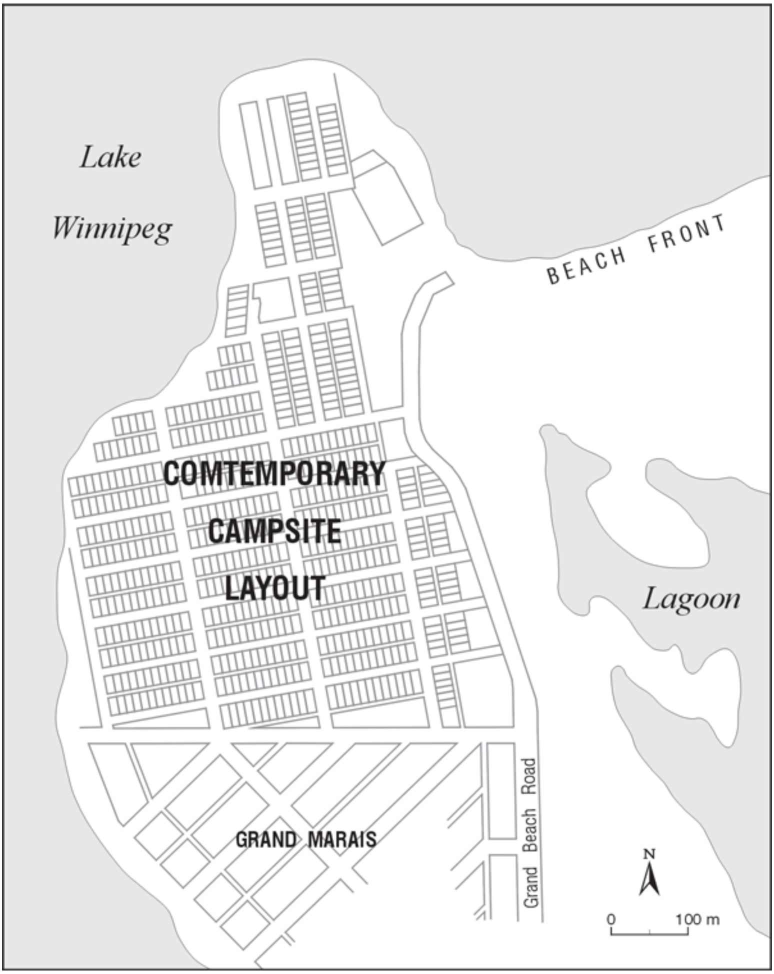

Figure 3: *Plan of Grand Beach Resort and 'Campsite'.*

Much to the annoyance of CNR oficials, in promoting his subdivision at Grand Marais, Vassar featured virtually all of the amenities and facilities that were actually located on the railway's property at Grand Beach. Vassar's promotional material indicates why holidaymakers so readily accepted it:

Figure 4: *An early 'Donaldo' at Grand Beach. Source: Public Archives Canada #88035*

Figure 5: *Older, original cottage on right. Note replacement cottages on left.*

YOUR OPPORTUNITY TO PURCHASE A SITE FOR THE SUMMER HOME IN THE HIGHEST CLASS SUMMER RESORT IN WESTERN CANADA

You all know the property, and have no doubt spent many pleasant hours strolling down the shady dells, bathing in the clear lake water, or taking sun baths on the wonderful sand beach.

Here you may partake of every form of summer recreation to your hearts' content. There are ample grounds for baseball, tennis, football, etc., the finest bathing beach in Western Canada, excellent boating and sailing facilities in the land-locked lagoon or on the open lake.

The ardent follower of Izaak Walton will find conditions to suit his taste, while the Nimrod will be at home in the duck marshes scattered at intervals along the lake shore, or later in the season, back in the deep woods after the big game. (*Manitoba Free Press* 4 August 1920, 20)

Life at the Campsite

Life at the cottage during the summer months at Grand Beach had a style of its own. The season's opening day at the Campsite was an auspicious occasion:

About 2,000 people were taken to Grand Beach on Victoria Day, where the opening of the camping season was ushered in with a great deal of pioneer activity. Two trains were run from the Union Depot, arriving at Grand Beach at 11 a.m. and 11.20 a.m. respectively. A single train brought the majority of them back to Winnipeg in the evening, the remainder staying over the week-end.

There were few or no ordinary day excursionists. The cool weather and a fringe of pack ice inshore discouraged the beach fans, pure and simple. The woods absorbed the crowds as soon as they left the train. The beach, with its bath-houses, dancing pavilion, lines of beached row-boats and other hall marks of a conventional summer resort was practically deserted. Occasional explosions of fire-crackers and shouts of celebration woke the echoes.

In the shelter of the woods a scene of industry presented itself. Camps of every description, from the folding tent of the Arab, gipsy wigwams and marquees, up to smart frame cottages were undergoing construction, extension, or house-cleaning. A jovial camping spirit, tempered with the earnestness of immigrant home-builders, was everywhere in evidence. Business men in bright, new overalls hammered their thumbs industriously, while daughters, in breeches and sweaters, sawed lumber

> and laid refractory flooring. Towards noon a great deal of water was carried – and not a little was spilt: smoke began to rise from fires, both in and out of stoves, and a sniff to the leeward of each camp gave appetizing intelligence of menus in course of preparation. Stores, boldly proclaimed as such by many finger posts and copious placarding, did a brisk trade in forgotten items, and arranged on shelves the nucleus of a summer's stock. (*Manitoba Free Press* 26 May 1924, 4)

This lyrical description effectively sums up the atmosphere at the beginning of summer 1924. Another passage from the *Manitoba Free Press* (2 July 1918, 4) suggests that the more relaxed life at the cottage led to more egalitarian behaviour between the sexes:

> It is probable that in camp is the only place where husbands do a fair share of the housework. There they are literally hewers of wood and drawers of water, besides sometimes assisting at truly feminine tasks. One hapless benedict was cheerfully performing that job which is so often a bone of contention, "dish washing." The very vigorous method in which he polished them left no doubt that they would be well done, and from the smiles with which he favored the passers-by it was evident that he harbored no rancour for "wifey," who had left him to his fate.

Life at the Beach was not always idyllic for 'wifey.' One early resident, when recently interviewed, recollected how reluctantly she spent her summers at Grand Beach, wishing she were back in Winnipeg where she had her modern conveniences (Anonymous(a) 2002). While her husband was away, working on the trains as a brakeman, she was marooned at the cottage for the entire summer, looking after her two young children and an infant, still in diapers. She recalled hauling water from the communal well, living with the rain, trying unsuccessfully to light the wood stove, freezing cold, and washing the diapers in frigid water while trying to keep the kids occupied. Her refrigerator was a secondhand store cooler, kept cold by a 25 cent block of ice, which by the time it reached the cooler, after being hauled in on a two-wheel cart over the rough road, 'had shrunk to the size of a chocolate bar.' Roads in the Campsite were then mere footpaths, winding through the bush and around large rocks. Everything for the cottage had to be carried in from the train station. However, there were stores at Grand Marais, just outside the Campsite, which stocked most necessary supplies for an extended stay. During peak season, it was common practice for families to live in the rear of their cottage and rent out the verandah, an arrangement that helped with the expenses, but which contributed to the intensity of activity in keeping with the communal atmosphere of the resort.

In its heyday, Grand Beach boasted a range of facilities and entertainments that went some way towards meeting the railway company's ambitions of making it the "Western Coney Island" (*Manitoba Free Press*, 14 June 1916, 10) and which also contributed to the variety of activities available to the cottagers. In high season, there were two 'Moonlight Special' excursions from Winnipeg each evening, running trainloads of young couples up to enjoy a flirtatious, romantic, or downright sexual evening at the magnificent dance pavilion or a stroll along the boardwalk into the sand dunes (Broadfoot, 1973). There were many other, more innocent entertainments enjoyed by the tens of thousands who visited Grand Beach each year. Along with a host of other company and institutional picnic excursions, the Caterers' Association, whose members were mostly drawn from the small grocery store owners of Winnipeg, put on the Caterers' Picnic on a Wednesday in July. It was the biggest social event of the season at Grand Beach, a festive occasion when up to eight, twenty-car trainloads of people from Winnipeg took their picnic lunches to the beach to enjoy an afternoon of parades, beauty pageants, races, free drinks and general carousal on the picnic grounds. The celebration wound up at the dance hall, before the excursionists took the train back to town. Of course, these events added zest to the life of the cottagers, many of whom were also active participants. (Anonymous(a) 2002).

However, changing fashions in recreation and regional improvements to the transportation system eventually undermined the popularity of Grand Beach. After the Second World War, growing automobile ownership led people to abandon the railway as their preferred transport mode. Although intrepid travelers had been able to reach Grand Beach via logging roads as early as the 1920s, the going was very rough until the 1950s when road surfaces were improved. By then, highway improvements in other parts of the province had opened up many new resort areas, leaving the beaches of Lake Winnipeg to wallow in declining popularity as the railways allowed their facilities to deteriorate and car owners used their new found mobility to motor further afield. The dance hall at Grand Beach was not rebuilt after it burned down in 1950; the trains finally stopped running in the late 1950s and the lines were torn up in 1963 (Lemoine and Barnfather 1978). Grand Beach also garnered a reputation as a gathering spot for rowdies, notorious for drunkenness, vandalism and other anti-social behaviour, giving the resort a very negative image (*Winnipeg Tribune* 9 July 1955; *Winnipeg Tribune* 4 June 1956). Fortunately for those who remained committed to Grand Beach, its reputation began to be restored after the provincial government took over the area in 1961, converting it into a

Provincial Park and beginning a long term and extensive program of improvements that are still underway (Lehr 2001).

Most of the improvements were designed to conserve and provide for better and wider public enjoyment of the parks' natural features, along with the restoration of a broader range of activities than had become available with the resort's decline. The cottagers benefited from many of these general improvements and they were also affected by changes in administration of the Campsite. By and large, services and infrastructure have been upgraded, although at the cost of increased leasing fees. Leaseholds are progressively being extended to twenty-one years and more stringent rules have been introduced pertaining to sanitation, wherein refurbished cottages are now required to have internal plumbing and to be hooked up to septic tanks. Other aspects of development are also more heavily regulated, with cottagers now being subject to provisions of *The Cottagers Handbook*, a 30-page booklet produced by the provincial government (Manitoba Conservation 2001). Many of these regulations stem from the trend towards the cottages being adapted for a longer season, or conversion into year-round, winterized habitation. Given these changes and their reflection in the cottage landscape, it was deemed appropriate to examine the effects they may have had on the cottagers' lifestyles and appreciation of their community.

The Cottager Surveys

During the summer of 2002, the authors undertook a systematic questionnaire survey of cottage owners at the Grand Beach Campsite and interviewed several residents in greater depth. These enquiries were designed to flesh out our understanding of the cottagers' appreciation of their holiday environment and to gain a better sense of their strength of attachment to the community. Space does not permit an exhaustive analysis of the questionnaire survey. However, some of the results can be highlighted. Unfortunately, it was not possible to obtain a comprehensive listing of the leaseholders from the province; therefore survey forms were deposited in the mailbox of every other cottage in the subdivision. Out of the 250 survey forms circulated, almost 70 usable responses, or nearly thirty per cent, were returned. The completed surveys reveal a number of significant observations, especially when taken in conjunction with the extended personal interviews and field inspections. Virtually all of the cottage owners are from Winnipeg, coming from a range of localities within the city (Manitoba Conservation 2003). Despite the modest size and the relatively low prices of cottages in the Campsite, their owners are not drawn primarily from lower middle income suburbs as one might expect. Moreover, since more than 50 per cent of respondents indicated that they spent virtually all of their time at the cottage during the summer months and almost all spent at least a week there, Grand Beach can be truly understood to be a community of second homes, especially since many of the cottagers used them well into the fall (Table 1).

Table 1: *Usage patterns.*

	Fall 2001		Winter 2001		Summer 2002	
	#	%	#	%	#	%
Someone stays nearly every day	5	7.2	1	1.4	35	50.7
At least one stay of 6 nights or more	7	10.1	1	1.4	26	37.7
Frequent short stays	36	52.2	1	1.4	6	8.7
Occasional use	17	24.6	22	31.9	N/A	N/A
Not used	3	4.3	43	62.3	N/A	N/A
Rented to others	N/A	N/A	N/A	N/A	1	1.4
No response	1	1.4	1	1.4	1	1.4
Total	69	100.0	69	100.0	69	100

Many leaseholders also claim a longstanding commitment to the Campsite, with over fifty per cent of families having owned their cottage for more than fifteen years (Table 2). Furthermore, some families boast multi-generational attachments to the area. For example, one interviewee told how she first went to Grand Beach on long weekends back in 1932 to stay with a group of young girlfriends (Anonymous(a) 2002). She later introduced her husband to Grand Beach, which they continued to visit periodically during the 1930s and through the Second World War. Those were quiet times, but as life returned to normal in the late 1940s, after a season of renting a cottage there, they bought a place in 1949. In 2001, the original cottage was removed in a ceremonial 'tear down' attended by relatives, including nieces, grandchildren and friends who had enjoyed holidaying at the place through the years. However, the lot is still in the family, now owned by the daughter, who has built a new fully winterized cottage with all modern conveniences. But the old cottage symbolically lives on, because when it was torn down, some of the boards were deliberately used to decorate the daughter's home. Ironically, after living most of her life in Winnipeg's south Fort Rouge and the east side of the lake, she is now back on the other side of the lake in a retirement home, but she still regularly visits the new cottage at Grand Beach, even during the winter.

Table 2: *Length of ownership of property.*

Period	Frequency	Cumulative Percent
1921-1959	5	7.2
1960-1969	8	18.8
1970-1979	8	30.4
1980-1984	7	40.6
1985-1989	10	55.1
1990-1994	12	72.5
1995-1999	14	92.8
2000-2002	5	100.0
Total	69	100.0

Other extended families possess several properties in the area. For example, one family group now has a total of six cottages in Grand Beach and Grand Marais (Figure 6). This five generation 'dynasty' of cottagers originated in the 1930s when a CNR patrolman at the beach met and married a young woman working as a cook at the hotel. They did not acquire a cottage at the beach, but a daughter and her husband purchased a cottage in 1950. They later acquired another cottage, eventually knocking that down and building anew in 1960. They still occupy this cottage. One of their children and four of their grandchildren also now own cottages in Grand Beach or Grand Marais. Due to the marriage of one of this family into another Campsite cottage owning family, there are currently six cottages owned by the extended family. Given that all family members, whether owners or not, have access to one or other of these cottages, when the youngest generation of children are included, there are now more than thirty family members who on occasion vacation in the community. At least one of the newer cottages is fully winterized and is used throughout the year for weekends and more extended stays. Its owners fully intend to retire at Grand Beach, converting their cottage into their principal residence (Anonymous(b) 2002).

Most cottages in the Campsite are occupied more heavily during the summer months. However, the majority are used at least occasionally through the fall and a goodly number into the winter months (Table 1). Overall, the cottagers feel very positively towards their cottage getaways and the beautiful natural surroundings. They are reasonably happy with the level of maintenance as well as the security provided by the park administration. They are generally well disposed towards their community and acknowledge that their relatively inexpensive lease on a modest sized

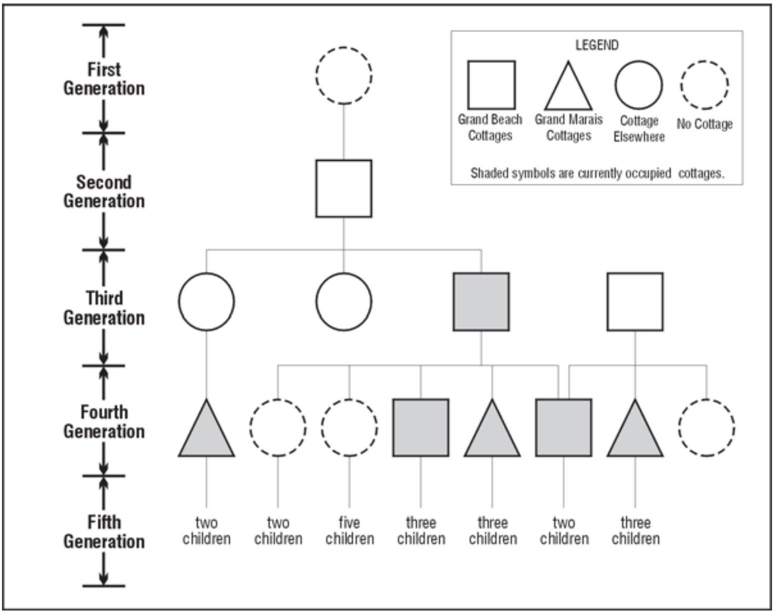

Figure 6: *Multi-generational links within an extended family and their cottagers.*

lot provides them with an economical holiday home. However, these positive attributes are partially offset by a number of concerns.

To some, the high density of the settlement and the constraints imposed by the leasehold generate resentment. A common complaint is that there are too many restrictions on cottage expansion, patio construction, and parking space. These complaints are fairly widespread and aggravated by allegations that the regulations keep changing and have not been applied uniformly. Although many of the cottages are being upgraded and winterized, there is little indication that they are being converted to principal residences. Many people still have qualms about the limitations imposed by the leasehold tenure, the additional levy on converted properties, and the special provisions imposed by the Manitoba Conservation Department (Manitoba Conservation 2001).

Survey respondents differed widely in their opinions as to what kinds of activities should be acceptable at Grand Beach. Some cottagers cherished the natural environment and the tranquility of their vacation home and were vehemently critical of beachgoers, neighbours and visitors who became rowdy, or partied well into the night. Others countered that such people were ‘party-poopers’ who needed to ‘loosen up’ and enjoy the relaxed atmosphere of the holiday community. Several cottagers felt strongly that there was not enough to do at Grand Beach and that a wider range of non-beach related activities was needed. These sentiments correspond with those of an earlier survey conducted among Grand Beach cottage owners, when a high proportion of them expressed their support for a luxury, four-season resort being established there (Manitoba Industry Trade and Tourism 1989). It is evident that there are contradictory notions about what a cottage vacation environment should provide.

Conclusion

Cottaging at Grand Beach now goes back almost a century and during that time the community has enjoyed periods of heightened activity, then languished in disfavour as other, alternative vacation spots became available. Nevertheless, some cottagers have retained an allegiance to the locality through several decades. The recent resurgence in the popularity of Grand Beach cottage community is reflected in the large numbers of people now upgrading the older cottages, bringing them into line with the more restrictive regulations imposed by the provincial Department of Conservation. Many of the older cottages are becoming 'tear downs' and being replaced by brand new structures. Although many cottagers acknowledge that the small lots and leaseholds make their property more affordable, they nevertheless recognize the disadvantages, chafing at the limited extent to which they can expand their living space. However, given the smaller lot sizes, the restrictions appear reasonable, so as to maintain vegetation cover, protect the amenity and privacy of cottagers, and retain the distinctive, compact nature of the community.

Numbers of the cottagers have close relationships with each other, through kinship ties and friendships, with many of them having very longstanding connections with the Campsite, often going back for generations. Now, even the hard times are recalled with some fondness and it is obvious that the sentimental attachment to the cottage at Grand Beach is still strong. Grand Beach therefore offers another example of the deep roots that can be put down in cottage country. Complex sets of family linkages demonstrate the strong affiliations that people can develop with their summer home away from home. They also illustrate how strong can be the ties that bind people both to place and to family. The length of these attachments is also striking and not atypical. Similar associations have been identified both locally and in other, more distant cottage communities (Russell 2000; Selwood, Curry and Kozberski 1995; Boholm 1983). In a world in which change of residence is increasingly common, the cottage acts as an anchor, giving people a sense of place, of identity and relative permanence. The progressive upgrading of cottage properties is another indication of the need to cultivate such roots. Should property values rise dramatically as they have done in other locations with high scenic amenity this situation might well change. However , this enquiry into the development of Grand Beach and the sense of place generated in the cottage community confirms the notion of the cottage being truly a home away from home.

Acknowledgements

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Perception and sustainable forest management: woodland owners in the Nova Model Forest

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Abstract: Forests are an important part of the economy and way of life of Nova Scotians. To explore such ideas, and to gain public input on the question of sustainable forest management, the Nova Forest Alliance Model Forest Project commissioned research on socio-cultural character and dimensions of woodland owners and the general public. The research, undertaken in the spring of 2000, used a postal survey approach with very similar questionnaires distributed to two groups within or near the Nova Model Forest Project area. The woodland owner sample (n = 379) responded to a wide variety of behavioural, demographic and perception questions. This paper focuses on responses from woodland owners related to: a) harvest practices, b) forest management practices, c) awareness and participation in forest issues, d) forest sustainability, e) attitudes toward forest management practices and f) threats to forests and forest industries. Woodland owners expressed deep concern about the forest both as a productive resource and as a viable ecosystem. They are seriously concerned with the over-cutting of forests and the future of the wood supply. Strong reservations were expressed about certain management practices, such as clear-cutting, and they did not see current forest management as sustainable. However, there was ambivalence about what steps need to be taken to achieve forest sustainability.

Introduction

Forests are an integral part of the economy and way of life of Nova Scotians. Among those interested in the long-term viability of the forest environment are woodland owners. Indeed, their beliefs and attitudes play an important role in determining how forests are managed and, ultimately, in how they are sustained for future enjoyment and economic return.

Within this context, the research reported here is part of a long-term program to develop an in-depth understanding of the perceptions, beliefs and behaviours of people living in and near a large forested area in central Nova Scotia – the Nova Forest Alliance (NFA) area (Figure 1).

This paper focuses on a recent component of the research program, a questionnaire survey of woodland owners in the NFA area. Following a brief description of the objectives of the project, we offer a review of selected literature related to sustainable forest management, particularly in the Canadian context, and an outline of the methodology used and various characteristics of the sample. This is followed by a discussion of the principal findings, emphasizing six major themes: a) harvest practices, b) forest management practices, c) awareness and participation in forest issues, d) forest sustainability, e) attitudes toward forest management practices and f) threats to forests and forest industries. Conclusions stress recurring issues and concerns in this and related research.

Two principal objectives help to define the research initiative. First, the Nova Forest Alliance recognized the importance of socio-cultural research and the need to develop a research program capable of exploring issues and concerns over a period of several years. This project is part of the second phase of that larger research program (Colborne *et al.* 1999a, 1999b; Sanderson *et al.* 1999, 2000a, 2000b). Secondly, the research is meant to provide useful information for NFA decision-making and committee work (*e.g.* related to 'criteria and indicators' of sustainable forest management), and for various levels of government (municipal and provincial) and their policy development processes.

Literature

Canadian public forest policy has evolved in recent years to take into account sustainable forest management and environmental concerns (Young and Duinker 1998). Despite financial and political constraints on sustainability, collaboration among stakeholders is on the rise because of this new emphasis (Griss 1993; Winget 1998). Provincial governments are also active in forest planning, increasingly with a focus on sustainable forestry initiatives (Bissix and Rees 2001; Erdle 1998; Stevenson *et al.* 1997).

Cooperation in movement toward sustainable forest management is also evident in the private sector. Private forest companies have shown their concern for sustainability by complying with certification systems (Rawlinson 1996) and by joining model forests allowing for improved partnerships with other forest stakeholders (Spencer 1997). Despite these positive developments in the forestry industry, various challenges face the forestry industry at the start of the twenty-first century (Paillé 1998). For

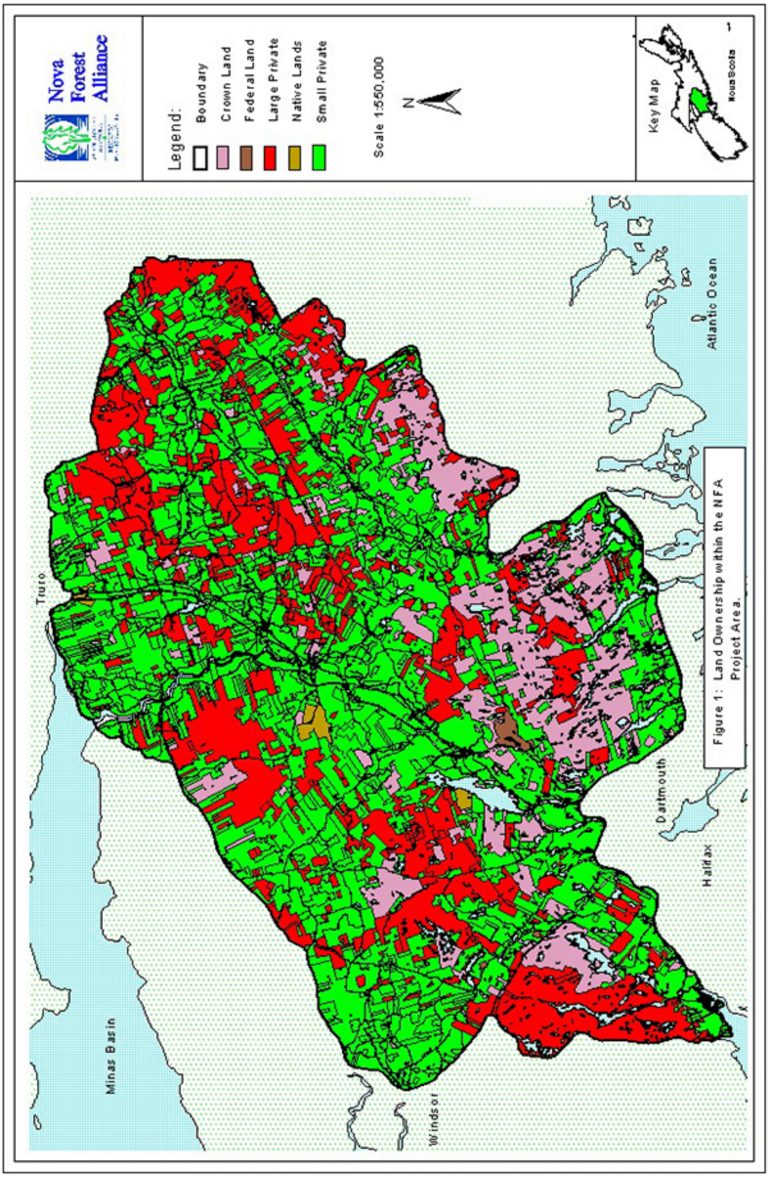

Figure 1: *Map of the Nova Forest Alliance (NFA) area.*

example, Holgen and Lind (1995) note that maximizing environmental values would reduce the volume of timber logged by 20% and the profits made by 10%. Clearly, to get a more accurate picture of forest values, both market and non-market benefits must be calculated and analyzed (van Kooten 1995; Haener and Adamowicz 2000). To improve environmental and economic benefits, within both the private and public sectors in British Columbia, Sahajananthan *et al.* (1998) argue for an efficient single-use land zoning system.

Forest dependent communities face a great deal of instability because of natural resource market fluctuations, but community economic development and local control of natural resources can reduce this instability and improve community sustainability (Markey and Pierce 1999; Nozick *et al.* 1999; Gunter and Jodway 1999). Other issues related to communities and forests include local economic development, government assistance and community participation in forest planning (Humphrey and Wilkinson 1993; McWilliams *et al.* 1993; Race and Buchy 1999; Carr and Halvorsen 2001). The growing role of sociology in forest research underscores the need to realize that social factors underlie forest degradation; conversely, it is important to consider the socioeconomic effects of forestry activity (Beckley and Korber 1995; Hansen 1995; Love 1997).

Recent analyses of public opinion have discovered a shift in emphasis toward non-timber values, such as recreational benefits, and away from economic forest benefits (Xu and Bengston 1997; Bengston *et al.* 1999; Environics 1989). In some cases forest values are consistent among rural and urban residents. For example, both groups disapprove of clear-cutting (Robson *et al.* 2000). While outdoor recreationists in Alberta do not support the economic development of forests, neither do they support further campground development (McFarlane and Boxall 1996; 2000). United States Forest Service employees are beginning to emphasize non-commodity uses of forests, whereas Canadian foresters do not think that more forestland should be set aside for protection (Brown and Harris 1992; Cramer *et al.* 1993; Omnifacts Research Ltd. *et al.* 1991).

Woodlot owners' opinions and activities have also been studied. In the five years before 1981, 45% of Nova Scotian woodlot owners cut firewood on their properties and between 1979 and 1981, 28% of landowners sold forest products (MacQuarrie 1981). A later survey found that nearly half of all Nova Scotian woodlot owners surveyed were willing to sell wood to pulp companies (Griffiths Muecke Assoc. 1989). The two most common reasons Nova Scotians gave for owning forestland were personal satisfaction and firewood (Wellstead and Brown 1995). In contrast, 42% of northern American forest landowners owned a woodlot because it was part of their farm or residence (Birch 1996).

Model forests combine the interests of government and private industry with the interests of other stakeholders to promote sustainability. While model forests do not have authority over the land, and their decisions are not binding on landowners, government must delegate responsibility to such partnerships, because forest planning needs to be grounded in the local context (Hall 1997; Brand *et al.* 1996). Individual model forests have been studied in detail to draw lessons from their experiences, and among these studies are work in the Prince Albert Model Forest in Saskatchewan (Bouman *et al.* 1996), the Manitoba Model Forest (Sinclair and Smith 1999), the Eastern Ontario Model Forest (Story and Lickers 1997) and the Fundy Model Forest in New Brunswick (MacLean *et al.* 1999).

The research reported in this paper contributes to this literature. First, it presents findings from empirical work with woodland owners, particularly focused on various themes related to sustainable forest management. Secondly, this research is located in a model forest area, where, perhaps, perceptions and concerns about sustainable forest management are particularly important to the future of Canadian forests.

Methods and Sample

A mail survey of woodland owners living in the Nova Forest Alliance Project Area was conducted in the spring of 2000. The initial process of questionnaire preparation began in the fall of 1999 with a meeting of the partners of the Nova Forest Alliance in Stewiacke. When a final draft was prepared, it was circulated to all members of the NFA Partnership for review. The first mailing took place in the second week of March, a postcard was sent two weeks later, and another questionnaire was sent out in April.

The sample was chosen from a database of woodland owners in the Nova Forest Alliance Project Area (Figure 1). This database consisted of individuals and companies registered in the 1997 municipal tax records as owning woodland. The respondents consisted of 379 woodland owners with wooded property in the Nova Forest Alliance Project Area. The population is composed of both individual and collective owners (the latter referring to corporations, societies, partnerships and farms); therefore, the sample was drawn to reflect this ratio. Since the number of wooded property owners of acreages larger than 250 was very small in comparison to total numbers of woodland owners, a disproportional stratified sampling process was instituted. Three hundred and fifty owners were contacted from each of the following groups: owning from five to 49 acres, owning from 50 to 249 acres, and owning 250 acres or more. The response rate was 36 percent, with 379 owners responding to the questionnaire. This represents a margin of error of five percent (19 times out of 20).

Respondents were older (54% over 55), largely male (78%), and reasonably well educated (55% had some post-secondary education). Approximately one-third (35%) were retired. Most respondents owned medium to large woodland properties (78% over 50 acres). Seventy-seven percent had owned land for over ten years. Most (75%) had purchased their woodland. The average number of parcels of woodland owned was three per owner. The ownership structure was primarily individually owned, which is representative of the population. Over half of the respondents (55%) lived on one of their woodland properties. When asked to rate the importance of 23 possible reasons for owning woodland, the top five reasons were as follows (rated by over 70% of respondents, starting with the most important): for the sake of future generations, for wildlife enjoyment, to give to my children, as an inheritance, and to protect water quality. Few woodland owners (8%) were members of forest-related organizations.

Harvest Practices

When asked about harvesting timber, most (64%) had harvested wood over the last three years, with an average of 1874 cords and an average of 99 acres harvested. Those who had not harvested wood indicated that they might harvest in case of a financial emergency (40%), if marketable timber was available (37%), or if woodland was damaged, diseased, or infested (8%). All woodland owners were asked what were the top three factors that would encourage them to sell wood from their woodland in the future, and the top three responses included: need for income (18%), maturity of wood (16%) and price of wood (13%). The response to this open-ended question reveals that the owners and managers of woodlands are primarily concerned with two things: their dependence on woodlands for income, and the need to manage their woodlands by harvesting when necessary.

Woodland owners not only harvest wood but gather other forest products as well. In order to obtain a picture of the types of products harvested, respondents were asked to indicate which products they or a member of their household had gathered or harvested from the forest for domestic use and for sale in the last three years. Multiple responses were allowed. The key products harvested or gathered for personal use in the last three years were firewood (65%), Christmas trees (29%), and brush (28%). Products harvested for sale included sawlogs (63%) and pulpwood (40%). Most harvesting was conducted by family members (51%) or contractors (25%). Most respondents (62%) did not rely on the sale of products for income, and for 24% it often represented a small proportion of their total income. Most respondents (91%) did not derive income from non-timber activities on forested land, such as sugaring, trapping, berry picking, guiding, handcraft, or recreation.

Forest Management Practices

The next series of questions dealt with forest management strategies of woodland owners, to get a sense of what mechanisms they use to manage their forests. Most woodland owners (73%) did not have a formal plan for their woodland. We then asked owners to tell us what forest management activities they had undertaken within the preceding three-year period, or planned to do in the next three years. The top five woodlot management activities undertaken on their property during the previous three years and proposed for the next three years included the removal of low quality trees and blowdowns, boundary line improvements, thinning, selection cutting, and planting. The timber harvesting methods used by most of the respondents who had harvested wood in the last three years (n=227) included salvaging dead and damaged trees (56%), cutting a few trees here and there (47%), clearcutting (42%), and cutting softwood while leaving hardwood (39%). On average, 3.5 different harvesting practices were utilized on a wooded property.

Awareness and Participation in Forest Issues

A high proportion (88%) of respondents were interested or very interested in forest issues, and 62% felt that they were at least somewhat informed. This result is comparable to that found in a previous Nova Scotia survey on forest values (Sanderson *et al.* 1999). Approximately half of the respondents (47%) said that they had quite a lot of experience working in the woods and 54% considered themselves to be somewhat to very knowledgeable about forest management. Over half (55%) of the respondents to the woodland owners' survey had not taken any action to express their views on the use of Nova Scotia's forests.

The final question in this series asked woodland owners to assess their level of knowledge regarding a variety of topics related to the practice of forestry, and to indicate about which they would like to learn more. We gave respondents a table to fill in, which gauged their familiarity with 27 forest management topics.

The topics with which most woodland owners were familiar were those concerning forest practices, such as boundary line maintenance (69% professed a lot or some knowledge) and harvesting methods (84%). About half of the respondents (49%) indicated that they had some or a lot of knowledge of most forest management practices listed.

When asked about which topics they were interested in learning more, 31% of woodland owners wanted to know how to use the best management practices for their forests. They also asked for information on forest regeneration (27%) and planning (25%). About a quarter (23%) of the respondents expressed interest in learning more about managing their woods for wildlife, bird habitat, and rare and unique plants. About a fifth (19%) expressed interest in topics related to recreation both for personal and commercial use. A quarter (25%) of the respondents were interested in income tax and estate planning. Since many of the respondents were older than 55 (54%) and retired (35%), this result is not surprising.

Forest Sustainability

The primary focus of this section of the survey was to assess opinions and attitudes toward forest sustainability and sustainable forest management, including perceptions of forest problems and forestry practices. The first question in this series of questions sets the context for the analysis of the remaining questions. Woodland owners were asked: "The following are three things people value about Nova Scotia's forests. On a scale of one to ten, please rate how important you think these are: economic benefits such as wealth and jobs, environmental benefits such as clean air and water and wildlife habitat, social benefits such as recreation and relaxation". All three were considered moderately to very important by at least 90% of respondents (Figure 2). Environmental benefits ranked notably higher than economic benefits and social benefits. Differences were noted among groups separated by age, gender, and acreage owned: younger owners considered social benefits more important, while men and larger landowners considered economic benefits more important (see Sanderson *et al.* 2000a for further details).

Questions about sustainable forest management explore woodland owners' perspectives on the use, present and future, of the province's forests. This subsection begins with a question designed to ascertain respondents' understanding of the meaning of the term 'sustainable forest

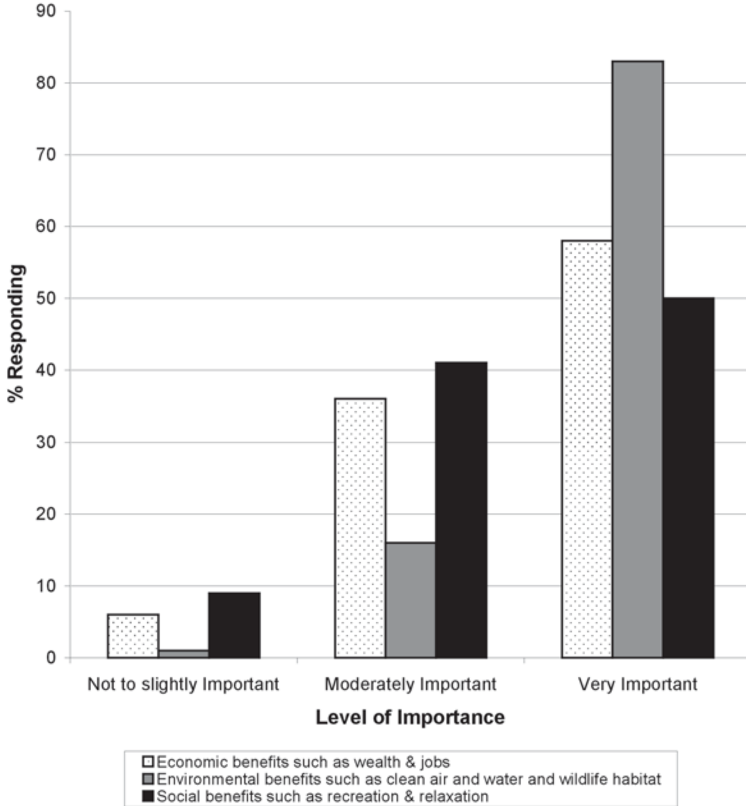

Figure 2: *Relative importance of forest values.*

management,' before continuing with questions that gauge their attitudes towards its practice.

People responded in many ways to the question: "What does sustainable forest management mean to you?" These often complex answers were organized by themes. A considerable number (50%) could not frame a response to this question, since they were not familiar with the term. For those who did respond, sustainable forest management was defined in terms of two main dimensions: a) the use or non-use of certain management practices, such as balancing harvesting and reforestation and clearcutting, and b) the promotion of ecological values, such as forest preservation (see Sanderson *et al.* 2000a for a fuller discussion).

Respondents who provided a definition for sustainable forest management were then asked how important they believed achieving

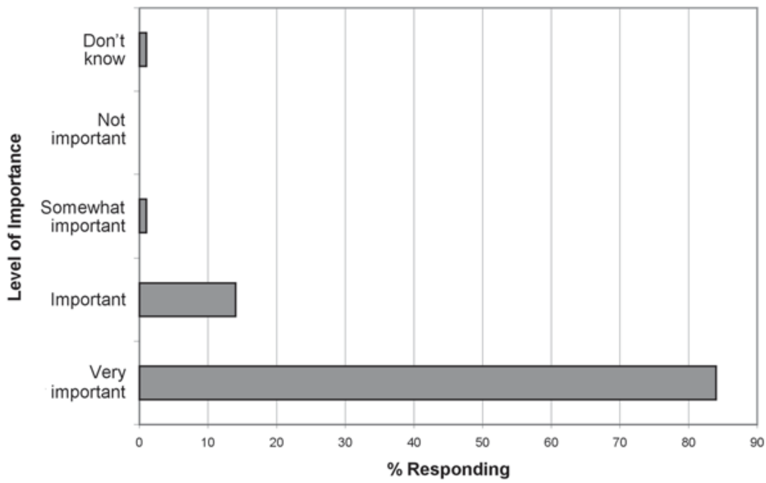

Figure 3: *Importance of achieving sustainable forest management in Canada.*

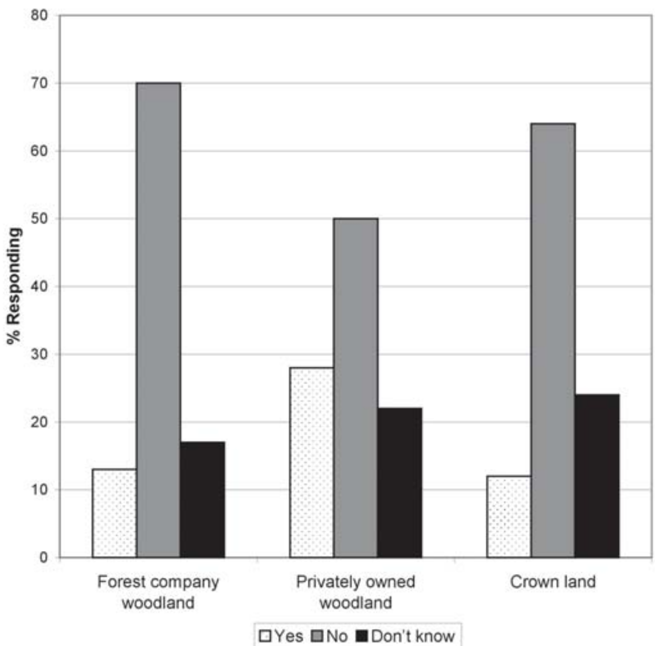

Figure 4: *Is forest management on company/private/crown lands currently sustainable?*

sustainable forest management in Canada to be (Figure 3). The response was very close to unanimous in favour of sustainable forest management: 84% of respondents deemed it very important. When examined more closely, there were no significant differences between groups separated by age, gender, or woodland ownership.

While the vast majority (84%) of respondents felt that it is very important to achieve sustainable forest management in Canada, most did not believe that forest management is currently sustainable as practised on private company woodlands (70%), on Crown lands (64%), or on privately-owned woodlands (50%). About 20% said that they did not know (Figure 4). This is a less optimistic perspective than that found when the same question was presented in earlier research (Sanderson *et al.* 1999). When asked about the commitment of various organizations to sustainable forest management in Nova Scotia, the three groups considered to have the strongest commitment to sustainable forest management were as follows: woodland owners, the federal government, and environmental groups.

The next subset of questions in this section focused on attitudes toward forest sustainability by asking respondents to indicate their level of agreement, or disagreement, with a series of thirty-four statements which reflect a variety of attitudes and perceptions about forests (Table 1). A four point scale, ranging from strongly disagree to strongly agree, was used. Statements which received the highest levels of agreement included: "Protecting jobs in the forest industry and protecting the forest environment are both possible" (91%); "Society has an obligation to protect endangered species" (89%); "Forest companies should do more to protect the environment" (85%); and "More forests need to be replanted" (84%).

Support was evident for the regulation of timber harvest contractors (78%), for incentives to establish protected areas (74%), for environmental protection (64%), and for increased efforts to protect old growth forests (61%). About the same number of respondents gave environmental protection top priority (64%) and were in favour of forest management that aimed primarily to produce quality wood products (62%). Respondents agreed that consumer demand for forest products threatens the environment (74%), and that Nova Scotia will have little harvestable wood in 10 to 20 years (62%). They felt that insufficient planting or natural regeneration was taking place to meet future timber needs (75%), and that there is not sufficient wood for all users (61%). There seems to be some question about the value of the forest as a landscape, about the abilities of woodland owners to manage the land, and about the long-term health and sustainability of the forest.

Table 1: *Attitudes towards forest sustainability (% responding).*

Statement	*n* =	Strongly agree to agree	Disagree to strongly disagree	Don't know
Protecting jobs in the forest industry and protecting the forest environment are both possible in Nova Scotia.	360	91	3	6
Society has an obligation to protect endangered species.	358	89	6	5
Forest companies should do more to protect the environment even if it results in the loss of some jobs.	355	85	9	6
More forests should be planted after harvesting.	356	84	7	9
Timber harvesting contractors should be strictly regulated.	354	78	12	10
The environment is threatened by consumer demand for forest products.	353	74	18	8
The government should provide incentives for private landowners to establish protected areas on their land.	354	74	16	10
The most important objective of forest management should be to protect the environment.	353	64	29	7
The primary goal of forest management in Nova Scotia should be to produce quality wood products.	354	62	31	7
Nova Scotia will have very little harvestable wood in 10-20 years.	365	62	18	20
Greater efforts should be made to protect Old Growth forests.	355	61	26	13
Ownership of forested land does not give people the right to do whatever they want with it.	351	61	33	6
The provincial government should not regulate private woodlot cutting.	358	54	35	11
There is too little "designated" wilderness in Nova Scotia.	357	51	23	26
Most woodland owners in Nova Scotia don't know how to look after their forests.	360	49	34	17
The use of ATVs in public forests should be banned.	355	49	41	10
Environmentalists go too far in trying to restrict logging.	352	48	33	19

Table 1: *(continued)*

I believe that woodland that is not actively managed is wasted.	356	47	46	7
Where forests are privately owned, society should not have any control over what the owners do with them.	354	45	47	8
Woodland owners in Nova Scotia are good stewards of the forest.	348	42	34	24
I would be willing to accept timber cutting restrictions on my own land.	355	41	48	11
Harvested areas should be allowed to regenerate naturally.	339	40	47	13
The view of a forested hill is more valuable than the timber harvested from it.	344	39	49	12
Legislation should be enacted requiring forest landowners to adhere to best forest management practices on their own land.	348	37	51	12
We are making progress in Nova Scotia towards sustainable forest management.	353	33	34	33
Some existing wilderness areas should be opened to logging.	349	29	57	14
The forest industry is taking a long-term interest in maintaining a healthy forest.	354	29	53	18
Scenic views are less important than the economic benefits of timber harvesting.	344	25	62	13
The forest industry represents a majority of Nova Scotians when it addresses forest issues.	354	23	54	23
Environmental groups represent a majority of Nova Scotians when they address forest issues.	355	16	54	30
There is sufficient wood in central Nova Scotia for all users including paper mills, saw mills, and domestic firewood cutters.	357	13	61	26
Enough harvested trees are being replaced by planting new ones or by natural seeding to meet our future timber needs.	361	13	75	12
Protecting jobs in the forest industry is more important than protecting endangered species.	356	13	81	6
Protecting jobs in the forest industry is more important than protecting the environment.	353	10	85	5

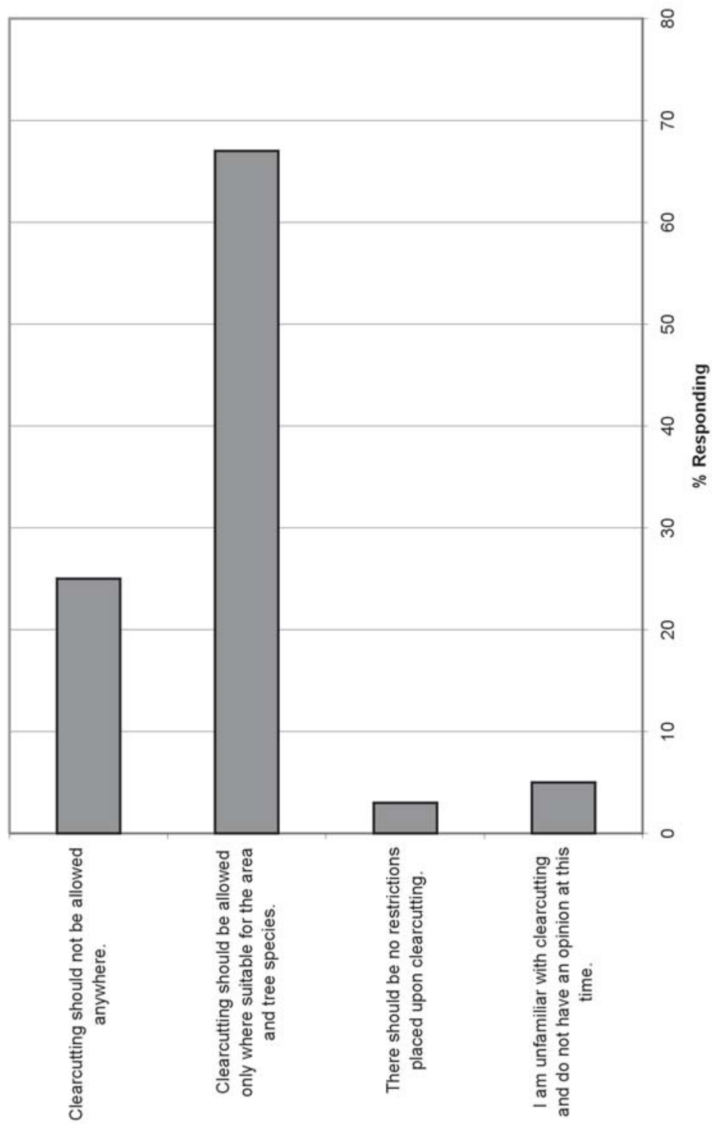

Figure 5: *Attitudes towards clearcutting.*

Attitudes Towards Forest Management Practices

This section looked at a variety of current management practices and attempted to assess woodland owners' perception of the value and acceptability of these. Woodland owners were more likely to find the use of herbicides and pesticides acceptable, however, over 30% were against their use. Woodland owners were in favour of forest management practices such as leaving clumps of trees to protect wildlife (92%), selection and partial cutting (87%), closing forest roads to control garbage dumping (84%), and using specialized equipment designed to protect the environment (70%).

Another subject of much discussion both in the forestry industry and the general public is the issue of clearcutting. Therefore we designed a number of questions to determine how woodland owners feel about clearcutting and under what conditions it is acceptable. Strong opinions were expressed about clearcutting. Two thirds (67%) of respondents said they felt that clearcutting should be allowed only where suitable for the area and species, and one quarter (25%) said clearcutting should be banned (Figure 5). However, although initially opposed to clearcutting when asked general questions about it, woodland owners were more likely to perceive it as an acceptable practice given certain circumstances: they felt that clear cutting should be used to harvest dead and dying stands (83%), and that it was acceptable if replanting was to occur immediately afterwards (59%). Most did not consider clearcutting to be an acceptable practice on publicly owned (61%) or privately owned land (55%). Most (65%) felt that the maximum size of a clearcut area should be less than 20 acres.

Threats to Forests and Forest Industries

Woodland owners appear to have many concerns about the future of forests in Nova Scotia and the impact of forest use. Leading threats to the forest as perceived by woodland owners included harvesting faster than forest growth, too little planting, a lack of long range planning, and clearcutting (indicated by over 74% of respondents). Recreational uses and oil and gas pipeline activity were not considered threats by over 68% of users. On the other hand, current forest uses were perceived as threats to wildlife and fish habitat, and to waterways, by over 70% of respondents.

The next question took a different perspective on problems and issues in Nova Scotia's forests, by moving to a more personal level and asking woodland owners what they perceive to be the greatest problems facing them today. They were asked specifically to rate 25 different potential

Table 2: *Problems facing woodland owners (% responding).*

A problem affecting woodland owners today is …	*n* =	Strongly Agree to Agree	Disagree to Strongly Disagree	Don't Know
Too much wood being cut	350	75	10	15
Lack of financial incentives for preservation	343	75	8	17
Lack of knowledge about ecosystem management	349	71	12	17
Lack of knowledge about forest regeneration	350	71	21	8
Lack of knowledge about wildlife management	342	67	21	12
Too much pressure to harvest wood	349	65	23	12
Lack of knowledge about how to choose a reliable contractor	347	62	14	24
Low level of funding for forest management programs	340	62	15	23
Lack of knowledge about what wood products are worth	343	59	25	16
Public perceptions of timber harvesting	333	57	20	23
High cost of silviculture	341	55	17	28
Taxation of woodland income	345	53	24	23
Lack of knowledge of cutting methods	347	50	34	16
Too few good contractors	345	49	20	31
Lack of strong landowner organizations	340	48	26	26
Too many regulations (red tape)	341	42	37	21
Woodland property taxes	346	42	45	13
Too much concern about private land management	337	37	41	22
Low wood prices	345	37	46	17
High interest rates	335	33	34	33
Too much pressure from society to protect the forest	341	28	60	12
Lack of a strong contractor organization	327	21	29	50
Lack of wood markets	340	21	62	17
Requirements for protected areas	336	31	38	31
High wood prices	325	23	51	26
Other	42	67	0	33

problems. The top five included too much wood being cut (75%), the lack of financial incentives for preservation (75%), forest regeneration (71%), wildlife management (67%), and a lack of knowledge about ecosystem management (61%) (Table 2).

The final question asked respondents to indicate their one wish for the future of Nova Scotia's forests. Essentially, they expressed the desire that the forest be preserved and protected for the enjoyment of future generations. Furthermore, they wished for responsible management practices and economic viability for the industry (see Sanderson *et al.* 2000a for further details).

Conclusions

Woodland owners are definitely worried about the forest environment. They expressed deep concern about the forest both as a productive resource and as a viable ecosystem. They are seriously concerned with the overcutting of forests and the future of the wood supply This sample had strong reservations about certain management practices, such as clearcutting, particularly among landowners with smaller acreages.While they support a variety of practices or initiatives to foster sustainable management of the forest, they do not see current management as sustainable. However, there was a definite ambivalence about what steps are required to achieve forest sustainablility, particularly through legislative action. Woodland owners saw their land as an investment in the future of their family, an investment in the environment, and an investment in preserving a quality of life. Finally the recurring theme of the need for the protection of the forest for future generations reflects a deep appreciation and concern for Nova Scotia' s forests. Woodland owners value their woodland, not only for the income it provides, but for of its beauty , its wildlife, and its importance to the quality of life found in Nova Scotia.

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Can whale-watching convey an important message of conservation?: an initial perspective from British Columbia, Canada

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Abstract: Whale-watching is marketed as ecotourism, a non-consumptive, educational activity. The benefits of whale-watching have been primarily measured in economic terms. Educational benefits have been assumed, yet rarely measured. Further, whale-watching, as a marquee of ecotourism, has yet to be proven to develop a conservation ethic among its participants. Whale-watching has three important barriers to cross with respect to achieving the ecotourism goals to which it aspires. These are, inaccurate preconceptions of the whale-watching experience, negative perceptions towards whale-watching, and the ability to deliver a lasting educational impact during the whale-watching trip. These first two elements are discussed, while the third is examined through a pilot study of B.C. whale-watchers. The pilot study indicates that whale-watchers in British Columbia, Canada exhibit tendencies that may make breaking through these barriers difficult and points to areas in need of examination.

Introduction

As whale-watching continues to grow in popularity as a global industry, the assumed benefits of the practice need to be discussed. The success of whale-watching in terms of industry growth and economic impact is well documented. Globally, whale-watching occurs in 87 countries and is currently estimated to produce US$1 billion in revenues annually, rising at a rate of 18.6% per year since 1991 (Hoyt 2000). Yet whale-watching is classified as *eco*tourism. Eco-tourism has been defined as "purposeful travel that creates an understanding of cultural and natural history, while safeguarding the integrity of the ecosystem and producing economic benefits that encourage conservation" (Ryel & Grasse 1991:1). In the case of whale-watching, the economic benefits measure the success of the *tourism* - but how successful is the *eco*? Following Ryel and Grasse (1991), the *eco* portion of whale-watching has two principal qualities: 1) that it is a non-consumptive, sustainable use of cetaceans, and 2) that it provides an educational experience in the form of a connection with nature and an important conservation message.

Whale-watching was accepted as a sustainable use of cetacean populations compatible with Agenda 21 of the 1992 United Nations Conference on the Environment and Development in Rio de Janeiro (United Nations Economic and Sustainable Development 1992). Therefore, the first aspect concerning the *eco* element of whale-watching is assumed. Whether this is so in practice is a continuing controversy that needs to be addressed scientifically through means more complex than superficial behavioural observations, and is not discussed in this paper. However, this controversy plays an important role in the second aspect of the *eco* element of whale-watching.

It is the second aspect of the *eco* that is discussed herein. That important education benefits are derived from whale-watching can not be assumed. Human disassociation with nature is well addressed by authors such as Lovelock (1986), Sheldrake (1991), and Wilson (1984), and is eloquently summarized in relation to whale-watching by Forestell (1993).

This disassociation with nature creates a barrier through which ecotourism education must pass, in order to deliver a conservation message (Forestell 1993). Wilson (1984) places the goal in perspective through his biophilia hypothesis, where he defines biophilia as "the innate [human] tendency to focus on life and life-like processes" (Wilson 1984:1). Wilson believes that this tendency is a human adaptation that has been suppressed since the industrial revolution, resulting in a human disassociation with nature. It is Wilson's hypothesis, however, that biophilia creates respect for nature, which in turn engenders a nature conservation ethic. Whale-watching, as a flag-bearer for ecotourism, and one which utilizes one of the most emotive creatures on Earth, should adopt the goal of becoming a tool to encourage a conservation ethic.

This perspective is addressed from the point of view of whale-watching in British Columbia, Canada. Three barriers to whale-watching as a route to foster conservation ideals are presented: 1) participants' false pre-conceptions of the whale-watching experience, 2) the public's perception of the whale-watching industry, and 3) effectively educating whale-watchers. The first two barriers are discussed and research needs given. The main purpose of this paper is the presentation of a pilot study that explores the third issue of education aboard whale-watching boats. To

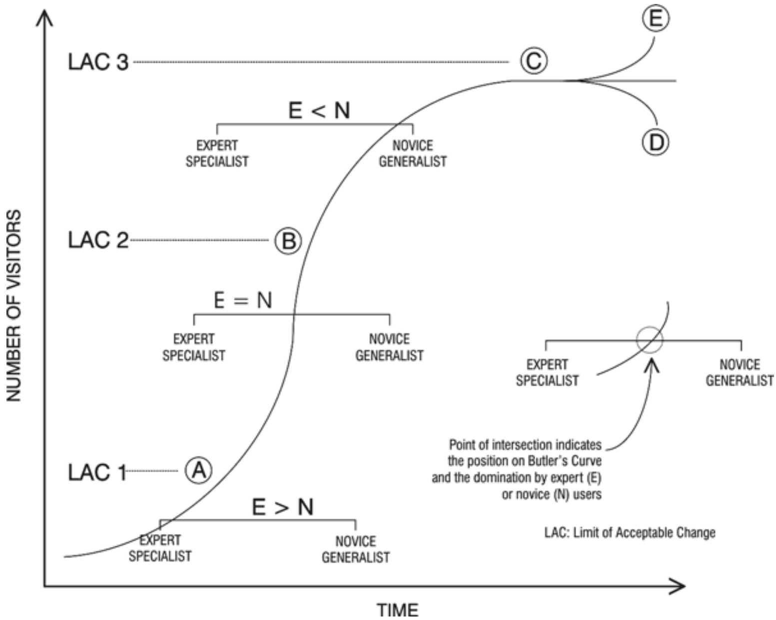

Figure 1: *User specialization and site evolution (Duffus and Dearden, 1990).*

address the development of a conservation ethic through whale-watching, we first examine the backgrounds of whale-watchers in B.C. Whale-watchers can then be placed on Duf fus & Dearden's (1990) continuum from expert-specialist to novice-generalist (Figure 1). Second, we examine what education whale-watchers receive during their experience by asking a recollection question, and link this with their backgrounds. With this type of information effective education programs, which address specific educational needs of the whale-watchers, can be developed.

The pilot study is used to begin to develop the character of the B.C. whale-watcher, in order to direct future research. Ultimately in the future, we need to understand whether whale-watching can achieve the second component of ecotourism, conservation education.

Defining the Whale-Watcher:

In order to address the question of whether whale-watching can engender a conservation ethic in people, we must examine those who go whale-watching. In addition, we must explore the whale-watching milieu that includes the presence of other attractions and level of infrastructure (*e.g.* accessibility, gift shops, bank machines, restaurants, accommodations, types of vessels utilized).

Duffus & Dearden (1990) present an adaptation of Butler 's (1980) tourism site life cycle to illustrate the evolution of the site user alongside the site (Figure 1). When few visitors utilize the site, it is underdeveloped in the sense of infrastructure. At this point, the group is dominated by the "expert-specialist," characterized as a user who has prior experience in the activity, is knowledgeable, knows what to expect, and does not demand extensive infrastructure. As more tourists begin to use the site, additional infrastructure is established and the site eventually becomes dominated by the "novice-generalist." The novice-generalist is a user who has little or no experience, little prior knowledge, has general expectations, and demands a high level of infrastructure. Limits of acceptable change (LACs) represent thresholds where the expert-specialists are no longer attracted to the site due to its development, and search for experiences elsewhere.

Using this model to address the user is important. How expectations, education, demands, and management are addressed will dictate how the curve evolves beyond point C (Figure 1); does the site become encumbered by infrastructure to the detriment of ecotourist demand, resulting in a decline of visitors (Point D), or is the site managed to maximize ecotourist demands, resulting in an increase in visitors (Point E). If ecotourists are interested in conservation education (this is not assumed here) then the site or activity (i.e. whale-watching) must provide this.

As mentioned above, three aspects are important in a discussion of whale-watching as a vehicle to encourage a conservation ethic within humans. The first two deal with perception: 1) false perception of what a whale-watching experience will be, based on their understanding of nature, and 2) their perception of the act of whale-watching. The third aspect is the educational message imparted during the whale-watching trip. The ability to deliver such a message is where a connection with nature has the opportunity to be anchored within the watchers who have experienced wild whales first-hand. The first two aspects are presented and discussed below; the third is examined through the pilot study presented.

Preconception of the Whale-Watching Experience:

The preconception of what a whale-watching experience will be is affected by factors such as television programs and books. There is the potential for these media to contribute to a disassociation with nature by presenting false perceptions in the form of simplified creatures, glamourized research, and shallow messages. Whales are one of the few phenomena on Earth that can inspire awe and strong emotion simply through pictures. However, people may not realize that television programs are the result of hundreds of hours of work, involving waiting for appropriate weather, waiting for whales, and actual filming. Only the best sequences, which most often involve specialized activities by the animals, and occur on sunny, calm days, are present in the final product. A whale-watching trip may involve a majority of the time traveling or occur during inclement weather and sea states. Whales may be viewed from large distances or may not exhibit exciting behaviours. Similarly, with books only the best shots out of hundreds taken are included. There are no shots of rain, blank seascapes, big waves, or seasick photographers. Underwater footage, both moving and still, may further create false expectations of what one might see on a whale-watching trip. In Victoria, B.C., a whale-watching passenger was once quoted as exclaiming "those aren't whales, they're fins!" as she watched killer whales surface (A. Rhodes, pers. com.). What did she expect to see?

Anthropomorphism of cetaceans sometimes occurs in television programs, books and movies. Implying that cetaceans possess human-like behaviours and feelings, such as being "happy" and then showing a breaching whale, or intimating that a whale is "sad" when a member of its pod dies, have no scientific basis and create an unrealistic appreciation of wild creatures.

False expectations of the whale-watching experience are exacerbated by advertising for whale-watching. Whales are often shown breaching very close to the viewer, on calm, sunny days. Often "Guaranteed Sightings," are advertised next to breaching whales. This type of advertising particularly creates false expectations when breaching whales are used to advertise in areas where whales rarely perform such activities (*e.g.* summering gray whales off the west coast of Vancouver Island, B.C. that are focused on feeding). The adventure and adrenaline of a whale-watching trip is also a common advertising feature (*e.g.* fast, open zodiac-style vessels) minimizing the connection with nature and education goals of ecotourism.

Whale-watching, however, is a competitive business. It would not make marketing sense to utilize a more realistic representation on an advertising brochure of viewing a whale from a distance when others depict close encounters with breaching whales.

Perception of the Act of Whale-Watching:

The second aspect is that of the act of whale-watching itself and thus the whale-watching industry. Whale-watching is marketed as ecotourism, and should be a non-consumptive, sustainable activity alongside the education goals. Thus, it should create the expectation of a unique connection with nature. However, there is a growing perception, whether scientifically founded or not, that whale-watching is harmful to whales. Whale-watchers frequently ask questions during trips that indicate their concern about whale-watching boats harming the whales (C. Garside, pers. com., J. Jackson, pers. com., author (C.M.) observation).This perception is likely being driven by the news media that headlines stories with titles such as “Can we love orcas to death?” (Henderson, 1998), “B.C whales brace for invasion of the ecotourists” (Gatehouse, 1999), “Eco-tourism excesses are endangering Baja’s whales” (Moore, 1999), and “Watching killer whales die” (Scott, 2000). Incendiary terms such as “death”, “invasion”, “endangering”, and “die” paint a negative picture of whale-watching.

Further, statements are made with no scientific basis:

> “How bad can it get? One day last July 108 zodiacs, kayaks, yachts and commercial boats crammed into Haro Strait, roughly as many boats as whales in the three pods that frequent the waterway in pursuit of salmon. And there are worrying signs that the traffic jams are affecting the whales. This season, four male orcas - Bernardo, 2, Raina, 8, Okum, 39, and Taku, 43 - that should have returned with their pod are missing and presumed dead.” (Henderson, 1998)

The insinuation is that whale-watching caused the deaths of these animals. While there is no reasonable basis on which to make such a statement, the inexperienced reader may attribute whale deaths to whale-watching.

These types of statements are not limited to a few stories: “The public at large is starting to view these whale-watching operations as detrimental” (Weatherbe, 1999), “People say killer whales harassed” (Gatehouse, 1999), “You can basically ruin their [the whales’] whole day” (Schmidt, 1999), “… questions are now being raised about the industry that pursues them [whales] in the wild” (McInnes, 1998), and “Whale-watching boom spurs local feeding frenzy and tourist yahooism” (Moore, 1999).

For an activity that flies a large ecotourism flag, publicity such as this can be damaging, both educationally and economically. There is currently no conclusive evidence that whale-watching harms whale populations. However, in this case, it is not whether whale-watching *does* harm whales – it is the *perception that it does* that is important and potentially damaging. As the global whale-watching industry continues to grow, this perception may grow as well. For whale-watching to be an important tool to help forge a conservation ethic the industry can not harbour a perception that it is harmful.

Methods

B.C. Whale-Watcher Pilot Study:

During August 1999 a pilot study to investigate the backgrounds of whale-watchers in British Columbia and what education they retain from their trip was undertaken. The pilot study collected general information to help develop a more specific, in-depth multi-year project. Some of these general characteristics are examined here as they indicate trends that need to be explored, both during the multi-year study as well as in other locations for comparison.

We administered questionnaires to whale-watchers in Victoria and Tofino, British Columbia. Development of the questionnaire followed principles advocated by Babbie (1995), Dillman (1978), and Ryan (1995). These principles include engaging in *a prioi* informal discussions with whale-watchers to aid in design and content, construction of short, single concept questions, and providing an information letter that identified the researchers and assured confidentiality. Questionnaires were administered through the intercept method and returned to the investigator; every whale-watcher on the trips sampled was approached and given the option of participating. As this was a pilot study designed to give us direction for further research, the sample size was not large (n=250).

Results

The first background question sought the participants' participation in "nature-related" activities: "How often do you participate in nature-related activities? (for example: hiking, wildlife viewing, kayaking, rock climbing, etc.)." The response indicated that 77% of the respondents engaged in nature-related activities ten or less times per year (Figure 2).

The second background question asked the importance of whale-watching in the participant's vacation (Figure 3). The greatest percentage of participants in both locations responded that whale-watching was one of several planned activities during their trip. While it is not uncommon for tourists to engage in numerous activities, it is important to know that whale-watching may not be a priority when developing educational programs. The multi-tasking tourist may have the next item on the agenda in mind during the whale-watching trip, especially during the return portion of the trip when important contextual elements of a conservation message are usually imparted.

Combined, there were approximately as many participants who responded "primary reason" as "unplanned activity" However, there was

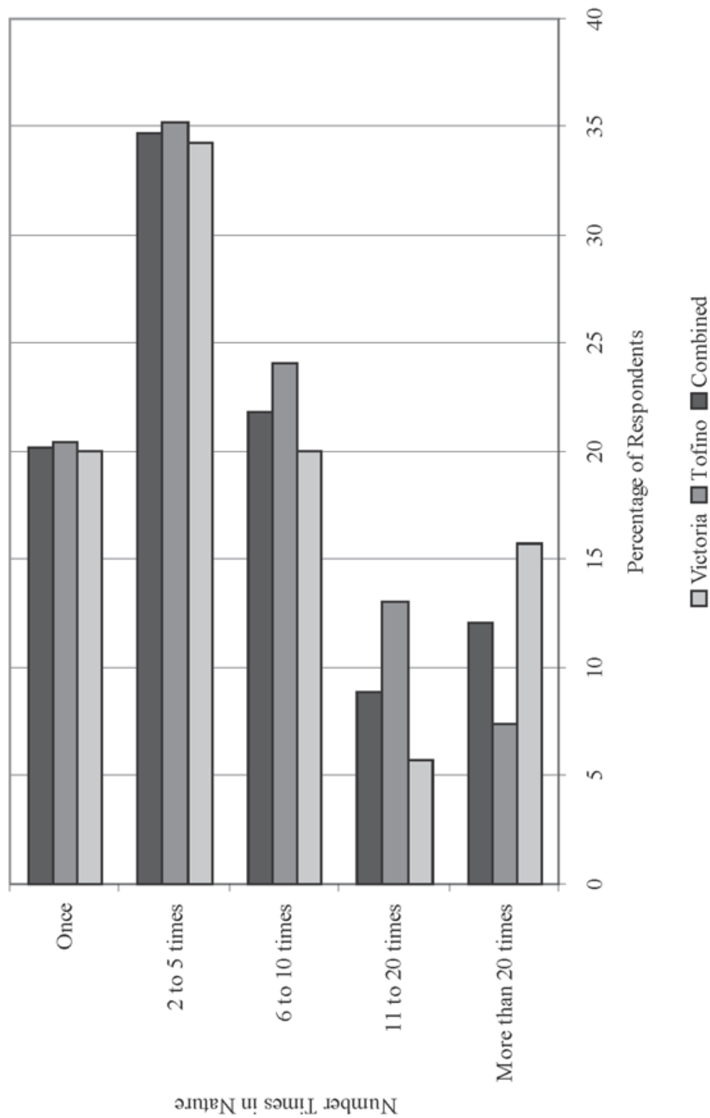

Figure 2: *Number of times per year participants engage in nature related activities.*

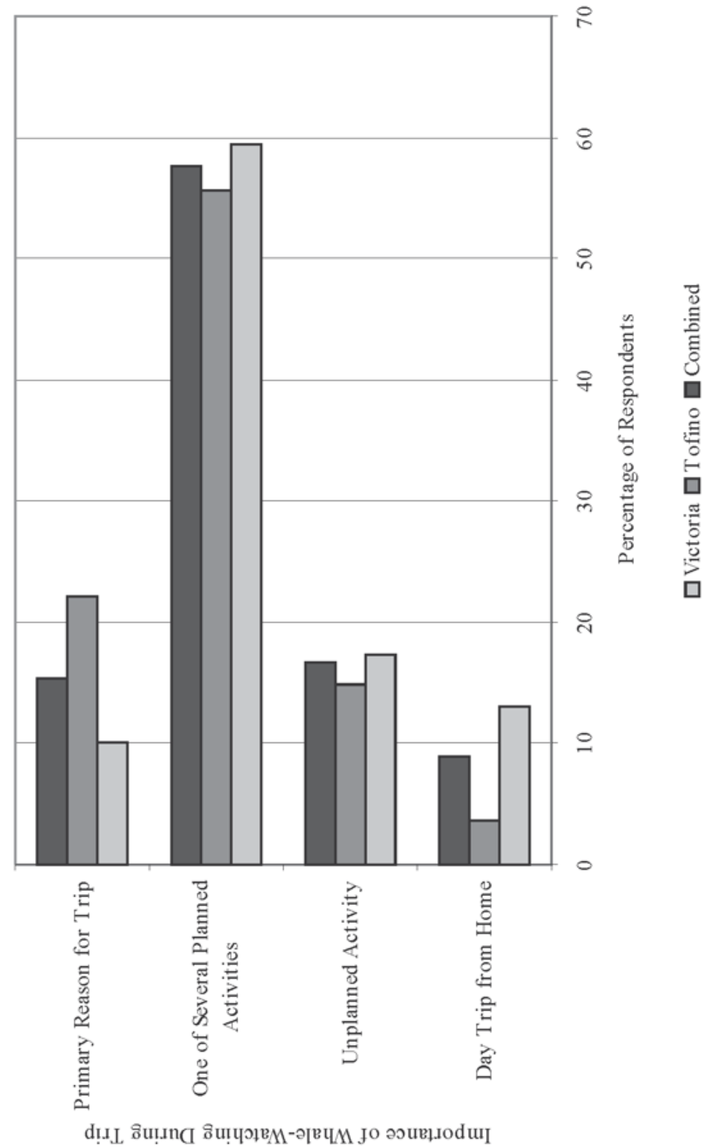

Figure 3: *Importance of going whale-watching during trip to whale-watching area.*

a significant difference for "primary reason" between Victoria and Tofino (Mann-Whitney U=42.0, p<0.000). This result reflects that Victoria and Tofino serve as different tourism foci on Vancouver Island. A larger percentage of tourists made the effort to travel to Tofino for the express purpose of whale-watching.

This difference in whale-watcher types is further highlighted by the question: "Before you came whale-watching today, did you spend any time learning about whales?" While 49.1% of Tofino whale-watchers had spent time learning about whales prior to their trip, only 27.1% of Victoria respondents reported having done so. This difference is statistically significant (Mann-Whitney U=1474.0, p=0.021). Combined, only 36.3% of whale-watchers had spent time learning about whales before their whale-watching trip. Television (69%) and books (66%) were reported as the most popular learning media.

Twenty-nine percent of the respondents had gone whale-watching before, 30% of whom, had gone more than once. There was no significant difference between locations in this response. Lastly a recollection question was asked. The question asked the participants to place a check beside items they remembered hearing about during the whale-watching trip. The question did not ask for specific facts, only that they remembered hearing about the subjects in the list. This question was restricted to respondents on a large vessel in Tofino. Participants from Victoria were spread over many small, zodiac-type vessels, with different operators on different days. Due to an inability to account for consistent education programs across the various boats Victoria whale-watchers were not included for this question. The Tofino participants were on four separate trips over two consecutive days, had relatively the same viewing experience, and received the same information. Each subject was mentioned during the trips. Information was given over a loudspeaker and included answers to questions asked by whale-watchers during the trip.

Figure 4 compares the percentage of Tofino respondents who remembered hearing about each item to those who did not. Responses indicate that the ability to remember information given during the trip was relatively poor. Approximately half the respondents did not recall hearing about reproduction or social behaviour. Recollection of research and conservation was extremely poor. Only the prey and size subjects were remembered by nearly all participants.

This pilot study starts to develop a profile of whale-watchers in British Columbia. The average whale-watcher here may have little association with nature, little prior knowledge or experience with whales, and may not retain much of the education that they receive during their trip. The data also suggests that there is a difference in the types of whale-watchers

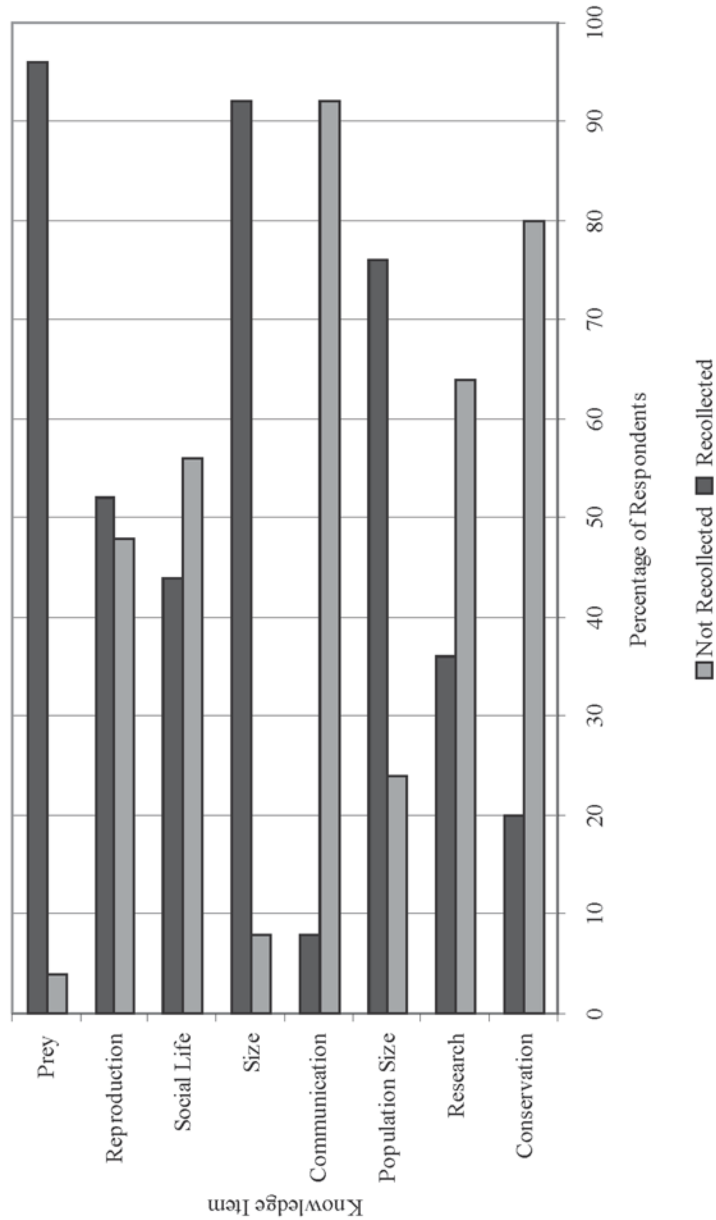

Figure 4: *Recollection of information imparted during whale-watching trip.*

attracted to different whale-watching locations. In this case, greater proportions of whale-watchers in Tofino report whale-watching as the primary purpose of their trip to the area and appear to have spent more time learning about whales beforehand.

Discussion

We have presented three main obstacles that face whale-watching as a conservation education tool. The first two obstacles deal with preconceptions of whale-watching. The first is the perception by potential whale-watchers of what a whale-watching experience entails. This perception has the potential to include an unrealistic vision of wild animals and the natural environment. Television, books, movies, and advertising may contribute to this problem by presenting an unrealistic perception of nature. The pilot study reveals that television and books are the main media used for learning by the small percentage of participants who had actually done so. An unrealistic perception of nature likely contributes to a lack of context in which to place conservation messages. Further research is needed to explore what whale-watchers' perceptions of nature are, in order to guide the development of efective education programs. The pilot study gives us an idea that whale-watchers may not have a great deal of knowledge concerning nature.

The second obstacle is the preconception of the act of whale-watching and thus the whale-watching industry. Recently, the news media has presented a negative account of whale-watching. The perception may be growing that whale-watching is harmful to the whale populations it watches. Whether whale-watching is actually harmful or not does not matter in this case. The perception that whale-watching is harmful will damage its ecotourism, non-consumptive character, and diminish its ability to present itself as a means to deliver an important conservation message. Research is needed to assess how whale-watchers are affected by media description of whale-watching. The whale-watching industry itself needs to address the issue as well. An understanding of the perception whale-watchers have of the environmental impacts of the activity will help the industry to do so.

The third obstacle is the ability to deliver that important message in practice. We have started to explore this question through a pilot study of B.C. whale-watchers. The pilot study begins to reveal a novice-generalist type whale-watcher in British Columbia (*sensu* Duffus & Dearden 1990). Almost 80% of respondents reported that they participate in 10 or less nature activities per year. Only 29% of whale-watchers in B.C. had been whale-watching previously. Almost 60% of respondents identified whale-watching as one of numerous activities for which they traveled to the area and only 36% of participants had spent time learning about whales before. Inexperienced and unlearned whale-watchers who are not exposed to nature likely have little context in which to place conservation messages. Education aboard whale-watching vessels may only begin to introduce whale-watchers to wild whales and their environment.

Here an important question is asked: is the boat the medium for the message? Is it overly optimistic to expect that a message of conservation can be imparted during a three-hour whale-watching trip? It may be, given the novice-generalist character of the average whale-watcher that has begun to be described here. Not only may whale-watchers be too disassociated with nature to be able to ingest such a message, they may be so overwhelmed by unfamiliar, fantastic stimuli during a whale-watching trip that they may be incapable of receiving such a message in any case.

Higham (1998) states that due to a lack of genuine ecological interest within the novice-generalist ecotourist, any information given during an ecotourism experience is simply introductory, rather than supplemental - the insinuation being that most ecotourists do not have basic ecological knowledge upon which to base a novel nature experience. Results from the pilot study discussed here reveal that whale-watchers have difficulty simply remembering some of the subjects they heard about immediately following the whale-watching trip, let alone receiving a message.

There are options in addressing the problem of whale-watching being unable to deliver conservation messages. First, a recognition that the whale-watching trip may not be, in and of itself, able to deliver an important conservation message and foster a strong biophilic connection with nature. Whale-watching can be a catalyst or a confirmation for the message, but it needs additional inputs, either before, after, or both.

These inputs may come in many forms and have been described in various articles. Forestell (1992) discusses environmental education in a whale-watching context and presents a whale-watching model that addresses pre-contact, contact (the whale-watch trip) and post-contact elements. Orams (1996) discusses the possibility of education as the primary management strategy for wildlife watching. IFAW *et al*. (1997) present the results of a workshop focused on the educational benefits of whale-watching for which the potential is concluded to be high if developed effectively.

In practice, these inputs need not be complex. Interactive displays at whale-watching centers could provide a pre-trip context including what whale-watchers can expect to experience, regulations that govern whale-watching, how the vessel will move when whales are present, and research and conservation that is being undertaken upon the whales they will be viewing. Trying to impart this information on the boat is difficult, as passengers are preoccupied by novel experiences.

Conclusion

All three barriers to whale-watching as a tool to engender a conservation ethic must be addressed in the future if whale-watching is to be considered true ecotourism (*sensu* Ryel & Grasse 1991). Unrealistic perception of the whale-watching experience as well as the negative perception of whale-watching can be addressed by the whale-watching industry itself, through education advocacy. This advocacy should involve a close alliance with scientific cetacean research and the establishment of a pre-whale-watching context for its customers upon which to base their experience.

The limited ability to provide education that persists beyond the whale-watching moment needs to be addressed through detailed examination of the demographics, previous experiences, and expectations of whale-watchers on a site-by-site basis. The pilot study presented here indicates that in British Columbia education may need to be developed to reach an audience that is disassociated with nature, has little previous knowledge about cetaceans, and is not receiving basic information – i.e. the “novice-generalist” user as described by Duffus & Dearden (1990). However, there is also evidence that whale-watchers with differing levels of experience, and therefore various levels of environmental knowledge, may be attracted to particular sites. A more complex study evolved from the pilot study presented here will investigate these general trends further to aid in the development of more effective education.

Acknowledgements

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"If it came in the mail, I wouldn't have even looked at it": contact triangulation as a means to increase response rates

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Abstract: Conducting survey research in the social sciences is becoming increasingly difficult as potential respondents are constantly flooded with junk mail and bombarded by telemarketers. If social scientists are to continue using surveys as a research technique, they must be sensitive to these trends and employ modified, comprehensive approaches emphasizing community contact and rapport. This paper explores this contention by examining the effect of 'contact triangulation' on response rates in Benito, a rural agricultural community in Manitoba's Parkland region. Community contact, an essential aspect of successful research in rural areas, was achieved through presence and visibility in the community, a 'knock and drop' survey technique and the use of local media for research information dissemination. While contact with residents through the knock and drop exercise alone did not appear to impact response rates, overall, the efforts to establish community contact contributed to an acceptable response rate.

Introduction

Response rates in self-completed surveys have consistently decreased in recent years (Frohlich 2002; Tuckel and O'Neill 2002). Attributed largely to intense social research, censuses, seemingly endless gallup polls, and the proliferation of telemarketing, these trends have led researchers to employ innovative means to gathering survey data. While techniques for improving survey designs were a dominant theme in the social science literature in the 1970s and early 1980s (*e.g.* Dillman 1972, 1978; Veiga 1974; Henley 1976; Heberlein and Baumgartner 1978; Eichner and Habermehl 1981; Li 1981; Frey 1983; Sheskin 1985), there appears to be a void in the literature until more recently (*e.g.* Drane *et al*. 1998; Shermis and Lombard 1999; Ruggiero 2001; McTavish and Loether 2002; Huang, Hubbard and Mulvey 2003). The purpose of this paper is to describe an alternative technique for conducting a community-scale survey with a focus on intense community contact in an effort to increase response rates. Derived from triangulation or multi-modal research approaches, this research employs 'community contact triangulation'. Community contact, an essential aspect of successful research in rural areas, was achieved in three ways: 1) presence and visibility in the community; 2) a 'knock and drop' survey technique; and 3) the use of local print and electronic media for research information dissemination.

The paper begins by providing the context for research conducted in Benito, Manitoba, one of 32 community sites included in a national study known as the New Rural Economy Project based out of Concordia University (Reimer 2002). Between 1997 and 2002, due to financial and resource constraints, only 20 of the 32 community sites were studied. Benito was one of the sites not fully included. The Village of Benito represents a small rural community with elements of both continuity and change. In terms of bringing Benito into the NRE Project, a 'snap shot' questionnaire was developed for administration to all households in the community. The methods employed in conducting the survey and the resulting response rate are discussed within the context of research methodology. The paper concludes by illustrating the importance of incorporating innovative techniques in order to improve response rates, and therefore, the representativeness of survey data.

The New Rural Economy Project and Manitoba

Based out of the Department of Sociology and Anthropology at Concordia University, the New Rural Economy (NRE) Project is a project of the Canadian Rural Revitalization Foundation (CRRF) that began in 1997 to examine social cohesion in rural Canada. Based on a sampling frame developed by a consortium of researchers, 32 communities in Canada were selected to be part of a 'rural observatory' (Reimer 2002; see also http://nre.concordia.ca). These communities were judged to be a sample reflective of rural communities across Canada (Figure 1). Indeed, the selected communities reflected each province and one territory (Nunavut), and a range of population and spatial delineations (*e.g.* villages and municipalities) and economic bases. For a variety of reasons, most importantly financial and human resource limitations, only 20 of the 32 communities were actually 'activated' for research throughout the five-year span of the NRE. In Manitoba, two sites were initially selected:

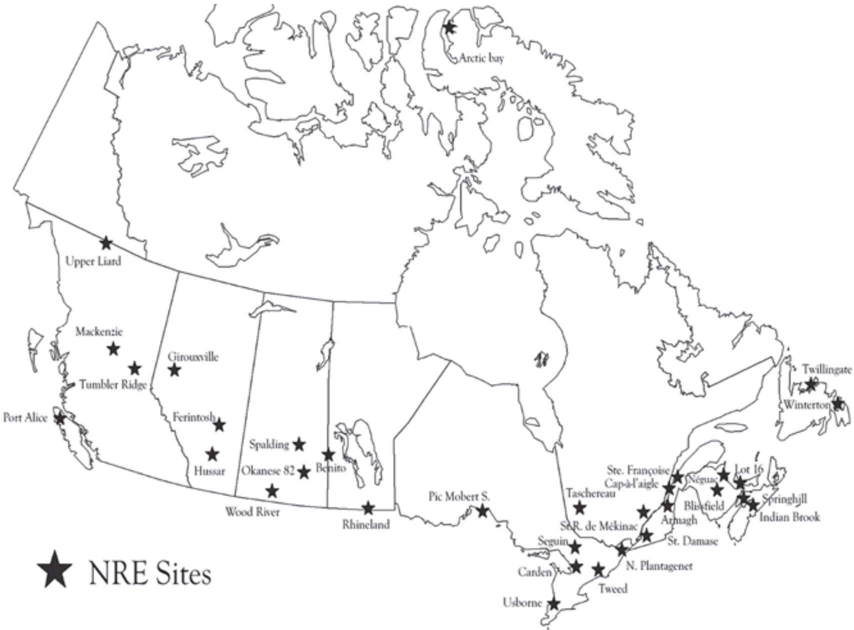

Figure 1: *Map of NRE Sites Across Canada.*

Benito and the Rural Municipality of Rhineland. However, only Rhineland was activated as part of the larger NRE project.

In order for the NRE work to be relevant to changes taking place in rural Manitoba, it was felt that the other site, Benito, ought to be activated. It was also an effort to create a comparable database since data had been collected in other activated NRE sites. Most particularly, in 2001, a researcher administered household survey was conducted in the 20 activated sites totaling 1,995 surveys of randomly selected households. As part of that survey, 146 households in Rhineland were interviewed. Using a local citizen as the first point of contact, approximately 850 people were telephoned for an interview. Even though 146 individuals were interviewed (the pre-selected sample was 148), the refusal rate was quite high. Of the total number of people contacted, 83% refused the request to be interviewed. This rate has a number of implications. First, the process was time consuming. Second and more important, a high refusal rate seems to challenge the representativeness of the sample. That is, who was actually interviewed? The researchers were hindered by vacation and working schedules, and a disproportionate number of seniors, arguably with more time on their hands, were interviewed. There were also spatial obstacles as the total area of Rhineland is 923 square kilometers. Together, spatial constraints and a low response rate resulted in a financial and labour intensive survey project that was possibly not a representative sample of the municipality as a whole.

Given the low response rate in Rhineland, the researchers felt that any research in Benito should take into consideration the obstacles of the larger household survey, particularly the data gathering method. In short, the researchers decided to apply a different research approach to Benito. In contrast to Rhineland, the Village of Benito is small, covering less than one square kilometer, and the population, despite fluctuations over the past 10 years, remains relatively stable. According to the 2001 Canadian Census, the population of Benito is 415, 45% of which are 55 years of age or older (Statistics Canada 2001a).

Benito's economy has historically been dependent on the agricultural resource base that surrounds it. Cereal crops including wheat, winter wheat, barley, oats and rye, as well as canola and flax oilseeds are grown in the Benito area. In terms of diversification, between the 1996 and 2001 Census, Manitoba outpaced the rest of Canada (Statistics Canada 2001b). Benito is no exception as diversification throughout the region includes specialty crops such as field peas, favabeans, cannery seed and alfalfa seed, feed corn and lentils, as well as horses, cattle and hogs. Like other regions across the prairies, Benito has experienced first-hand changes in agribusiness. Where several large grain elevators once stood, the last was demolished in the fall of 2002. Aside from agriculture, the Benito area supports a strong logging industry, a manufacturing base and numerous local services.

Survey Methodology

Techniques for employing a questionnaire-based survey are varied, including: face-to-face interview surveys, mail surveys, telephone surveys, intercept surveys, and dual mechanisms that combine any of the aforementioned (Sheskin 1985). Surveys can be self, group, or interviewer administered (Jackson 1988). While in the early 1980s, telephone surveys came into vogue (Frey 1983), the facsimile and e-mail-based survey techniques are more recent additions to survey types (Kitchen and Tate 2000; Ruggiero 2001; Shannon and Bradshaw 2002). However, they are limited to samples with access to such technologies and make it more difficult to ensure either confidentiality or anonymity . In comparing attributes of various survey methods, Czaja and Blair (1996) state that while face-to-face interviews yield the highest response rates and the lowest sampling frame and response bias, they also cost more and take more time. The researcher is also in the best position to be aware of the respondents' understanding of the questions (Rea and Parker 1992). Given the propensity toward telemarketing, it appears that the telephone survey has become more problematic. More recently , Shannon and Bradshaw (2002) found that while electronic surveys resulted in faster responses, mail surveys had a higher response and lower undeliverable rates. Thus, it appears that there continue to be pros and cons to various survey techniques.

The Benito survey was a scaled-down version of the 26-page survey administered in the NRE 2001 Household Project, and included select questions from other surveys conducted in 2000. Jackson (1999) recommends a maximum length of 50 questions for mailed surveys. Based on experience and the survey literature (Dillman 1972; 1978; Jackson 1999; Huang *et al.* 2003), the length of the questionnaire and the time required to complete the survey were taken into account. The final instrument was limited to six pages, printed double-sided and was divided into eight topic sections with a variety of question styles.

Given that the surveys were self-administered, a variety of question types, including Likert-type (Jackson 1999) closed-ended statements as well as open-ended questions were incorporated into the questionnaire design in order to keep the respondents interested and provide them with multiple means to express their opinions, and because this format is the most appropriate technique for collecting such information. The first section addressed demographic characteristics and employment information. The second section, which was comprised of predominantly closed-ended questions, dealt with the adequacy, usage and quality of a variety of community services. Respondents could also provide commentary on each of the services.The third and fourth sections, covering economic and community change, and natural resources respectivelywere comprised of mostly open-ended questions. It was believed that placing these sections mid-survey would increase the inclination to respond, given that open-ended questions are often discouraged in self-administered surveys (Bourque and Fielder 1995; Rea and Parker 1992; Jackson 1988). The remaining sections on personal action and participation, community action, leadership and Internet usage were mostly close-ended, although there was room for commentary.

In terms of sampling, the population of Benito (415), the number of households (192), and the community's geographic size made it possible to distribute the survey by hand. These community characteristics also made it possible to pilot new research approach techniques. Specifically, the researchers employed what they refer to as 'contact triangulation'.

This approach is a modification of other well-known approaches, including triangulation (Opermann 2000), case studies (Yin 1993; Hamel 1993), the Delphi technique (Bardecki 1984; Green *et al.* 1990), multi-modal research approaches utilizing both quantitative and qualitative methods (Tashakkori and Teddlie 1998), and the 'Total Design Method' (TDM) (Dillman 1978; Huang *et al.* 2003). In varying ways and degrees, these methodologies adopt the notion of broadening the baseline from which to collect data. In the research reported here, the focus has been on broadening the initiatives that can be employed to increase the utility of survey research. In doing so, however, these other methodologies were drawn upon. First, in balancing the questionnaire between closed and open-ended responses, the multi-method approach was adhered to. Second, whereas triangulation in its purest sense refers to multiple ways to collect the same information, in the Benito survey, triangulation was adopted in the sense of using different techniques to improve response rates, thus our adoption of the term 'contact triangulation'.

The TDM is an approach that remains a leading survey design technique described in social research methods textbooks (*e.g.* Bernard 2000; Huang *et al.* 2003). Essentially, it argues that developing a comprehensive set of procedures and steps in survey research design maximizes response rates. In revisiting Dillman's original TDM, Huang *et al.* (2003) examined six factors affecting response rates: degree of participant interest, whether researchers understood their participants, quality of mailing lists used, selection criteria in using the mailing list, incentives adopted, and the importance of study sponsorship. For the Benito survey, interest was sought through the media contacts and covering letter, both of which outlined the importance of the study to rural communities. In terms of sponsorship, several techniques (as outlined below) were employed to ensure awareness of Brandon University.

Calahan and Schumm (1995) also examined six of Dillman's mail survey steps: quality of covering letter, use of follow-up contact, the importance of the study, the appearance or readability of the survey, the length of the survey, and the sampling frame. They argue that based on employment of these considerations, the TDM offers both reliability and validity at a low cost. As outlined in the following, all steps apart from the sampling frame were considered in the development and administration of the Benito survey.

In the Benito study, participant interest was fostered by making prior contact. An understanding of potential respondents was sought through contact with a resident in each household. Mailing lists were unnecessary since contact was made with each household in the community. Although suggested by others (Wilk 1993), no financial incentives were offered for participating in the survey. However, the sponsorship of Brandon University was made clear throughout the survey design. Thus, in developing the survey for Benito, the TDM, and specifically Huang *et al.*'s view of it, was used as a reference point.

In addition to the points raised above, other initiatives were incorporated into the survey design. First, contacts were made with the local municipal office and the village council to describe the survey, its purpose, and connection to the NRE (Table 1). In consultation with Brandon University's Communication Officer, a press release was then developed and distributed to local print and radio media including the *Swan River Star and Times*, a regional newspaper serving the Village of Benito. The importance of pre-notification is also evidenced in the survey literature (*e.g.* Chebat and Pickard 1991; Schlegelmilch 1991; Faria, Dickinson and Filipic 1990; Jolson 1977). Unfortunately the press release was not immediately picked up by local print media sources. Later, the reporter at the *Swan River Star and Times* newspaper apologized for not informing others of the impending press release before she went on holidays. Having said this, however, some community members were aware of the survey, most likely through radio news based out of Swan River or Dauphin.

Table 1: *Survey stages, July and August, 2002.*

Date	Initiative
July 9	Letter sent to municipal council
July 12	Press release sent for coverage in July 16 issue of the *Swan River Star and Times*
July 22-23	Knock and drop conducted
July 30	Advertisement placed in local paper announcing consultation
July 31 & Aug. 1	Return site visit and consultation
Aug 23	Reminder and thank-you cards mailed to all households

Bernard (2000) describes the 'knock and collect' technique whereby a survey is dropped off at a particular location for future pick-up, which is similar to the 'drop-off/pick-up' method described by Steele *et al.* (2001). A modification of this technique was employed in the Benito survey, in that surveys were dropped off at all households in the Village with an addressed, stamped envelope for return to the researchers. This 'knock and drop' technique is similar to that described by Sheskin (1985). The instrument and cover letter were placed, along with a self-addressed stamped envelope, into an envelope addressed to 'community resident'. The covering letter included a handwritten note to remind respondents of the deadline to return their surveys. The technique of individualizing the survey is noted in the TDM (Dillman 1978; Calahan and Schumm 1995). Furthermore, as part of the survey design, attempts were made to contact each household. If residents were at home, the survey was described, and if the resident was willing, a survey was left for completion (Table 1). If contact was not achieved, the envelope was left at the home.

Visibility during the 'knock and drop' exercise was maximized by the presence of Brandon University clothing, buttons, and nametags worn by the researchers. Sponsorship has been found to influence response rates (Heberlein and Baumgartner 1978; Greer *et al.* 2000). Posters were also placed strategically throughout Benito, including at local merchants, the municipal office, the community events board, and on hydro poles. Following the 'knock and drop', an advertisement was placed in the *Swan River Star and Times* thanking residents for their participation and announcing that consultations would be held over a two day period at the local coffee shop. Finally, reminder/thank-you cards were mailed to all households in the third week of August (Table 1). Reminder cards and other attempts at follow-up have been found to increase response rates (Dillman 1972; Anderson and Berdie 1975; Etzel and Walker 1974; Drane *et al.* 1998; Greer *et al.* 2000).

Compared to the survey techniques described by Czaja and Blair (1996), the 'knock and drop' technique closely resembles mail survey techniques. Table 2 reproduces the three categories described by Czaja and Blair (1996) (mailed, telephone, and face-to-face). The 'knock and drop' technique employed in this project is described in the additional fourth column in Table 2. As noted, this technique is similar to the mail-out survey. Several important differences include the fact that the 'knock and drop' must be administered to a clustered sample, rapport can be more easily established given researcher presence in the community, and there is more personal contact. Also important to mention is that in this case, the length of data collection was similar to that of face-to-face interviews (Czaja and Blair 1996) since respondents were given less than six weeks to complete the survey. Not noted in Table 2, however, is that with the 'knock and drop' technique, researchers can be more confident that most of the questionnaires were delivered to dwellings that appeared to be occupied, whereas with mail-out surveys there are always margins of error in delivery through the post. Steele *et al.* (2001) note that their 'drop-off/pick-up' method is appropriate for small dense settlements because there is an assurance that all households are contacted. Similarly, the methodological strength of the Benito research is the lack of a sampling frame bias given that all households in the community had an equal opportunity to respond.

Table 2: *Survey design issues.*

Aspect of Survey	Mailed Questionnaire	Telephone Interviews	Face-to-Face (in-home) Interviews	Knock and drop*
Administrative, Resource Factors				
Cost	Low	Low/medium	High	Low
Length of data collection period	Long (10 weeks)	Short (2-4 weeks)	Medium/long (4-12 weeks)	Medium (4 weeks)
Geographic distribution of sample	May be wide	May be wide	Must be clustered	Must be clustered
Questionnaire Issues				
Length of Questionnaire	Short/medium (4-12 pages)	Medium/long (1/4-3/4 hour)	Long (1/2-1 hour)	Short/medium (4-12 pages)
Complexity of Questionnaire	Must be simple	May be complex	May be complex	Must be simple
Complexity of Questions	Simple to moderate	Must be short and simple	May be complex	Simple to moderate
Control of question order	Poor	Very good	Very good	Poor
Use of open-ended questions	Poor	Fair	Good	Poor
Use of visual aids	Good	Usually not possible	Very good	Good
Use of household/personal records	Very good	Fair	Good	Very good
Rapport	Fair	Good	Very good	Fair to very good
Sensitive topics	Good	Fair/good	Fair	Good
Nonthreatening questions	Good	Good	Good	Good
Data-Quality Issues				
Sampling frame bias	Usually low	Low (with RDD)	Low	N/A (population sample)
Response rate	45%-75%	60%-90%	65%-95%	33%
Response bias	Medium/high (favors more educated persons)	Low	Low	Medium/high (favors more educated persons)
Knowledge about refusals and noncontacts	Fair	Poor	Fair	Fair
Control of response situation	Poor	Fair	Good	Poor
Quality of recorded response	Fair/good	Very good	Very good	Fair/good

Source: Adapted from Czaja and Blair (1996)
Note: *Column added based on present survey

Response Rate

Of the 192 households identified in Benito, contact was made at 104. Nine refused participation and a questionnaire was left in the door of the remaining 88 households. A coding technique was employed to classify the questionnaires completed by those where personal contact was made and those where personal contact was not made. The result was a total response rate of 32.8% (n=63). Interestingly, a slightly higher response rate resulted from the cohort where no contact was made (36.3% or 32) compared to that where contact was made (29.8% or 31). For those respondents without contact, there was a greater propensity for the individuals to be between the ages of 18 and 54. Of those who responded and had contact with the researcher, they tended to be above the age of 55, a reflection of the time of day that contacts were attempted. That is, the 'knock and drop' was conducted during the late morning and early afternoon when those of a working age would not normally be home. Further, in making contact with those over the age of 55, it was apparent that many would not be able to complete the survey due to factors such as literacy and frailty.

While it appears that making contact had an adverse effect, the higher response rate for those not contacted could be the result of the surveys being dropped off at the door in a community with no household mail delivery. Thus, residents would perceive the survey drop as being an attempt to make contact. As noted by one resident where contact was made, "if it came in the mail, I wouldn't have even looked at!" That is, the survey was not simply bulk-mailed to a household's post office box, which is considered a less personal and less successful technique (Veiga 1974). Given the possibility that such a drop would be considered to be contact by some, the contact response rate could be higher than indicated by the study. Nevertheless, having approximately one-third of all households in Benito respond to the survey is adequate according to the literature. Bourque and Fielder (1995), for example, state that a 20% response rate is good when no incentives are included.

In this sense, the 'knock and drop' approach to community-level surveying was a success. The 33% response rate was more than adequate given the technique, the time of surveying and the population. Table 3 lists the responses from community residents as they were post-marked. Follow-up, including a return site visit and thank-you/reminder card, appear to have increased response rates. As illustrated in Table 3, in the week following the advertisement and return site visit, the proportion of total responses received increased from 27% to 59%. A further 9% were receiving following the mailing of the mail-out thank-you/reminder card. While it is not possible to verify whether these actions were responsible for all responses made during these two periods, together they accounted for 29 of the total 63 responses, or 46% of the total.

Having said this, several issues did emerge that could be considered a downfall of this specific approach, or the use of the self-administered questionnaires in general. While 78% (49) of respondents provided at least one comment in the first services section and only four failed to provide any responses to open-ended questions midway through the survey,

Table 3: *Survey actions taken and date surveys mailed by respondents, Benito.*

Survey Action	Month	Date Post-Marked	Frequency	Percent	Cumulative Percent
Conducted Knock and Drop	July	Monday 22			
Conducted Knock and Drop		Tuesday 23	4	6.3	6.3
		Wednesday 24	3	4.8	11.1
		Thursday 25	2	3.2	14.3
		Friday 26	2	3.2	17.5
		Saturday 27	1	1.6	19.0
		Sunday 28			
		Monday 29	4	6.3	25.4
Advertisement in Paper		Tuesday 30	1	1.6	27.0
Return Visit and Consultation		Wednesday 31	5	7.9	34.9
Return Visit and Consultation	August	Thursday 01	4	6.3	41.3
		Friday 02	2	3.2	44.4
		Saturday 03			
		Sunday 04			
		Monday 05			
		Tuesday 06	6	9.5	54.0
		Wednesday 07	3	4.8	58.7
		Thursday 08	1	1.6	60.3
		Friday 09	4	6.3	66.7
		Saturday 10			
		Sunday 11			
		Monday 12	4	6.3	73.0
		Tuesday 13	2	3.2	76.2
		Wednesday 14	1	1.6	77.8
		Thursday 15	1	1.6	79.4
		Friday 16	2	3.2	82.5
		Saturday 17			
		Sunday 18			
		Monday 19	1	1.6	84.1
		Tuesday 20			
		Wednesday 21	1	1.6	85.7
		Thursday 22	1	1.6	87.3
Reminder/Thank-you cards		Friday 23			
		Saturday 24			
		Sunday 25	1	1.6	88.9
		Monday 26	2	3.2	92.1
		Tuesday 27			
		Wednesday 28	2	3.2	95.2
		Thursday 29	3	4.8	100.0
		Total	63	100.0	

Note: shaded areas denote days when Canada Post Offices were closed. Post marks in the shaded areas could be due to clerical errors at Canada Post
Source: Authors' Survey

there appeared to be a high propensity to omit or skip questions. In fact, of the 63 respondents, 73% (46) omitted or skipped at least one question. While this could have been due to any number of reasons including complicated question wording, being unsure of the answer, making a choice not to respond, illiteracy or simple oversight, it is impossible to know with any certainty, therefore illustrating a weakness of this technique. A high incidence of missing cases on one or many variables makes any cross tabulation or regression-based analysis dif ficult to conduct and compromises the use of such variables as indices of social phenomena.

By way of example, Table 4 lists the responses given in the service provision section of the questionnaire. As noted, while in general few written comments were provided for most services, more than two-thirds of respondents provided written comments on health care. In fact, while a topic dealt with in more detail elsewhere (Walsh and Ramsey 2003), health care issues were raised in other points of the questionnaire, including the open-ended responses to the question: "What are he most important things you feel Benito should attempt to achieve over the next few years?" Thus, propensity to provide responses to open-ended questions is in part a reflection of the level of interest in the subject. The issue of interest and relevance of questions is illustrated in Table 5 where non-response ranged from 16% (10) for garbage collection to 50% (31) for high schools. The high degree of non-response to the latter is both a reflection of Benito lacking a high school as well as older respondents not having school-aged children. Together, Tables 4 and 5 illustrate a comparable level of non-response between closed and open-ended questions and statements.

Table 4: *Resident perception of adequacy of service provision in Benito.*

Service	Yes	No	Not Applicable	No Response	Number of Written Comments
Health	13	47	1	2	43
Recreation	46	7	5	5	14
Transportation	19	19	10	5	17
Government	34	16	4	9	11
Education	47	3	7	6	14
Communication	42	5	7	9	11

Source: Authors' Survey

Research in Rural Areas: The Importance of Community Contact

As indicated earlier, conducting research in rural areas is a challenging process, given that research methods reliant on mail, e-mail and fax technology have evolved to become more eficient, cheaper and ultimately, more impersonal. Added to this is an overall societal shift in communication means including an increasing reliance on computer-based technologies (*e.g.* e-mail, chat, teleconferencing, web videos, *etc.*), rather than face-to-face contact. Even telephone survey technology includes dimensions that

Table 5: *Perceptions of the quality of municipal services in Benito, 2002.*

Service	Very Poor	Poor	Neutral	Good	Very Good	No Response
Elementary School	1	2	8	17	15	20
High School	3	1	10	13	5	31
Police/RCMP	3	7	17	17	6	13
Fire Protection	1	0	5	17	28	12
Municipal Water Supply	2	0	4	23	22	12
Municipal Sewage	2	0	6	26	18	11
Garbage Collection	0	4	5	26	18	10
Recreational Facilities	4	3	8	30	6	12
Recreation Programs	4	2	16	22	6	13
Source: Authors' Survey						

are impersonal such as automated dialing systems. In smaller rural communities such as Benito, contact triangulation as a research approach can be employed to overcome these obstacles and quality contact with community residents can be achieved to increase response rates, while still keeping within the research budget.

While this research approach shows that contact did not necessarily increase the propensity for general response, it did lead to higher response rates among Benito's aging population. Given that the Canadian population is aging (Statistics Canada 2001a) and that 20% of Canada's seniors live in rural areas (Keating, Keefe and Dobbs 2001), the contact triangulation approach, including the 'knock and drop' technique could prove to be an important means to discover the needs and realities of this vital Canadian population. In doing so, however, return visits to households would be recommended as a means to clarify the survey purpose, answer any questions a potential respondent may have, and ultimately, increase response rates.

Steele *et al.* (2001) indicate that presence in the community allows exposure to local conditions and residents and ultimately, a greater understanding of the community. Undoubtedly, the presence of the researchers in Benito provided them the opportunity to understand the survey results in a more informed context.The researchers were aware of residents' perceptions and were able to interpret written comments based on other informal conversations and field notes.While telephone and mail surveys do provide an indication of what is occurring among the population under study, the absence of a researcher in the field could potentially mean that many important aspects of the respondents' reality is unobserved. This is not to say that a brief presence in the community can lead to the deep understanding often achieved through ethnographic methods whereby researchers live in the research area for months or even years at a time.

However, even a quick glimpse can lead to a sense of community conflicts, power relations, demographics, as well as the social, economic and political realities of the people living there.

Recommendations for Future Research

The purpose of the research was to bring Benito into the fold of a larger, national study (Reimer 2002). As such, an instrument was developed drawing from previous surveys. Based on the experience of a modified instrument and survey employment, a number of comments can be made in recommending future survey research. Building rapport is important in survey research, particularly with the elderly. While others have noted a higher response rate with face-to-face interviews (Sheskin 1985; Czaja and Blair 1996), and such a technique may be desirable, it is not always possible. The 'knock and drop' technique, while not perfect, does offer potential. One recommendation would be to drop only when contact is made. At the very least, it would eliminate the question regarding contact being personal versus contact perceived where no household mail delivery is provided. Developing a schedule that allows one to return at a different time period of the day may increase the response rate. At a minimum, more than one visit to each household could bolster response rates as well as provide the opportunity for researchers to answer questions residents may have. Finally, personally addressed covering letters should be attempted if the necessary information is available.

Regardless of the delivery method chosen, however, it is important to realize that survey research is constrained. For example, accessing people can be difficult and the interests of potential respondents can vary. Reading and comprehension levels are also variable. Simplicity is key. The instrument must be user friendly and use simple language, and researchers must accept that few people in a general population survey will provide written details. As such, closed-ended structure to questionnaires should be employed. Further impediments to survey research are more recent, such as the trends toward telemarketing and the lack of privacy that results. In short, there appears to be an increasing wariness towards surveys that researchers need to be aware of when designing their survey instruments and employment techniques. Utilization of some form of 'contact triangulation', such as that employed in this research, offers potential for survey research in the future.

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East to Arden Ridge: cultural icons and landscapes of the "Beautiful Plains" region of Manitoba[1]

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Introduction

Within a few hours driving distance of the Town of Neepawa there are a variety of physical and cultural landscapes, many of which are unique to the stereotypical 'prairie landscape'. A select few sites were chosen for the field trip offered to participants attending the 2002 annual meeting of the Prairie Division of the Canadian Association of Geographers (PCAG) (see Figure 1). Proximity to Neepawa, the host site for the meeting, the Arden Ridge, and cultural landscapes and icons, were the key factors in designing the tour. The field trip, although 'human' in design, attempts to focus on the human use of the environment, and thus, as all good geography should, tie together the physical characteristics and the human response to these features.

The human history of the area began almost 12,000 years ago, and it was occupied by bands of Assiniboine and Cree when the first Europeans arrived (*Neepawa* n.d.). Most of the early 'white' settlement in this area was by people of British background. The Graham family was the first to settle in what is now the Town of Neepawa – on a high well-drained plateau that is now part of Riverside Cemetery. Early ethnic settlement was unusual enough to be clearly noted in many of the local histories, but the presence of the St. John the Baptist Ukrainian Catholic Church is evidence of the arrival, in the early twentieth century, of Eastern European immigrant populations.

(Km 0) — Neepawa:

The tour begins at the Vivian Hotel in downtown Neepawa, that according to a welcoming billboard on the Yellowhead Highway leading into town from the east, is a town "996,600 short of one million people"

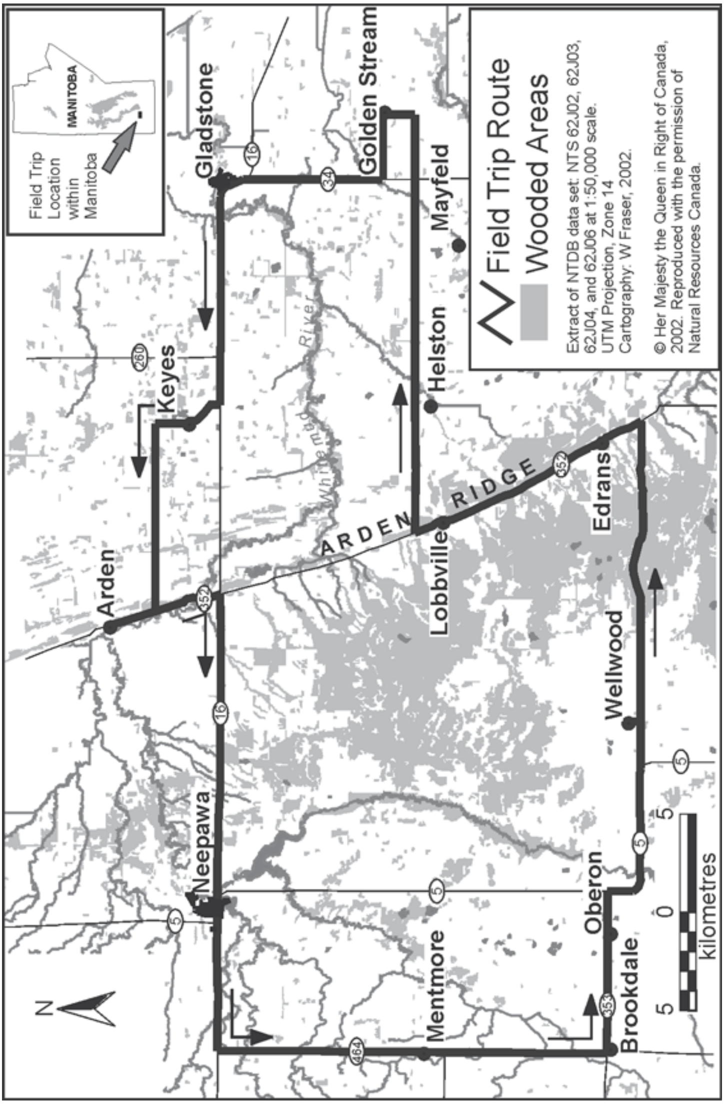

Figure 1: *Field trip route.*

Its population in the 2001 census was actually 3,325, an increase of 24 (0.7%) since 1996. Founded in 1880 by immigrants from Ontario (via Palestine[2]), in 1891 Neepawa had 774 people, rising to a peak of 3,508 in 1976. The billboard was obviously always optimistic. The toponym is a Chippewa Indian word which means ‘plenty’ or ‘abundance’ - hence the widespread presence of the cornucopia (‘the horn of plenty’) which was adopted as the town’s emblem in 1884 (or 1912, depending upon which source you believe) (*Neepawa* n.d.).

As Neepawa existed before the railroad, it has a different town plan from most other prairie ‘t-town’ settlements. The Manitoba and North Western Railway (MNWR) was built from Portage to Minnedosa in 1883, after the Town of Neepawa gave the railway free lots and $16,000 as an incentive (see Figure 2). It was leased to the Canadian Pacific Railway (CPR) for 999 years in 1900. For some time this north end of town out-competed the south end around the original nucleus, but by 1900 the present-day commercial area had established its dominance.The Canadian Northern (CNor) branch from Hallboro to the south was built to Neepawa in 1902 under a Morden and North Western Railway charter, as were continuations to Birnie and Clanwilliam (1903).The Clanwilliam line was later continued by the CNor north-west along the ‘turkey trail’ to Erickson, Rossburn and Russell (1908), and north along the edge of the Manitoba Escarpment to McCreary (1903) where it met the CNor line (once the Lake Manitoba Railway and Canal Company route) from Grandview to Sifton and Winnipegosis (opened 1897). The MNWR/CPR is at the northern boundary of town, the CNor/Canadian National (CN) to the west. Downtown Neepawa remains free of railway influences.

In 1900, there were seven licensed elevators owned by six different companies on the CPR. By 1902, there were nine (eight companies) on the CPR (none on the CN), and by 1912 this number had dropped to three (Dominion, Lake of the Woods, and Ogilvie) — again all on the CPR. Elevators were built in later years on the CN line by the United Grain Growers (UGG) (in the mid 1950s) and by the Manitoba Pool (1970s). Currently there are no line elevators operating within the town limits, although at the time of writing, the Pool and the UGG ‘houses’ were still standing.[3] In addition to its many central place services, a salt factory helped to make Neepawa famous. The salt deposits were discovered by pioneers seeking oil (History Book Committee 1983).The last incarnation of this operation was closed in 1970 but some of the buildings remain as part of the Yellowhead Arena complex.

Neepawa appears to have a vibrant economy tapping into both the agricultural and tourism sectors. In terms of agriculture, Neepawa is home to the Springhill hog processing plant (Springhill Hutterite Colony is a

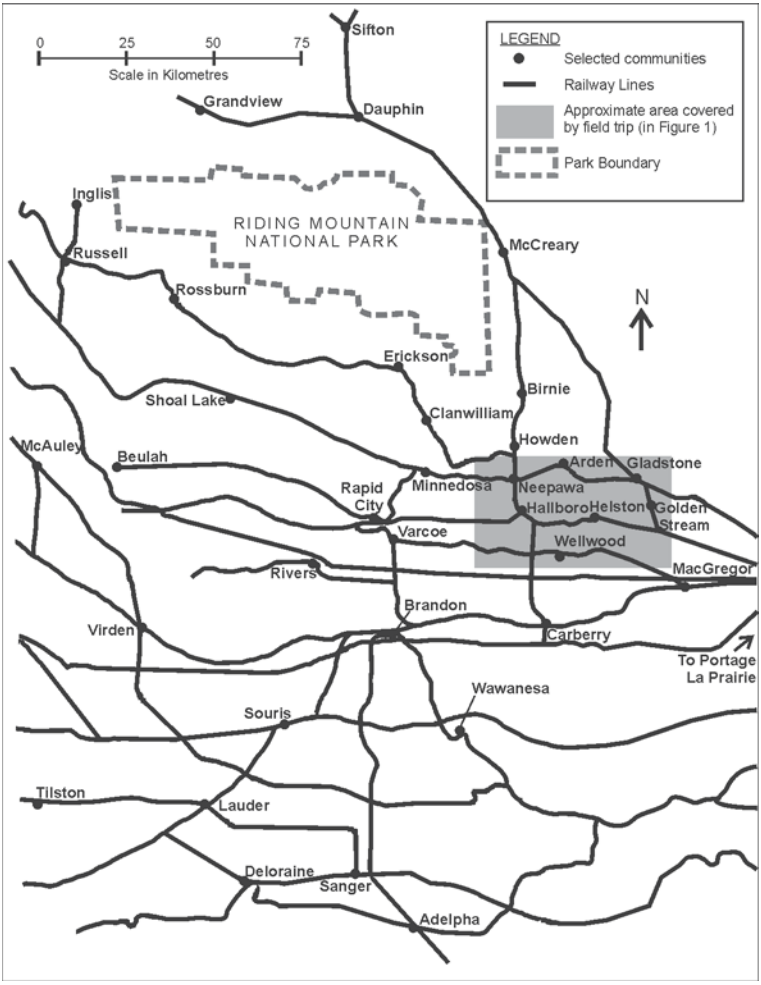

Figure 2: *Railway lines in South-West Manitoba, 1922 (Source: Tyman 1972, 53).*

few miles to the north-west) and Neepawa Food Processors, a division of Champ Food Systems Limited' s Hatchery and Farm Division that specializes in "Quality Day Old Chicks" (15-20 day olds).The hog plant is located on the eastern edge of town; the hatchery is located one block south of the Chicken Delight and Chicken Corral restaurants that are located on the Yellowhead Highway. Neepawa is also home to the main ofice of the Whitemud Conservation District. Its location on the Yellowhead

Highway has provided Neepawa with tourism and travel benefits. Most prominent is the recent opening of a McDonald's Restaurant – an outsized function for a community of this size.

Neepawa is famous for its Margaret Laurence connections, with her house (she lived in it for some time) open as a museum, and with 'The Stone Angel' a landmark in the very well kept cemetery. The latter is located on the grave of John Andrew Davidson, one of the founding fathers of Neepawa (the other was Jonathon J. Hamilton). Also take a look at the "Beautiful Plains County Court Building" on Hamilton Street, constructed in 1883 and nicely preserved and conserved. It was designated as a provincial historic site in 1982. South-east of town is Lake Irwin, a 1950s PFRA water-provision project, now a recreational/cottage area. The Beautiful Plains Museum is a converted train station located along the main rail line just north of McDonald's.

From Neepawa, the tour heads west along PTH 16, the Yellowhead Highway, past a lumber yard (Prairie Forest Products Ltd.) that all but obscures its original use as a World War Two training field (which is 1282 feet above sea level). As the Neepawa town boundary is crossed, the tour enters the R.M. of Langford. About five kilometers west of the town centre is the first cairn on the trip: "Stoney Creek School Division #133" to mark the location of a school site that existed from 1881 to 1950. Its opening predated the railway, which came in 1883. The site of an old Drive-In movie theatre is to the south.

(Km 6.5) — Great Plains Interpretive Centre (GPIC):

In the late 1990s there were attempts to build a tourist destination point for Neepawa. The GPIC has not yet got off the ground. The land has been purchased but its location was not the original choice. It had been hoped to have it closer to Neepawa. A business plan has been produced, and the provincial government and other sources are being asked for funding. The attempt to develop this centre is an illustration of the local desires to diversify from the traditional agricultural economy.

The Road to Brookdale

At kilometer eight, we turn south along provincial highway 464 and enter the little known area between the Trans Canada and Yellowhead Highways – the focus of this field trip. At this point the land slopes gently from west to east. Later in the trip, as we head towards Arden Ridge, it drops more rapidly before reaching the floor of glacial Lake Agassiz where the ground becomes more level once again.

(Km 19) — Mentmore (26-13-16-W):

Located on the Western Extension Railway (WER) that was opened from Hallboro (on Highway 5 between Neepawa and Carberry) to Beulah (south-west of Shoal Lake) in 1911. Eastwards it connected through Carberry Junction and Muir (Canadian Northern) to Portage. We will cross the abandoned line again at Helston. The WER company was amalgamated with Canadian Northern in 1903. The station (Mentmore) was apparently named by the owner of the site, who thought his home "meant more"!! However, the first elevator was not built until the late 1920s (by the Manitoba Pool). This was the only elevator company represented at this point. An elevator still stands and is used by a local farmer ("Drayson Bros. Ltd. Feed Service"). This stretch of the line (Hallboro to Beulah) was closed in 1978. The elevator annex was moved by road to Franklin in 1980 and attached to the Pool elevator in that settlement. The hamlet of Mentmore (at 1337 feet ASL) had a population of eight in 1941 and nine in 1956. It had however, a post office, a short-lived grist mill and several other central place services (Channon and Morrison 1972). [4] No more recent population data has been found for Mentmore but you can draw your own conclusions!

We continue south on 464 crossing from Langford R.M. into North Cypress R.M. about one mile north of Brookdale (this boundary is part of the Fourth Base Line). Note that further down the road, just north of Brookdale, is "Sunnyview U-Pick" an example of on-farm diversification of activities. While strawberry production declined by 24.3% in Manitoba between 1996 and 2001, Saskatoon berry production increased by 43.8% over the same period, further illustrating the degrees of change in diversification initiatives.

(Km 28) — Brookdale (26-12-16-W):

Brookdale (1279 feet ASL) is located at the junction of highways 464 and 353 on the now abandoned railway line that was the Varcoe Branch of the CPR. It was one of two branch lines (the other was the WER/CNR Neepawa/Rapid City Subdivision) that ran east-west between the CPR's Minnedosa Subdivision (through Neepawa) and the main CN line (once the Grand Trunk Pacific (GTP) 'alphabet line'). The Varcoe line branched off from MacGregor on the CPR mainline in 1901. It reached Wellwood that year, Brookdale in 1903, and Varcoe in 1905. Varcoe was on what had been the Great North West Central Railway from Chater to Hamiota (opened 1890). Varcoe was situated just to the west of the current Brandon-R.M.N.P. highway (PTH 10). It was named after an early settler. A local brook was the origin of the toponym 'Brookdale'. As will be seen, these naming practices were fairly typical of the region. The Wellwood to Varcoe section of this line (and thus the Brookdale siding) was closed in 1978. The MacGregor to Wellwood stretch had gone in 1975.

Brookdale has never been a large settlement, but as a result of its community spirit and its all-weather road connections it has survived as a village (Channon and Morrison 1972). Its peak (known) population was in 1956 (156 people) but it was likely larger in earlier days. It declined after 1956, reaching a low of 76 in 1981, but has since grown to just under a 100. Its community centre/curling rink, school, relatively good roads, and centrality, probably explain this success. Brookdale has a mixture of long-term residents and Brandon commuters. The town used to have many services, including a brickyard, but now has only a few. Still in operation are a small convenience store that also acts as a postal outlet and an elementary school. The community centre was built in 1979 on the site of the former school (1927-1971). In addition to the "Good Neighbours" centre, there is a complex which houses a community hall, two pad curling rink, and a small arena that is used officially for minor hockey only.

Brookdale has had a variety of elevators over the years. In 1912, Brookdale had two elevators, one owned by the Lake of the Woods Milling Company and one by the Grain Growers Grain Company (GGG Co.). Lake of the Woods had one of the major lines of elevators in the southern prairies, gathering good quality grain for its milling operation in Keewatin. Sir George Stephen and William Van Horne were among its original shareholders. It was torn down in 1947-48. The GGG Co. was a farmer owned company set up to help combat the major line elevator and milling companies. Its elevator had been purchased from the Manitoba Elevator Commission (MEC) (the second government owned utility after the Telephones) in 1910. It had been built in 1902 and sold to the MEC by the Carberry Elevator Co. in 1910 for $5,369, and was bought by the GGG Co. for $6,142. The GGG Co. later formed the basis of the UGG. The Pool elevator was built in 1929. As of 2002, the old Pool elevator was owned by a local farmer ("J.R. Jones Farms"), and the United Grain Growers (UGG) structure appears to be abandoned. But there still remains, on its original site, one of the few extant 'flat warehouses' that predated most elevators in Manitoba. Unfortunately this structure is in poor repair and may not survive much longer. Rings for hitching the horses that drew the grain wagons can still be seen. The foundation of the octagonal CPR water tower can be seen at the east end of the village.

As is common in prairie settlements, the local cemetery is located out-of-town, about a quarter of a mile south on 464. Nearby is an old railway station moved in about five miles from Ingelow (the 'I' on the Grand Trunk Pacific/CNR alphabet line). It was meant to be the marital home of a young couple but they divorced before refurbishment could take place. The mother of one of them now owns it but lives elsewhere. Although there have been a number of requests, it is not for sale!

The Road to Arden Ridge

We now go east on provincial highway 353 (which now bypasses Brookdale, once having cut through town) past a succession of changing agricultural landscapes, which in part reflect a variable physical environment. Millet is one of the first alternative crops seen. We also pass a horse stable operation. While Ayerst Organics in Brandon has been instrumental to the burgeoning PMU industry, the total number of horses and ponies in Manitoba declined by 8.7% between 1996 and 2001, whereas the Canadian total increased by 3.8% (Statistics Canada 2002a). East of Brookdale, near Oberon, is a unique abandoned farm. A local resident indicated that the two-story barn with windows (less the panes) was a chicken operation. At 30-12-15, a small farm with oddly designed out-buildings represents failed diversification into the ostrich industry. A further attempt into the hog sector (400 hogs) also failed. The farmhouse is an old railway building that was imported from Oberon. One mile north (32-12-15) is an expanding hog farm, currently housing 2,600 hogs with turnover three times per year. In contrast to horses, hog production increased by 42.9% between 1996 and 2001 in Manitoba. Sows and gilts for breeding increased by 62.4 % over the same period, double the national rate of increase (Statistics Canada 2002b). The barley is grown for feed on the farm, whereas all other feed comes from other sources. While barley is an important component to hog feed, actual production of barley actually fell by 25.2% between 1996 and 2001.

(Km 36) — Oberon (29-15-12-W):

The settlement was originally named Boggy Creek and later McKenzieville after a prosperous early landowner (Adam McKenzie), known as 'Manitoba's Wheat King'. Also a wealthy landowner in the Arden area, he once took 32 carts of flour to Edmonton, taking two months to cover the 1,500 kilometres but making enough profit in the process to buy 12,000 acres around Oberon. The hamlet (at 1,278 feet ASL) was renamed Oberon in 1905 after the local post office, itself named after a town in North Dakota – which was named after the fairy king in Shakespeare's *A Midsummer Night's Dream*. Also located on the Varcoe branch, Oberon lost rail service in 1978, but the elevator remains and is used by a local farmer. Once having a G.B. Murphy elevator[5], this site was an Ogilvie Flour Mills elevator point until this company's elevators were taken over by the Manitoba Pool in 1959. There were 23 people in Oberon in 1951, and 5 in 1966. No more recent population data exists for the settlement. There are presently three occupied dwellings, the abandoned elevator and a deserted store, and a welding shop (Arctic Welding) that is in operation.

We continue east on ‘353’ (which also now bypasses Oberon) and skirt the northern edge of North Cypress R.M.Three and a half miles east we cross (but can no longer distinguish) the route of the old CN rail-line that ran north-south connecting the Carberry area lines with those around Neepawa. This particular stretch ran from Carberry Junction to Brandon Junction (on the CN line south of Carberry) and was opened by the Canadian Northern in 1905. The section from the CN line to the south, to the CN mailine (‘alphabet line’) still operates. The townsite of Munroe (named after the local landowner John Munroe) once lay one mile to the north, but little is known about this place. It does not appear to have ever had a siding or an elevator.

(Km 49) — Wellwood (28-12-14-W):

The pre-railway community was named after a Presbyterian Minister/ School Inspector in the early 1880s when postal service came to this area. The name was transferred to the railway point after the CPR line arrived in 1901. The line was closed to the east in 1975 and to the west in 1978. Two elevators were built in 1901, a ‘W estern’ and a ‘Winnipeg’. These were both sold to the MEC in 1910, were dismantled and rebuilt into one elevator in 1919. This new structure (which also included materials from a Binscarth ‘Canadian’ elevator) was leased to the UGG that bought it in 1924 for over $28,000.The UGG elevator remained in the community for some time after abandonment and was used by local farmers/businesses, but was eventually dismantled. Wellwood’s population was 97 in 1957 and 69 in 1966, but has steadily dropped since that time. It may now be between 50 and 60, but it still functions as a social central place for the local region.

At present there is a community hall and large auto salvage operation roughly located on the old elevator site. Beyond these features, Wellwood stands ubiquitous to many prairie communities - an abandoned hotel and garage, and monuments to where a school (1919-1976) and church (1881-1985) once stood. While the ball diamonds are no longer in use, the curling rink on the same site appears to be.

Leaving the hamlet of Wellwood and continuing east toward the Arden Ridge, we descend about 200 feet and pass through deltaic deposits (the Assiniboine Delta into Lake Agassiz) that are part of the flight path of pelicans and other migratory species and include conservation district projects. An area with many dissected sand dunes, this marks noticeable land use variations including community pastures, shelterbelts, grazing land, crop land, livestock operations and even the local dump servicing Brookdale, Wellwood and Fairview. Coming to a T-intersection we begin traveling on one of the relatively few prairie-surveyed roads that does not conform to the section-township-range survey system.

Provincial Highway 352 is known locally as the 'Ridge Road'. Just south of this intersection is a unique operation, "The Penfolds-Oakwood Grange - Breeders of Traditional British Livestock". Originally from England, with stints farming in Nova Scotia and Saskatchewan, this family operation is home to rare roosters and chickens, sheep, a 'guard' donkey, and beef cattle. Traveling north from the T-junction along '352' there are numerous flooded creeks and wet areas - mostly resulting from beaver activity.

The Road to Gladstone

(Km 68) — Edrans (35-12-13-W):

Edrans and Highway 352 are located on the Arden Ridge of glacial Lake Agassiz - one of "Manitoba's Scenic Secrets", according to Neepawa author Bill Stillwell (1997). This beach ridge was formed about 12,000 years ago and is also referred to as the Campbell Beach. It can be traced north to the Swan River area. Edrans (1,073 feet ASL) was the next elevator point east of Wellwood. It was named after an estate in Ireland from where the original landholder originated. Never a large settlement, it had 25 people in 1986 — the last date when data is available — but this seems unlikely today. The Varcoe Subdivision was built through here in 1901, and the line was closed in 1975. A Western Canada Flour Mills (WCFM) elevator was located here during the early years, but it was unlicensed by 1916 and gone by 1919, and has never been replaced. The look of the surrounding countryside (and its current land use) reinforces a supposition that this is not important grain growing country and its proximity to Firdale (the 'F' on the GTP line) and Helston (on the CNor) did not help its profitability as an elevator point.

More than most settlements to this point in the fieldtrip, Edrans has elements of both abandonment and lack of prosperity (past and present). In addition to abandoned homes and an abandoned outdoor hockey rink, Edrans does have a community centre that is still in operation. Unique though is the "Edrans Church" that now operates a K-12 school with a total of 28 children. In operation for four years, members of the congregation practice the Charismatic Faith. The community cemetery is located just north-west of the townsite, with another old church building associated with it. The cemetery is on the beach ridge, which provides easy digging and good drainage to a number of such cultural landscape features as it wends its way north-west. The R.M. boundary of Lansdowne (which is also part of the Fourth Base Line) is crossed just after we pass the cemetery and Edrans Community Chapel. North-west of Edrans (in Lansdowne) is a large community pasture.

North of Edrans, we pass the "Midnight Rodeo Company", a travelling rodeo company that taps into the small country fair market. They 'grow their own' bucking horses and transport the complete show to their customers. The owner began life as a rodeo participant and went into management in the twilight of his active career. In the off-season, activities convert to trucking general goods. Note the bison on the east side of the roads. Family pets!

(Km 80) — Lobbville (28-13-13-W):

This place was also on the WER/CNor line from Portage to Beulah. There is little recorded evidence of this settlement - other than on a map in *The Lansdowne Story* (the history of the R.M.), and the discontinued 1:125,000 'Neepawa' topographic sheet, and its name has slipped from local usage (McKenzie 1967). It doesn't appear to have been much more than a stopping point (probably a 'flag stop' and maybe a siding) on the railway as it crossed the beach ridge/road. It appears to have been named for the Lobb family, local farmers. No Lobbs appear on the current tax rolls of Lansdowne R.M., but there were once many in the Lobbville-Helston area. West of Lobbville, is Hummerston (22-13-14-W), which was once a grain shipment point named for its first shipper. It no longer exists, and is not on this tour, but this sandhill area is now the site of a community pasture, and is said to be another of Manitoba's "scenic secrets" (Stillwell 1997).

(Km 81) — Sinclairville (32-13-13-W):

Sinclairville was another early community based upon a school district (No. 2063) that was organised in the home of local farmer John Sinclair. The school was built on the Ridge Road. It was closed in 1966. No obvious trace remains of this community (and the name is no longer used locally) other than a cairn commemorating the school. We turn east one mile south of the Sinclairville school-site and go down the ridge side (about a sixty-foot drop from the near eleven-hundred foot height of the ridge) towards the Agassiz lake plain along a section road.

(Km 88) — Helston (25-13-13-W):

Originally known as Berton, and founded in 1902 as a CN siding, the name of the community (at 992 feet ASL) was changed in 1924 and now commemorates Helston, in Cornwall, England. The School District (No. 1912) was named Berton until amalgamation. Helston is bisected by the Lansdowne-Westbourne R.M. boundary. Students went to a school in Westbourne before Berton School was opened in 1918. In order to interpret Helston, one needs to examine the monument/cairn just south of where the railway once ran, as it includes a map of the community as it once was. The old "CPR Red" Manitoba Pool elevator (c. 103,000 bushels capacity), while abandoned, has been maintained and appears in good structural shape, although this first impression apparently masks all sorts of problems. It is now owned locally, but is for sale. You could pick it up for about $1,000, with the land around it costing you $2,500 on top. Gordon Lariviere, an (Alberta-based) elevator expert rates this structure in the "top ten" for contemporary Manitoba (Lariviere various dates). Helston had a population of 41 people in 1956, and 31 in 1966. It seems likely to have dropped considerably more since that date. The railway line was closed from Muir to Helston (eastwards) in 1978 and from Helston to Carberry Junction (westwards) in 1975.

The cairn in Helston, located at the site of Public School #1912, includes a map of the former hamlet that indicates that at one time a railway station, manse, skating and curling rink, school, community hall, post office, store and 10 houses once stood. The cairn does not include a church, however, one possible explanation is a cairn for Knox United Church that is located 6 km east of Helston. This church apparently existed before Berton was founded, and may have served a large local region.

(Km 100) — Silver Stream Cairn (35-13-12-W) (N.B. Mayfeld 23-13-12-W):

As we proceed deeper into Westbourne R.M. we reach Silver Stream/ Mayfeld, about five miles east of Helston (and just above the 925 foot contour). The site also has a cairn with a map illustrating where a train station, ice rink (1950-1969), school (closed in 1969), Orange Lodge, elevator, and post office once stood. The cairn appears to be located just over a mile north of the actual site of the settlement of Mayfeld (given the location of the former CNor railway), although no clear indication is given of such on the monument. A small flat warehouse (6,000 bushel) in the townsite was owned by W.H. Squair, and then operated (possibly after conversion to an elevator) by Wiley-Low until 1925, one of the companies that managed to profit from the mismanagement of the Manitoba Elevator Commission - although this structure was not an MEC house. The latest

1:250,000 map calls the settlement Mayfield, the 1:50,000 Mayfeld. Most other sources term it Mayfeld, after an early settler (John Mayfeld)About four miles south-west of Mayfeld there used to be a water tank for the steam engines. Many early settlements were located by geometry rather than environment principles, while water tanks were built where water could be found.

(Km 109) — Golden Stream (35-13-11 and 33-13-11-W):

There are two monuments denoting Golden Stream. A school cairn located at 35-13-11 W indicates the structures that once stood at that location: a log school (1873), one room school (1895), modern frame school (1949), and the school's closure in 1968. The actual site of the community of Golden Stream (33-13-11-W) includes an abandoned rail line and siding, a church, an occupied home, and a cairn containing a mixed historical inventory as it indicates that the community was once home to a CN station, elevator, Sears store, church, blacksmith shop, store, post office, and a school that appears to be located south-east of the community roughly where the school cairn is located. Can we presume that the Sears outlet and blacksmith shop were not in operation at the same time? Golden Stream (at 888 feet ASL) had a small (10,000 bushel capacity) non-line elevator (owned by P. Broadfoot) in the early nineteen-teens. It was on the CNor line from Portage via Beaver to Gladstone that was built in 1902. The house was sold to Wiley-Low in 1916 and then to Federal Grain (along with the rest of the company) in 1932. It was located just north of the contemporary main road. It was rebuilt/replaced by a larger structure at some point after the Federal takeover. The CN line is still open but the elevator has now disappeared (probably after being bought by Manitoba Pool along with the other Federal houses in the province in 1972). By 1972 Golden Stream had become "too small to classify" as a community (Channon and Morrison 1972, 13).

(Km 121) — Gladstone (14-11-W):

Turning north, we travel to Gladstone (at 892 feet ASL it is a hundred feet lower than Helston). A pre-railway town (the first settlement west of the old parishes), and one of the oldest in Manitoba (dating to 1871), this settlement was first known as Third Crossing (for Red River carts on the Whitemud River) and later as Palestine (for the bounty of the 'promised land') (Morton Fahrni and Morton 1946).[6] Its location on the Whitemud has caused it some problems over the years. After the village was incorporated in 1882 the town fathers got ambitious and named it for the British Prime Minister, W.E. Gladstone. The CN line from Golden Stream to Dauphin passes through town, as does the CPR line from Portage to Neepawa. The latter was originally the Manitoba and Northwestern Railway. It had been hoped that the CPR mainline would pass through the town, but it went south and so did many of the hopes of the early inhabitants of Gladstone who had incorporated nine square miles into the settlement in 1882. Before the railroad arrived, the S.S. St. Boniface plied the Whitemud to Third Crossing but this didn't survive for long. The Westbourne and North Western Railway, later becoming the Portage, Westbourne and North Western, then the Manitoba and Northwestern, reached Gladstone in 1882 - after the owners of the railway received a 'bonus' to stop them by-passing the settlement. This bonus, in addition to the boom and bust cycles of the time, led to severe financial problems for the town in its early years.

The town has had a variety of elevators over time, but currently no major company operates in town. Our Alberta expert has termed the old UGG structure (part of the defunct flour mill) the "ugliest elevator in Manitoba" and it is hard to ague this point. Gladstone had 883 inhabitants in 1881, but the number dropped soon after and did not regain this level until 1956 (882). Its size then fluctuated, peaking in 1976 at 976. Since then it has dropped to 848 (in 2001). This represented a decline of 8.5% from 1996. It is the largest settlement in Westbourne R.M. North of Gladstone is the Big Grass Marsh, a stopping place for over 200,000 waterfowl in spring and fall – and thus a favourite place for hunters. It is another of Bill Stillwell's "scenic secrets" (Stillwell 1997).

The Road to Arden (with a few diversions)

We now turn westward along the Yellowhead Highway (#16) and start heading uphill again. A few miles west we turn north to see some other changing landscapes. This gravel road marks the 1870 boundary between the Northwest Territories and Manitoba (the 'postage stamp province').

(Km 133) — Keyes (36-14-13-W):

This settlement (at 975 feet ASL) was originally known as Mosquito Lake (be warned) and later Midway as it is located midpoint between Portage la Prairie and Minnedosa. The Keyes family (from Ontario) was dominant in this area with farmland, stores, and the post office, and in 1900 the settlement was renamed in honour of William Keyes. The settlement had a number of services, including an Ogilvie elevator, a station - with the 'best kept grounds' on the CPR for several years running

(McKenzie 1967) - a school, two blacksmiths, and at least two churches. Lord Strathcona apparently helped to fund the local Church of England building (giving land and money). It is uncertain how much land he owned in this area or why but it is known that he also had four sections south of Lobbville (McKenzie 1967). A stake near the post office used to mark the fact that Keyes was at the north-west corner of the original 'postage stamp province' of Manitoba. Today it is just inside Lansdowne R.M. There are currently two occupied dwellings and an abandoned home. The abandoned siding also remains. We continue north and west along section roads, passing the now invisible site of Twyford School (3-15-13-W) that closed in 1951 (and amalgamated with Arden S.D.). Riverside Hutterite Colony, located near Arden, owns land throughout this area.

(Km 150) — Arden (13-15-14-W):

The Carleton Trail, its best-known local name, was one of the Indian trails that connected the prairies together for trading purposes. In the late nineteenth century it ran from Fort Garry to Prince Albert, SK, passing a few miles north of Neepawa. It was also used by General Middleton in 1885 to reach Batoche to attack the Metis. It became the main route for supplies for this part of Manitoba before the railways arrived. It made use of the Arden Ridge, as did the Manitoba and North Western Railway (now CPR), in its search for a crossing point of the Whitemud River on its way to Neepawa. The Whitemud River, located just west of town, is diverted considerably from what might have been its path along the Arden Ridge. It eventually cuts through the beach ridge near the Yellowhead Highway. The ridge is also the site of a number of Indian burial mounds, although little evidence of these remains. Other beach ridges that run parallel to (but lower than) the Arden Ridge include the Robbins Ridge, the Rose Ridge and the Purple Ridge. Sloughs and meadows lie between the ridges, forming excellent pastureland.

The origin of Arden's name is in dispute, but probably commemorates Arden in Yorkshire (UK). In its early days Arden was quite the central place. Arden (between 1,050 and 1,100 feet ASL) once had a bank, a flour mill (burned in 1908), a lumber mill (destroyed by a flood on the Whitemud River); there was also a local cheese factory (15 miles out of town and out of business by 1905) amongst its services. Reflecting the spirit of the time, Arden banned nude bathing within the village limits in 1908. The land for the local cemetery was given to the town by a (Scots-origin) farmer, who with great foresight retained a block for his own use. There were stockyards and stables in the settlement, Methodist, Anglican, and Mennonite Churches, schools, various fraternal societies, and several recreational groups. There was also a mink ranch — not uncommon in this area. Gravel has always been a major source for mining in this part of Lansdowne R.M. In 1900, there were five elevators in Arden (including the flour mill's structure), two owned by Manitoba Milling, and one each by Lake of the Woods and the Northern Elevator Co. As Arden's centrality declined, the number of elevators was reduced to two in 1912 (Lake of the Woods (LofW) and Western Canada Flour Mills (WCFM)). When the Pool entered in 1926 there were again three, but eventually the Pool took over WCFM (1940) and LofW (1959) and integrated these structures into its Arden operation. The current house was purchased from the Pool by a local group, the Canadian Organic Commodity Marketing Co-op. You may notice that Arden has adopted the Crocus as its town symbol — after an extensive search to find something unused elsewhere. Around the base of the giant crocus are some cast cement blocks that were retrieved from a demolished building. Several structures in this region are made of this very durable material. In 1894, the town had 150 inhabitants. It had reached 237 in 1941, but has mostly fluctuated downwards since that date. In 1991, there were 157 people in Arden. Today it once again has about 150.

The Road to Neepawa

From Arden we return to Neepawa via the Yellowhead Highway (#16). We pass Riverside Hutterite Colony south of town (founded in the early 1930s on land once owned by Adam McKenzie) just before reaching the Yellowhead Highway at the Arden Ridge Service Station, where we pass back into Langford R.M. Just to the south of the Colony are the remains of a concrete bridge (possibly built in 1919) that was once part of the east-west highway. We will also see other houses built of cast concrete blocks that flank the giant crocus. One was almost certainly one of the McKenzie family's farmhouses.

Seven kilometres east of Neepawa is the Fulford-Trail walkway (another "scenic secret", and the last of this field trip (Stillwell 1997)) on 130 hectares of Crown Land. Note the extensive fringe functions east of Neepawa — far greater in number than might be expected to exist near such a small settlement, a sign of the volume of traffic that uses the Yellowhead Highway. The McDonald's in Neepawa is a function of the Yellowhead traffic, rather than the population of Neepawa and District. The restaurant sits on the abandoned right of way of one of the few north-south railways in this region that connected Neepawa to Hallboro.

Closing Comments

This tour offered only a selection of the sites and landscapes located within the Neepawa area. Much diversity exists north and west of Neepawa, however, time did not permit the inclusion of all of it. We chose to focus on key elements within a smaller area. In doing so, we chose routes that were products of technical survey lines as well as topography. The resulting settlement geography is an anomaly within the standard section-survey system of the Canadian prairies. While much of the local history has become limited to cairns depicting 'what once was but is no longer', this tour also illustrated a continued attachment to the land and desire to preserve the culture on that land.

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Endnotes

[1] Much of this field trip is based upon the authors' field work. References to places names mostly come from Penny Ham (1980) *Place Names of Manitoba.* Another major aid was A.F. McKenzie (1967) *The Lansdowne Story: Grain, Gravel, Growth*.

[2] Palestine is now called Gladstone.

[3] Apparently all equipment was removed from the UGG elevator during the summer of 2002.

[4] Channon and Morrison (1972) has a classification of communities in the field trip region. The terminology used (hamlet, village, etc.) is used in this paper.

[5] Apparently this elevator was dismantled (around 1918) and taken to Alberta. The economics of such situations are now very different!! Brookdale Historical Society (1987).

[6] Palestine was actually a short distance south from present-day Gladstone, but it was located in the same Township and Range (14-11-W) and to all intents and purposes it was a forbear of the town.

Multiple stream captures in a glacial spillway: Huns' Valley, Manitoba

R.A. McGinn and K. Zaniewski, Brandon University

Introduction to the Region

The Manitoba Escarpment:

In the Riding Mountain area (see Figure 1 for general location), Manitoba Escarpment is formed by outcroppings of Cretaceous shales, which rise 230 to 425 m above the Manitoba Plain (Figure 2). Tyrrell formulated the basic stratigraphic nomenclature in 1890 and 1892. Since then, Kirk (1930) and Wickenden (1945) have presented additional descriptive information and subsequent revisions to the stratigraphic nomenclature. Bannatyne (1970) has further investigated the properties of the cretaceous shales and summarized the stratigraphy of the Manitoba Escarpment. Most recently, McNeil and Caldwell (1981) have published a comprehensive Geological Association of Canada Special Paper revising the Cretaceous System in the Manitoba Escarpment. Figure 2 illustrates the formations and members present in the Riding Mountain area and Table 1 provides additional information regarding the physical characteristics of these members.

Following an interval of erosion of Jurassic rocks, deposition of the Cretaceous beds began. The sandstone and shale beds of the Cretaceous Swan River Group are thought to indicate a transition from the terrestrial Jurassic environment to a marine environment (Wickenden 1945). Throughout most of the Cretaceous, continued subsidence resulted in the deposition of marine shales and limestone beds. The members of the Ashville and Favel formations and the Morden Shale and Niobrara formations were deposited during this interval. Near the end of the Cretaceous the axis of deepest sedimentation, formerly centred in Saskatchewan, shifted eastward and resulted in the deposition of the Pierre Shale and Boissevain formations. This displacement is believed due to

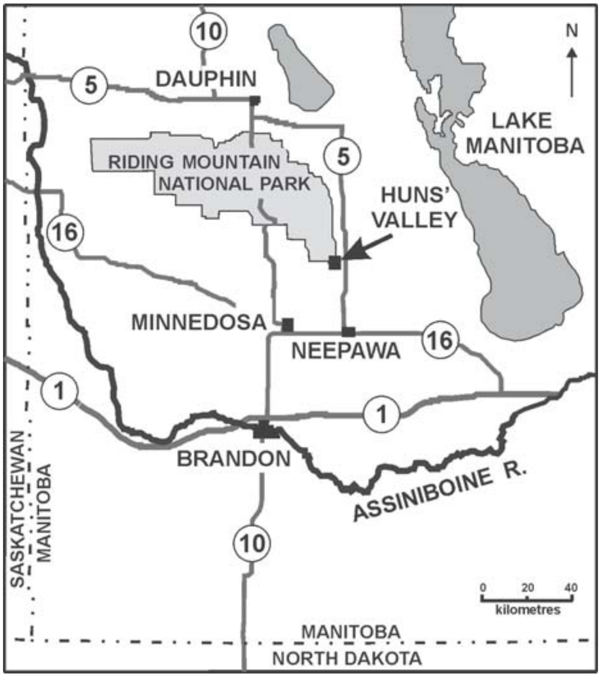

Figure 1: *South-Western Manitoba.*

initial orogenic uplift of the Rocky Mountains. The main uplift resulted in the withdrawal of the seas from the Interior Plains and cessation of Cretaceous sedimentation.

The advent of the Tertiary is characterized by continued emergence, subsequent erosion and pediplanation (Douglas et al. 1970). Bird (1972) suggests that the general process of scarp retreat in Tertiary times established the Manitoba Escarpment at its present-day geographic location 190 to 240 km west of the Precambrian Shield. No Tertiary deposits have been found on the Riding Mountain Uplands and it is believed that the pre-Pleistocene topography of the Riding Mountain area is closely approximated by the bedrock topography (Klassen et al. 1970).

Glacial History of the Riding Mountain Uplands:

The last glaciation of the Riding Mountain area occurred during the late Wisconsinan (20,000 - 12,000 B.P.). Glacial ice covered the entire region and generally flowed towards the southeast, (Klassen 1965).

The late Wisconsinan deglaciation of the Riding Mountain Uplands was associated with the Lockhart Phase of Glacial Lake Agassiz (11,600

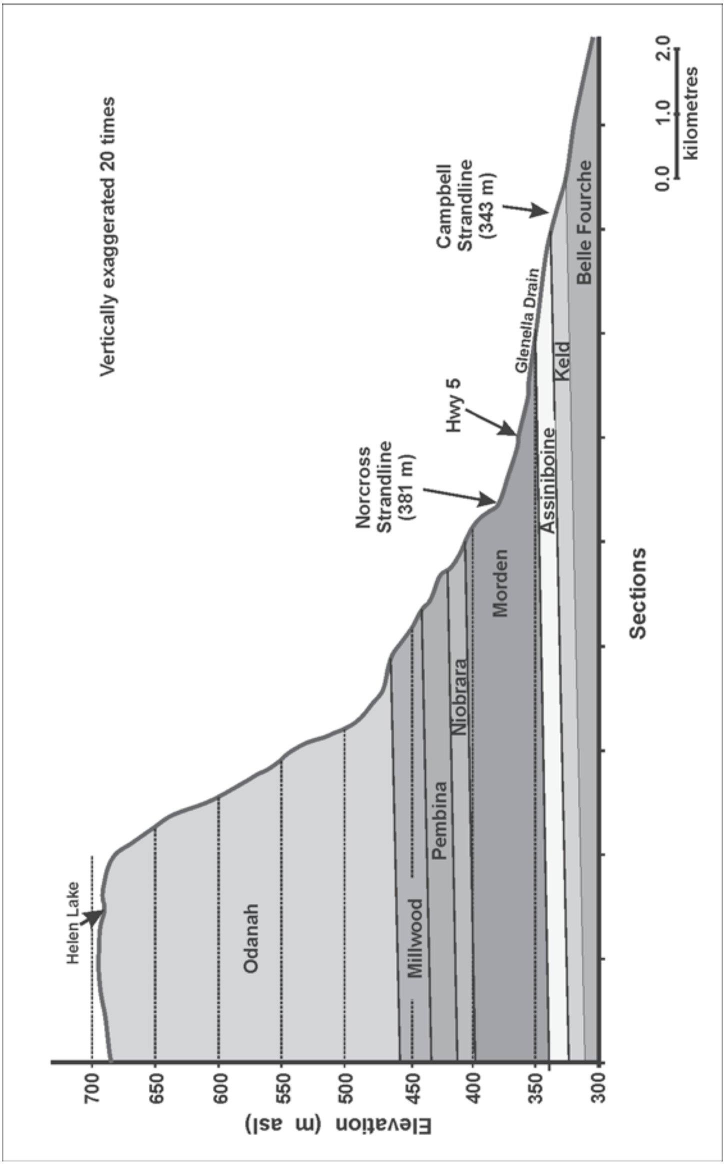

Figure 2: *Cross-section of the Manitoba Escarpment, Riding Mountain, Manitoba.*

Table 1: *Cretaceous Formations of the Manitoba Escarpment.*

FORMATION	MEMBER	BED
Boissevain		
Pierre	unnamed member	
	Odanah	
	Millwood	
	Pembina	
	Gammon Ferruginous	
Niobrara	unnamed member chalky shale	
	unnamed member calcareous shale	
Morden Shale		
Favel	Assiniboine	Marco Calcarenite
	Keld	Laurier Limestone beds
Ashville	Belle Fourche Shale	Ostrea beloiti beds
		fish-scale marker beds
	Westgate	
	Newcastle Sandstone	
	Skull Creek Shale	
Swan River		

- 10,800 B.P.). During the waning of the Falconer advance (post 11,400 B.P.) (Fenton et al. 1983), a large area of glacial ice stagnated on the Riding Mountain Uplands. Subsequent downwasting generated a drainage network consisting of several supraglacial lakes,spillways and meltwater channels (Figure 3). Meltwaters generally drained southward into Glacial Lake Hind (McGinn 1991). Many of these glacial rivers eroded their ice beds and incised into the substratum. Glaciofluvial sediments were deposited as sandurs, eskers and kames. Sub-aqueous fans were deposited in the supraglacial lakes and a major delta was built into the north end of

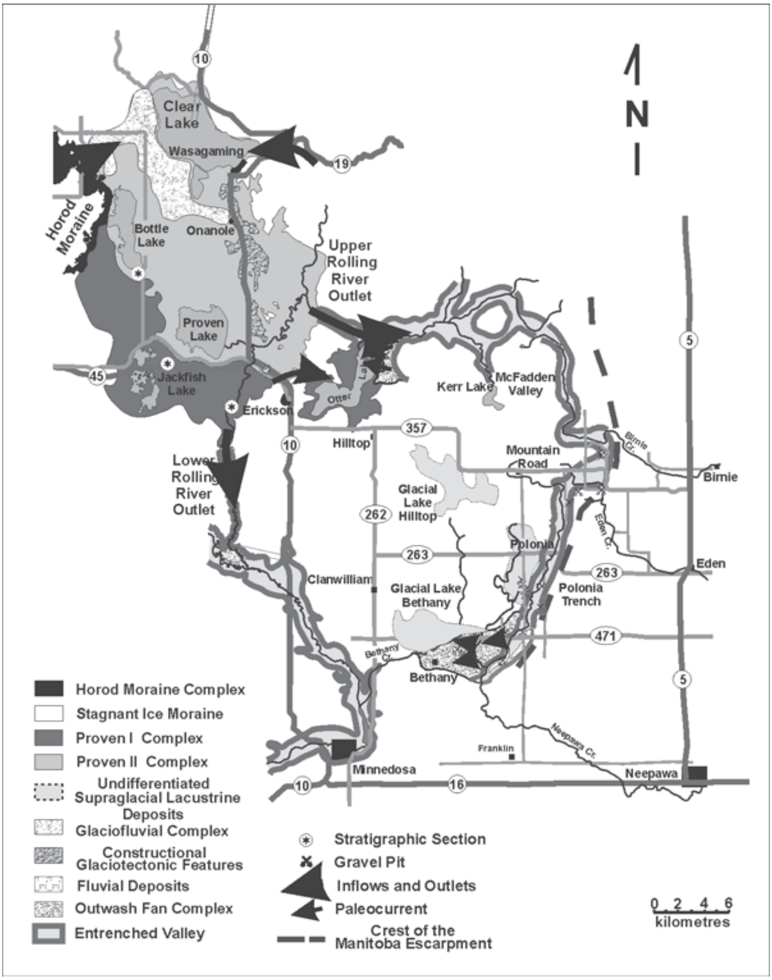

Figure 3: *Surficial deposits in the Glacial Lake Proven basin and the McFadden Valley and Polonia Trench.*

Glacial Lake Hind. As downwasting of the stagnant ice on the uplands continued, the supraglacial lakes drained and an entrenched drainage system developed on the stagnant ice moraine complex.

The McFadden Valley - Polonia Trench Spillway System parallels the crestline of the Manitoba Escarpment and illustrates many physical and sedimentological characteristics commonly associated with glacial meltwater channels (Figure 4). Paleocurrent measurements suggest that the flow was from the north towards the south-south-west through a deeply

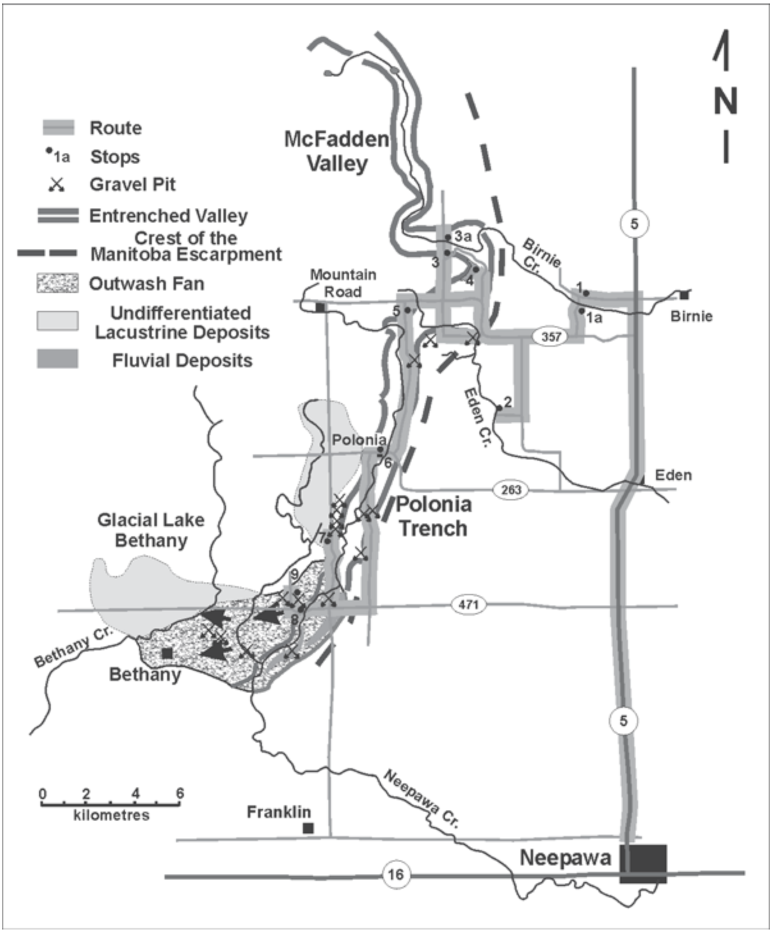

Figure 4: *Route map and stops, Huns' Valley physical geography field trip, PCAG 2002.*

entrenched channel and thence westward across a sub-aqueous outwash fan. In the northern section of the spillway complex, meltwaters were apparently diverted by sub-cropping bedrock hummocks and active glacial ice that created forced bends, associated scour pools and point bar deposits (Stops 3 and 4). Along the length of the valley, terrace deposits indicate an anastomosing stream environment, whereas the valley floor consists of outwash gravels overlain by recent colluviums and alluvial fan deposits. In one area along the west valley side, mudflow flow deposits overlie terrace gravels and there is evidence of active ice overriding the residual terrace deposits. The sandur plain/outwash fan is composed of braid stream deposits that grade into a sub-aqueous fan. The lithologies of the local glacial diamicts, terrace deposits and valley floor sediments are highly correlated.

The Route Description

The field trip route is illustrated in Figure 4. The field trip leaves Neepawa following Highway 5 north to the town of Eden. As you travel north, initially over the northern most deposits of the Assiniboine Delta and later over the LakeAgassiz lakebed, the Manitoba Escarpment is visible to the west. Near the town of Eden the escarpment rises approximately 230 m in relation to the Manitoba Plain. Four kilometres north the route turns west climbing approximately 90 m up the escarpment to the Birnie Creek viewpoint. Stops at the viewpoint and at the bottom of the valley provide an appreciation of the Holocene erosion and a view of ZelenaTill and underlying Odanah shales.

Stop 1. Birnie Creek View Point and Photo Stop:

NTS 62J/5 Clanwilliam, UTM 464500 E, 5588200 N
Approximate Elevation: 490 m.

The 60 m deep and 600 m wide valley (locally referred to as “Big Valley”) is believed to have formed during the Holocene and headward erosion into the scarp face of the Manitoba Escarpment has led to the capture of the McFadden Valley drainage (Stop 3a).

A 0.5 -1.5 m thick till veneer (the Zelena formation) overlies the Odanah Shale of the Pierre formation. Klassen (1979) suggests that the Zelena formation was deposited during the final stages of glacial ice stagnation during the Late W isconsinan. Consequently, the Zelena formation represents the uppermost tills and intertill sediments on the Riding Mountain Uplands. Oxidized ZelenaTill is usually yellowish brown or very dark grey brown in colour Fresh (unoxidized) exposures are dark olive grey or very dark grey . The till is massive and of moderate compaction. The prominent clasts in the till are typically the more resistant Interlake region carbonates and shield metasedimentaries as the locally incorporated and softer Odanah Shale clasts have been quickly crushed or abraded to matrix size or terminal grade during glacial transport. Some larger shale clasts are evident but difficult to remove without fracture, so it is difficult to determine a percentage composition of shales.According to Klassen (1979) carbonates constitute approximately 26%-36% of the clasts.

In the Riding Mountain region, the Odanah Shale represents the uppermost member of the Pierre formation. It has a maximum thickness of approximately 150 m and consists of olive-grey siliceous shale with interbeds of softer darker olive-grey shale. Fresh exposures are greenish grey when moist. Variations in clay content create hard and soft shale. The shales are jointed and the joints are frequently stained reddish to purplish brown. Ironstone concretions are common. Thin bentonitic beds occur in the lower part of the formation.

Stop 1a. Bottom of Birnie Creek Valley:

NTS 62J/5 Clanwilliam, UTM 464490 E, 5588000 N
Approximate Elevation: 430 m.
Glaciotectonic deformation of Pierre Shale (Odanah Member).

Birnie Creek flows year around. The mean discharge is recorded to be 0.33 $m^3 s^{-1}$ and the highest recorded flood discharges exceed 23.0 $m^3 s^{-1}$.

Although bedrock exposures are not readily eroded by water, Odanah shales have a 4% - 8% absorption and air -dry shrinkage rates. Consequently the shale mechanically weathers rapidly by a combination of hydration and freeze-thaw activity facilitating bank erosion and mass wasting into the stream channel. The low saturated specific gravity (1.8) and blade- or plate-like cross-sectional shape (Cory shape factor of 0.2) enables stream traction and transport.

From the Birnie Creek valley the route is southward to PTH 357 (Mountain Road), then west rising another 85 m up the escarpment. A one-stop detour to the south (1.0 km) provides a view of the entrenched Eden Creek valley.

Stop 2. Eden Creek View Point and Photo Stop:

NTS 62J/5 Clanwilliam, UTM 460800 E, 5583300 N
Approximate Elevation: 565 m.

Eden Creek is ungauged and characterized by intermittent flow. Low flows often infiltrate into the alluvial fan near Eden. The mean discharge is estimated to be 0.04 $m^3 s^{-1}$. Spring freshet discharges and severe storm floods have been metered and can exceed 10.0 $m^3 s^{-1}$.

The headwaters of Eden Creek are located approximately 3.0 km upstream. The valley is 38 m deep and 350 m wide.The 36° active slope of the bank combined with the physical properties of the Odanah shale (see stop 1a) supplies sediment to the stream.

Bentonite layers interbedded with the Odanah Shale provide moisture for the stunted aspen trees contoured along the slope.

Returning to PTH 357, the route rises another 55 m to the crest the escarpment and turning north enters the Eden Creek capture zone - the junction of the McFadden Valley and Polonia Trench. Stops in this area view the deeply entrenched McFadden Valley spillway, the Birnie Creek capture zone and a prominent point bar deposit in a forced meander bend.

Stop 3a. McFadden Valley View and Photo Stop:

NTS 62J/5 Clanwilliam, UTM 458600 E, 5590300 N
Approximate Elevation: 665 m.

The McFadden valley is 55 m deep and approximately 1300 m wide. It is the middle segment of a glacial spillway/meltwater channel draining Glacial Lake Proven and other supraglacial lakes southward along the crestline of the Manitoba Escarpment (Figure 3).The spillway channel is twice as wide as the "BigValley" of Birnie Creek and four times the width of the Eden Creek valley at stop 2. Much of the valley appears to have been cut through thick deposits of Zelena till. There may be a terrace remnant on the north side of the valley.

Stop 3b. Bottom of McFadden Valley View and Photo Stop:

NTS 62J/5 Clanwilliam, UTM 458600 E, 5590700 N
Approximate Elevation: 610 m.

The stream is fourth order according to the S trahler classification system. Basin length is calculated to be 17 km and the Shreve number is 35.

In the McFadden Valley, meltwaters were apparently diverted from the preferred southerly route by sub-cropping bedrock hummocks, which created forced meander bends and associated point bar deposits.A forced meander bend is morphologically defined as having a radius of curvature/ stream width ratio ranging from 2.5 to 3.0. One kilometre downstream is the elbow of capture where Birnie Creek has captured the Holocene drainage of the McFadden Valley. It is estimated that the capture of the McFadden Valley drainage has quadrupled the watershed area of Birnie

Creek. Georgison, (1985) estimates the normal (prior to capture) watershed area was 18.1 km^2. Birnie Creek watershed now drains 65.4 km^2.

Stop 4. Point Bar and View of Eden Creek Headwaters and Capture Zone:

NTS 62J/5 Clanwilliam, UTM 459800 E, 5589500 N
Approximate Elevation: 650 m.

The stream is third order according to the Strahler classification system. Basin length is estimated to be 14 km and the Shreve number is 18.

This massive point bar was formed as the flow encountered the active ice of the Red River Lobe spilling over the Escarpment crest and the Odanah shale bedrock sub-crops in the headwaters of Eden Creek. The eastern flow was diverted at first 180 ° to the west and then 90 ° to the south.

On the inside of this large forced meander accretion surfaces built up. These are composed of generally finer grain deposits (ripple laminated sands up-bar and accreted gravels down-bar). A lag deposit of very large rounded boulders is found at the apex of the forced bend with finer sediments down flow. A calculation of the potential discharge based on these lag deposits was not undertaken due to problems in defining the hydraulic geometry and hydraulic radius (depth of flow). To the south is the elbow of capture where Eden Creek has captured the Holocene flow from the McFadden Valley. Today, Eden Creek drains 33 km^2. It is estimated that the capture has almost doubled the early Holocene watershed area. Georgison (1985) estimates that the normal watershed area for Eden Creek was approximately 18.9 km^2.

The route turns south from Mountain Road along a section road to the Polonia Trench viewpoint.

Stop 5. Polonia Trench View and Photo Stop:

NTS 62J/5 Clanwilliam, UTM 456990 E, 5587600 N
Approximate Elevation: 650 m.

The Polonia Trench represents a relatively straight segment of a Late Wisconsinan spillway channel draining south southwest along the crest of the Manitoba Escarpment (Figure 3). Sinuosity ratios near unity characterize an anastomosing channel. The meltwater stream has entrenched 40-55 m into the Zelena and underlying Pierre formations (Stop

7). The valley is, on average, 1300 m wide. Terrace gravels are common along both rims and occasionally along the east side of the valley.

Dropping into the valley the route travels south along the trench paralleling Stony Creek to the town of Polonia (formerly called "Huns' Valley"). The route traverses the northern part of the Polonia Trench, crossing a more recent alluvial fan deposit and then rising along the eastern edge of the valley. Remnant terrace deposits are exposed at lower elevations in the valley sides and at higher elevations Zelena till can be observed.

There is a short "historical geography" stop at St. Elizabeth of Hungary church and the Polonia shrine.

Stop 6. Polonia ("Huns' Valley"):

NTS 62J/5 Clanwilliam, UTM 456000 E, 5581800 N

In August 1885, 17 families (43 individuals) of Austro-Hungarian miners (Magyars, Ruthenians, Czechs, and South Slaves) from Hazeltop Pennsylvania travelled via the Manitoba and Northwestern Railway. They settled on land donated by the M&N railway in Huns' Valley close to Stony Creek, specifically, Twp 16, Rg 16, Sections 17, 21 and 33. By 1888, there were 30 families (122 individuals) on 30 homesteads. Each homestead had 20-70 acres broken, a team of oxen or horses, 10-16 cattle and pigs and poultry. During the winter the Huns' Valley settlers cut firewood for Neepawa and the railway.

St. Elizabeth of Hungary Church, constructed in 1902 for approximately $2000, replaced the original church that was located at the cemetery. Huns' Valley was renamed Polonia in 1921.

From Polonia the route continues southward travelling along the western edge of the trench, dropping to cross Stony Creek and then rising along the eastern rim of the Polonia Trench. Here there are several exposures of outwash sands and gravels deposited prior to channel entrenchment. A thin diamict (approximately 1.0 m) overlies the easternmost glaciofluvial deposits suggesting a overriding of the outwash by a flow till or a readvance (the Marchand Advance) of the Red River Lobe.

The route continues south through the northwestern extension of the Franklin moraine (Marchand advance) to join PTH 477. Turning west then north the route re-enters the southern part of the Polonia Trench, crosses Stony Creek and rises up the western edge of the valley. Here road-straightening construction has exposed the general stratigraphy of the southern part of the Polonia Trench.

Stop 7. A stratigraphic section in the Polonia Trench:

NTS 62J/5 Clanwilliam, UTM 453700 E, 5577500 N
Approximate Elevation: 610 m.

Approximately 4.0 m of glaciofluvial sands and gravels overlie a relatively thin (2 m) Zelena till. Three metres of Odanah Shale are exposed at the base of the section. At this site, it is believed, the usually thick Zelena formation has been scoured close to the bedrock by glacial meltwaters prior to the deposition of the sands and gravel and the lateral shifting of the main spillway channel.

Returning to 477, turn west, pass through the Stony Creek elbow of capture and turn north.

Slowdown Stop 8. Stoney (Neepawa) Creek:

NTS 62J/5 Clanwilliam, UTM 452400 E, 5575100 N

Stony Creek is a fourth order stream according to the Strahler classification system. Basin length is calculated to be 26.8 km and the Shreve number is 36.

Stony Creek has headwardly eroded into the Polonia Trench and captured the Holocene drainage. Georgison, (1985) estimates that stream capture has increased the watershed drainage area of Stony Creek by 110.9 km^2 to a value of 131.0 km^2. The pre-capture watershed area is estimated to be 20.9 km^2.

The last stop is in the rural municipality of Rosedale gravel pit located near the apex of the sub-aqueous fan deposited by the meltwaters in supraglacial Lake Bethany.

Stop 9. Bethany Fan:

NTS 62J/5 Clanwilliam, UTM 452000 E, 5576400 N
Approximate Elevation: 605m.

The rural municipality of Rosedale gravel pit is located near the apex of the sub-aqueous fan deposited by McFadden Valley-Polonia Trench meltwaters into supraglacial Lake Bethany (Figure 3). Paleocurrent indicators suggest flow towards the west. The coarse gravel and cobble lithologies are predominantly Interlake carbonates and shield metasedimentaries. Fine gravels are predominantly weathered shale. It is believed that the coarser shale gravels have been transported downflow where they comprise the bulk of the outwash fan.

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