PRAIRIE PERSPECTIVES:
GEOGRAPHICAL ESSAYS

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Preface

The 28th annual meeting of the Prairie Division of the Canadian Association of Geographers was held October 1st to 3rd at St. Peter's College, Muenster. Hosted by the University of Saskatchewan's Department of Geography, the conference attracted more than 100 delegates representing a broad range of research interests in physical, environmental, and human geography. Thirty-six papers and 17 posters were presented by more than 80 authors from the Prairie Provinces, Ontario, British Columbia, Arizona, Massachusetts, North Dakota, and Nanjing. Amongst the attendees were Jamie Hogan, the 2004 RCGS award winner, and Dr. Evelyn Peters, Canada Research Chair in Aboriginal Identity and Diversity, the conference's keynote speaker. Member departments were well represented and, consistent with the friendly atmosphere of the Prairie meetings, many graduate students from the member Universities presented their research.

The 2004 PCAG Fieldtrip was organized by the Centre for Rural Studies and Enrichment at St. Peter's College. The fieldtrip started at St. Peter's Abbey, the Benedictine Monastery established more than 100 years ago as the spiritual centre of St. Peter's Colony. The Colony itself was settled by German Catholics who came from Minnesota, recruited by the Catholic Settlement Society and the German Land Company. The tour passed through several towns that were founded as the Colony grew, many of which are readily identifiable by their German names such as Humboldt and Muenster. The tour then headed west to St. Denis where participants met with Dr. Garth VanderKamp of the National Water Research Institute. Dr. VanderKamp led the group to a number of sites where researchers are examining carbon sequestration in small wetlands under various management options; tree invasion and its effect on slough water balance; nitrous oxide emissions from cultivated land; and the effects of land-use change on soil moisture and slough hydrology. Following the fieldtrip the group returned to St. Peter's College where conference came to a close with an excellent prairie fall supper and the obligatory PCAG slide competition.

Of the 53 conference presentations, eight papers are included in this year's volume of *Prairie Perspectives* - plus an additional paper that, due to an unfortunate oversight, was omitted from last year's volume. All papers submitted to *Prairie Perspectives* are subject to a double-blind peer review process. For each paper we were able to solicit reviews from

leading researchers at universities across Canada. We are pleased to present a collection of papers that demonstrate research of high quality.

The first grouping of papers focuses on Canada's Prairie grassland ecosystems. Black et al. address the relationship between photosynthesis rates, soil moisture, and local bio-geographic variables affecting grassland photosynthesis in Grasslands National Park. This is tied to Guo et al.'s analysis of remote sensing techniques for monitoring grassland health, and Zhang's assessment of broadband vegetation indices to monitor biophysical attributes of the northern mixed grassland. The focus on Canada's Prairie grassland ecosystem is concluded with a paper by Guo et al. that examines the feasibility of remote sensing techniques for predicting breeding bird populations using vegetation indices and spectral reflectance relationships.

The second group of papers takes us out of country to address issues in environmental and human geography. The paper by He et al. investigates the influence of climate change, namely UV-B radiation, on agricultural net primary productivity in China. The second paper examines the 'virtual university' and the quality and structure of higher education in the United States' military system.

The final group of papers reflects the work of human geographers on the Canadian Prairies. The first paper, by Mosset et al., presents the results of a study of the recreation and tourism behaviour of a sample of residents in Brandon, Manitoba, suggesting that recreational facilities and programmes need to take account of the spatial variations in recreational behaviour. Everitt et al. turn their attention to health care and the geographic effects of place and scale upon provision of health care services for seniors with hopes to help to explain how and why communities are aging differently. The final paper, by Thraves, discusses the unusual circumstances of three plebiscites of the 1985 and 1988 Regina civic elections, the voting patterns that characterized Regina's inner city and suburban areas, and the longer-term outcomes of the plebiscites.

We would like to thank all conference participants and the countless number of individuals who helped organize the 2004 meeting of the PCAG at Muenster, Saskatchewan. We would also like to thank the authors for their contribution to *Prairie Perspectives,* and the manuscript reviewers for their valuable service to the PCAG. Finally, we are grateful to Weldon Hiebert, University of Winnipeg, who once again managed the layout and production of the journal.

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Evaluation of photosynthesis rates of introduced and native species in a mixed grassland ecosystem

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Abstract: In an effort to gain an understanding of the environmental factors contributing to photosynthesis rates in the northern mixed prairie grasslands as a carbon sink, this study investigated the effects of location (either sloped or upland), soil moisture and species type on photosynthesis rates measured in the West Block of Grasslands National Park, Saskatchewan, Canada. The study was conducted during June and July of the 2004 growing season. The first ecosystem studied is the naturally occurring mixed grass prairie consisting mainly of June grass (*Koeleria gracilis*), needle-and-thread grass (*Stipa comata*), blue grama (*Bouteloua gracilis*), and western wheat grass (*Agropyron smithii*). The second ecosystem consists of the introduced species crested wheat grass (*Agropyron cristatum*). It was found that introduced species (*Agropyron cristatum*) located on the upland sites, had significantly lower photosynthesis rates, while the native species located on upland sites had the highest rates of photosynthesis. It was also found that the introduced species are located in areas of significantly higher soil moisture than the native species when soil moisture was measured with the soil moisture probe.

Introduction

Increasing atmospheric CO_2 concentrations and the potential for climate change have made global carbon balance an important scientific and political topic. Researchers believe that the photosynthetic process in terrestrial ecosystems will contribute to the lowering of anthropogenic CO_2 emissions (Goudriaan 1992; Taylor and Lloyd 1992; Ham and Knapp 1998; Lloyd 1999). Lloyd (1999) reviewed a number of studies that examined the relationship between atmospheric CO_2 concentrations and plant growth. In almost all cases the studies reported increased growth in

response to increased CO_2 concentrations. This has been further supported by studies conducted in laboratory conditions. In a compilation of literature sources, Poorter (1993) reviewed the growth responses of 156 different plant species to a doubling of atmospheric CO_2 concentration and found that growth stimulation on average was approximately 37%. It can be concluded then, that since plants respond to higher levels of atmospheric CO_2 by producing more biomass, vegetation will contribute to the management of increasing atmospheric CO_2. However, neither of these studies, nor the articles they reviewed, focused explicitly on the productivity (as measured through CO_2 exchange rates) of different grassland species.

Given that grasslands comprise the majority of the grazing capacity of the world (Burke et al. 1989), a further reason to investigate grassland ecosystem productivity is because of its economic importance as a rangeland resource. Degradation and desertification of grasslands are becoming increasingly common problems due to intense agricultural activities (Li and Ji 2002; Archer 2004). To ensure that this natural resource remains viable, an understanding of the biological and environmental components contributing to grassland productivity is required.

Human activities, particularly those related to ranching have heavily modified the prairie landscape during the twentieth century (Kepner et al. 2000). The introduced species crested wheat grass (*Agropyron cristatum*), a C_3 species, was transplanted to the North American prairie landscapes from Siberia. Plantation was encouraged because of its rapid spread and establishment, high coverage and, therefore, ability to improve pastures and bind soils prone to erosion. However, this species is now considered a pest as it is very competitive with high rates of seed production (Ambrose and Wilson 2003), and tends to reduce species diversity in the native prairie where it is found (Christian and Wilson 2002). Furthermore, this species is resistant to typical methods of weed suppression; in a northern mixed-grass prairie location, four years of herbicide treatment did not affect the emergence of the crested wheat grass seedlings (Ambrose and Wilson 2003). A literature review on the long-term effects of crested wheat grass indicated that this particular species has significantly higher above-ground productivity, but significantly lower below-ground biomass when compared to several native species found in the mixed grass prairies (Lesica and DeLuca 1996). Because the above-ground biomass and as a result, photosynthetic material is greater for crested wheat grass than for native species, it follows that the photosynthesis for crested wheat grass is also higher than the native species. However, there is no research comparing the photosynthesis rates of the crested wheat grass to the native species. A study comparing the rates at which the various grass species remove

carbon dioxide from the atmosphere would greatly contribute to this research field.

In an effort to quantify the mixed prairie grasslands as a carbon sink; this study will investigate the effect of various environmental and biological components on photosynthesis rates. More specifically, the objectives of this study are to 1) investigate the effect of location (sloped vs. upland) on photosynthesis rates; 2) investigate the effects of soil moisture on photosynthesis rates; and 3) examine differences in rates of photosynthesis between several different native grass species as well as one dominant introduced species found in Grasslands National Park.

Methods

The study area is located in the West Block of Grasslands National Park (GNP) and surrounding pastures, which is in southwest Saskatchewan, Canada (49º12', 107º24'). This area falls within the Great Plains, which are characterized by semiarid climate, flat landscape and large areas dominated by grass species (Coupland 1992). Grasslands National Park is further located within the mixed grass prairie, one type of biome found within the Great Plains. This biome is a transitional zone between tall grass and short grass prairie (Davidson 2000). The climate in the study area is semi-arid; winters are long, cold and dry while the summers are short, hot and comparatively wet (Environment Canada 2000). Average temperatures range from -12.4ºC in January to 18.3ºC in July, and the average precipitation is approximately 350 mm per year (Environment Canada 2000). The soils in the study area are brown Chernozemic clay loam soils (Saskatchewan Soil Survey 1992). The dominant native grass species found in the study site are June grass (*Koeleria gracilis*), needle-and-thread grass (*Stipa comata*), blue grama (*Bouteloua gracilis*), and western wheat grass (*Agropyron smithii*). A dominant introduced species included in this study is crested wheat grass (*Agropyron cristatum).*

Field data collection:

Data were collected in June and July of 2004. This was a preliminary study, and unfortunately was limited to only one growing season due to time and financial constraints. In June, a total of 18 randomly selected sites were visited. Of these sites, five were upland ungrazed, five were upland grazed and eight were sloped ungrazed. The field methods employed in this study were developed for this study in the previous year, for details on the development of these methods, please refer to Zhang at al. (2005). At each of these sites, two plots were set up with 100 m transects

running perpendicular at north-south and west-east directions. Soil moisture and photosynthesis rates were measured along these transects at 20 m intervals. A total of 605 samples were collected during June. All of these samples represented only native species. During July, a total of four sites were visited. Two of the sites visited were located in upland sites with native species. The first site was a transect, where photosynthesis and soil moisture measurements were collected every 3 m to a distance of 381 m. The second site was a 49 × 49 m quadrat, where the samples were collected from 41 randomly selected locations. The third site was a 500 m transect along sloped land with native species, where the samples were collected every 10 m. The final location was an upland site dominated by the introduced species crested wheat grass. At this site, the soil moisture and photosynthesis measurements were collected every 3 m along a 20 m transect. During July, a total of 259 samples were collected. An LCPro (ADC BioScientific Ltd.) was used to measure the photosynthesis of the leaves. The soil moisture at each plot was measured using an Aquaterr moisture meter. The method of data collection changed between June and July because the current study is a component of a larger study being conducted, which had changed their approach. However, because the current study compiles the June and July data, and does not compare the two sampling methods directly, this should have no effects on the results.

Data pre-processing and analysis:

Using the method described by Stevens (1996), outliers located three standard deviations above and below the mean were identified and then removed from the photosynthesis dataset. To determine if this dataset was normal, the distribution was tested using four parameters (refer to Figure 1). First, the Kolmogorov-Smirnov test resulted in a significance value of 0.2; there is no difference between the data and a normal distribution, which indicates that the data are normally distributed. The same conclusion was derived from the Shapiro-Wilk test (a=0.211). As well, the skewness (0.245) and kurtosis (-0.195) also indicated the data are normally distributed. Tukey's post hoc Analysis of Variance (ANOVA) was used to test for significant differences in photosynthesis rates between site locations (upland locations with native species, upland locations with introduced species and sloped locations with native species). Although the soil moisture data were not found to be normally distributed, it was related to photosynthesis rates using Pearson's correlation coefficient employing the methods described by Ebdon (2000). An independent samples *t* test was used to compare the soil moisture of areas of introduced species with areas of native species, also using methods described by

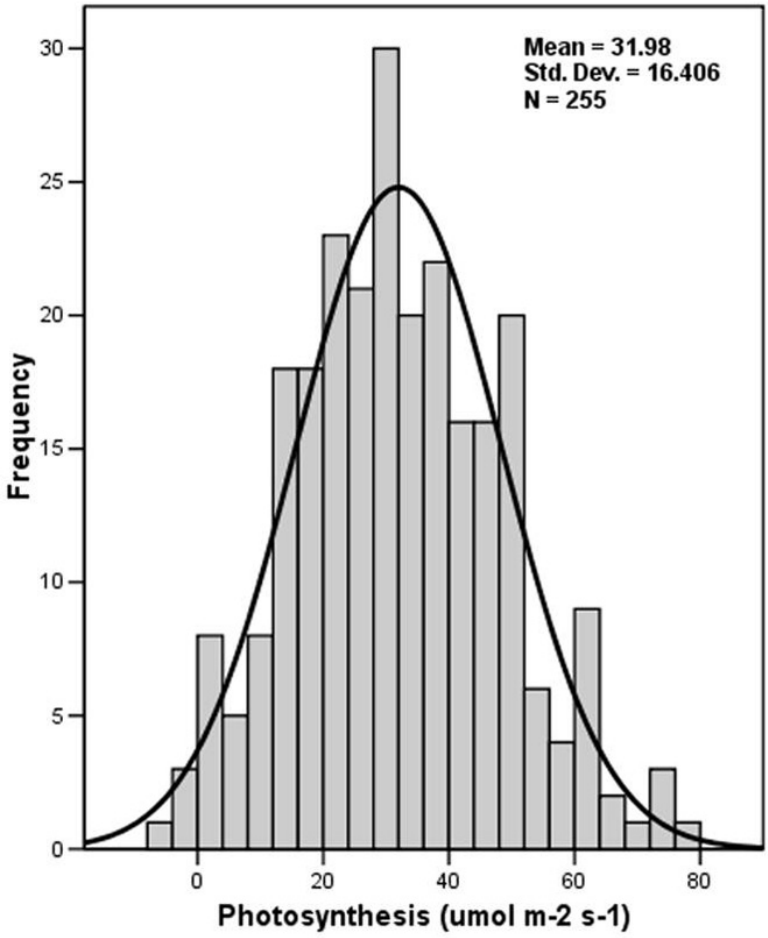

Figure 1: *Histogram of photosynthesis samples.*

Ebdon (2000). Tukey's post hoc ANOVA was also performed to investigate differences in rates of photosynthesis between grass species.

Results

Location differences:

A one-way ANOVA comparing photosynthesis rates by location and ecosystem type, found that upland sites with introduced species had the

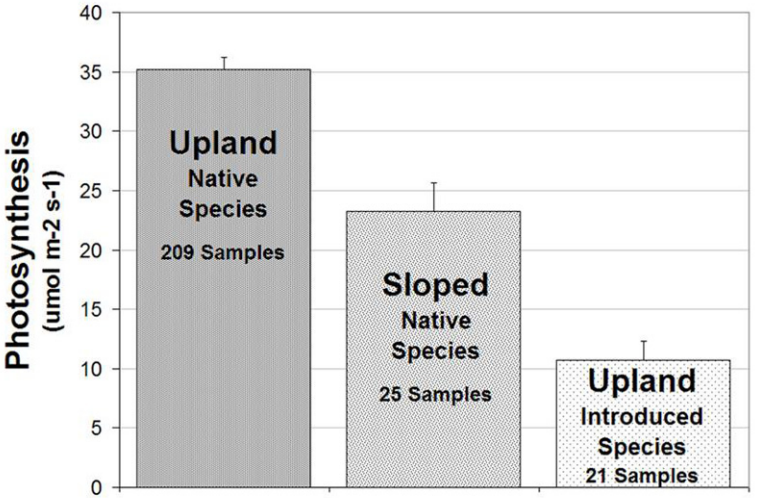

Figure 2: *Mean photosynthesis rates with standard error bars by site location.*

lowest rates of photosynthesis, sloped sites with native species had higher rates, and upland sites of native species had the highest rates of photosynthesis ($F_{2, 252}$ = 31.07 (p < 0.001)). Tukey's post hoc analysis showed that each of these groups is significantly different from one another (Fig. 2).

Soil moisture differences:

There was a small significant negative correlation found between the photosynthesis rates and the soil moisture (r = -0.23, p < 0.001) using Pearson's correlation analysis. When comparing the soil moisture of areas of introduced species with areas of native species, it was found that the introduced species are located in areas of significantly higher soil moisture ($t_{32.461}$ = -5.58, (p < 0.001)). The mean soil moisture measurements for areas of native and introduced species are presented in Table 1.

Table 1: *Mean soil moisture rates for native and introduced species.*

Species	Mean (% of maximum)	Standard Deviation
Native	78.02	9.29
Introduced	85.29	5.27

Species differences:

It was found that the introduced species crested wheatgrass (*Agropyron cristatum)* has significantly lower rates of photosynthesis than all other species measured ($F_{4, 250} = 12.91$; $p < 0.001$). Tukey's post hoc analyses divided the species into groups based on their mean rates of photosynthesis, displayed in Table 2. Thus, Group 1 consists of the introduced species crested wheat grass and has a significantly lower rate of photosynthesis than all of the native species. Group 2 consists of the following species: western wheat, June grass, needle and thread grass, and blue grama (*Agropyron smithii*, *Koeleria gracilis*, *Stipa comata* and *Bouteloua gracilis* respectively), all of which are native to the mixed grass prairie. These species were grouped together because they do not have statistically different mean rates of photosynthesis.

Table 2. *Mean rates of photosynthesis for different species.*

Grass Species	N	Group 1 (mean photosynthesis $\mu mol/m^2/s^1$)	Group 2 (mean photosynthesis $\mu mol/m^2/s^1$)
Crested Wheat Grass	21	10.71	
Western Wheat	48		31.16
June Grass	15		33.97
Needle and Thread	18		40.01
Blue Grama	15		47.53

Summary and Conclusion

The finding that crested wheat grass photosynthesizes significantly less than indigenous species found in Grasslands National Park indicates that the indigenous species make for a better carbon sink. In areas where this aggressive species is found, it often becomes the dominant species, as evident by the observation that some upland areas were almost exclusively crested wheat grass. This implies that with the spread of this introduced species, the northern mixed grass prairie is becoming a less efficient carbon sink. Although not statistically significant, another interesting find was that blue grama, which is the only C_4 species included in this study, had the highest rates of photosynthesis of all the native species. Had this study been extended into August, perhaps we would have found that this difference would become more exaggerated, as the C_4 species are more suited to function in higher temperatures than C_3 species.

The finding that the upland and sloped locations were associated with different photosynthesis rates is likely due to different types of plants

making up the each of these communities, and each of these plants having slightly different rate of photosynthesis (Lloyd 1999). As well, the photosynthesis rates of upland crested wheat grass communities were found to be significantly lower than the photosynthesis rates of upland native species. The establishment of the different plant communities across the landscape is a result of a combination of different environmental factors such as soil fertility, moisture availability and slope aspect. This is further confirmed by the finding that soil moisture was found to be significantly higher in areas with introduced species compared to areas with native species. The concentration of native species in low moisture areas could be because the native species flourish in well-drained soils, but is more likely a result of competition from the aggressive introduced species, crested wheat grass (Ambrose and Wilson 2003).

In conclusion, although crested wheat grass is known to have larger above-ground biomass than native species (Lesica and DeLuca 1996), it is intuitive that this species should also have a larger quantity of photosynthetic material and therefore higher photosynthesis. However, this was not found to be true for this study, crested wheat grass photosynthesizes significantly less than the native species found in Grasslands National Park.

Further research:

Due to financial and time restraints, this study had a limited data collection span. Further investigation of the change in photosynthesis rates throughout the growing season, particularly for the introduced species, would provide more thorough information about photosynthesis.

To further understand the mixed grassland ecosystem, the link between the photosynthesis data with other biophysical factors, such as available CO_2, humidity, and photosynthetically active radiation, should be investigated. Relating these findings to remotely sensed images would be beneficial in that it would provide information about large areas, and allow for the construction of a model that could estimate the overall photosynthesis rates of a mixed grassland ecosystem.

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Monitoring grassland health with remote sensing approaches

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Abstract: Grassland condition is not only important economically, as it reflects the number of grazers rangeland can support, but also crucial ecologically, as it indicates the integrity of wildlife habitats. Even though studies have demonstrated the effectiveness of remote sensing in grassland monitoring, it is still a challenge to use remotely sensed data in mixed grasslands because the large proportion of dead material complicates analysis for indices that were not developed for heterogeneous landscapes, especially in conservation areas. In this study, we investigated the relationship between remote sensing data and grassland biophysical measurement including aboveground biomass and plant moisture content in the native mixed prairie ecosystem, with its high litter component. Biophysical and spectral data were collected in the summer of 2003 at west block of Grasslands National Park of Canada and surrounding pastures. Field data collected at five ungrazed sites within the park and five grazed sites outside the park. The results from this study indicated that the Normalized Difference Vegetation Index (NDVI) is not suitable for biomass estimation although a moderate relationship was found between NDVI and plant moisture content. Compared to NDVI, leaf area index (LAI) provided promising results on both biomass and plant moisture content estimation.

Introduction

Grasslands, covering 24% of the Earth's vegetated area (Sims 1988), rank as the most human altered landscape worldwide. The long history of manipulation, together with ongoing conversion of native grassland to cultivation (and back) leaves us with little information on natural grassland ecological function and poses a problem for effective monitoring of the processes we do understand. The repeated monitoring of grassland condition is an essential tool both in developing our understanding of important ecological processes and for conservation. This, plus the strong

agricultural and economic role of grasslands, makes monitoring grassland health of a broad interest among policy makers, ranchers and ecologists.

Remote sensing has played an important role in grassland ecosystem monitoring at landscape scales. With the improvement of remote sensing techniques and newly developed satellite sensors, remotely sensed data have been used in four major areas in grassland ecosystems study: plant composition including C3/C4 proportion and component of native species (Lauver and Whistler 1993; Goodin and Henebry 1997; Tieszen et al. 1997; Davidson and Csillag 2001; 2003), biophysical parameters, mainly component of biomass (Tucker 1978; 1980; Asrar et al. 1986; Weiser et al. 1986; Dyer 1991; Frank and Aase 1994; Csillag et al. 1996; Liang and Chen 1999; Guo et al. 2000; Nouvellon et al. 2001; Thoma et al. 2002; Wylie et al. 2002; Zha et al. 2003); climate change (Yang et al. 1998; Jobbagy et al. 2002; Ji and Peters 2003) and spatial pattern (Lobo et al. 1998; Rahman et al. 2003). Normalized Difference Vegetation Index (NDVI), the ratio of the difference of near infrared and red reflectance to the sum of these two variables, is the dominate spectral vegetation indicator of grassland biophysical measurements. NDVI tends to enhance the vegetation signal, reducing the atmospheric and edaphic influence, and standardizing the spectral data. This is particularly true when vegetation shows vigorous photosynthetic activity. Therefore, it has been used extensively in studies of vegetation production during the growing season.

However, NDVI has yet to prove its value in semi-arid and arid regions. This has been hypothesized to be due to lower biomass levels and strongly influenced by environmental factors such as temperature, precipitation, topography and soil condition (Huete and Jackson 1987). In addition, a mixture of living, senescent, and dead materials as well as exposed backgrounds makes arid rangeland remote sensing more complex. As Huete and Jackson (1987) indicated, "Remote sensing techniques have had little success in evaluating the quantity and quality of rangeland forage in arid ecosystems". Tucker (1979) found that brown or dormant vegetation is not as highly correlated with spectral data as is green vegetation. Liang and Chen (1999) also found that the value of NDVI extracted from National Oceanic and Atmospheric Administration (NOAA) images increased as the grassland becomes greener or denser. In a study conducted by Guo (2002) for the Canadian prairie ecosystem, the lowest correlation between NDVI and climate variables was in the Mixed Grassland ecoregion compared to Moist Mixed grassland and Aspen Parkland ecoregions. A reverse correlation was found between NDVI and biomass in Grasslands National Park (McCanny et al. 1996). So while NDVI has remained the most popular spectral vegetation index in the mixed grassland ecosystem, it is unclear

why NDVI fails to accurately reflect grassland biomass and production in some ecosystems.

The objective of our study was to determine how the components of native mixed grassland contribute to spectral reflectance in order to understand why NDVI performs as it does on these landscapes. NDVI is also compared to Leaf Area Index (LAI), which is a related, optical measure of grassland biomass.

Methods

Study Area:

Our study took place in Grasslands National Park, Saskatchewan, Canada (GNP) and surrounding pastures. Ten study sites were selected in upland native grasslands within the Park, and on federal, provincial, and privately managed rangelands surrounding the park. The area is a characteristic semi-arid mixed grass prairie ecosystem, with approximately 340 mm annual precipitation falling mainly in the growing season (May – September) and a mean annual temperature of 3.4^0C (Environment Canada 2003). The dominant plant community in the upland of the mixed prairie ecosystem is Needle-and-thread—Blue grama (*Stipa-Bouteloua*), which covers nearly two thirds of the park's ground area. The dominant species in this community include needle-and-thread grass (*Stipa comata Trin. & Rupr.*), blue grama grass (*Bouteloua gracilis (HBK*) *Lang. ex Steud.*) and western wheatgrass (*Agropyron smithii Rydb.*). Spikemoss (*Selaginella Beauv.*) and June grass (*Koeleria macrantha (Ledeb*) *J.A. Schultes f.*) are always present as well (Fargey et al. 2000). A comprehensive description of variety of site conditions was described by Scott (1995).

Field Data Collection:

Field data collection was conducted in the summer of 2003 (June-July) at the 10 sites with 3 plots in each site. Two 100 meter transects were set in each plot perpendicularly at north-south and west-east directions. A 20 x 50 cm quadrat was placed at each 10 meter intervals along each transect. LAI was measured using a LiCor-LAI-2000 Plant Canopy Analyzer at each quadrat. The spectral measurement was done with an ASD FR Pro spectroradiometer within 2 hours of solar noon on clear days at each quadrat. Vegetation was clipped to ground level at every second quadrat along each transect providing 12 biomass samples per plot, for a total of 36 per site. These are compared to 20 spectral and LAI readings for each plot (60 for each site). Biomass samples were weighed immediately after clipping to determine wet biomass. The samples were then sorted into green grass,

forb, shrub and dead materials, and placed in a drying oven for 48 hours at 60^0C. The difference between wet biomass and the dry biomass was the plant moisture content.

Data Preprocessing and Analysis:

LAI, reflectance and oven-dry biomass (refer to biomass thereafter) data were averaged for each plot, then to each site. Simulated six optical Landsat Thematic Mapper TM bands were derived from the field spectral measurements; these are band 1 (Blue 0.4-0.5 um), 2 (Green 0.5-0.6 um), 3 (Red 0.6-0.7 um), 4 (Near Infrared (NIR) 0.7-0.9 um), 5 (Middle Infrared 1.55-1.75um (MIR1)) and 7 (Middle Infrared 2.08-2.35 um (MIR2)). NDVI was calculated based on the formula of (NIR-Red)/(NIR+Red). Correlation analysis was run between biophysical variables (total biomass, live grass biomass, forb biomass and plant moisture content) and NDVI as well as between biophysical variables and LAI. Further, regression analysis was performed for prediction of total biomass and plant moisture content using NDVI and LAI separately to determine the precise variation biophysical variables that can be explained by spectral data and LAI. Results were validated with Jackknife method. This approach was implemented by withholding the sample data for one site and building the regression model using the data from the remaining sites. The process of removing one site from the dataset was repeated until all sites had been withheld.

Results

Biophysical Measurements:

In the study area, dead material contributed nearly half (47%) of the total biomass, ranging from 38% to 61% among the 10 sites (Table 1), the

Table 1: *Field measured biophysical parameters, isolated components of biomass and plant moisture content. Numbers in parentheses are percentage in total biomass.*

Site	Total biomass (g/m^2)	Grass (g/m^2)	Forb (g/m^2)	Dead (g/m^2)	Shrub (g/m^2)	Moisture (g/m^2)
1	201.9	91.4 (45.3%)	20.2 (10.0%)	90.3 (44.7%)	0.0	115.2
2	151.3	77.5 (51.2%)	9.9 (6.6%)	63.9 (42.2%)	0.0	67.8
3	178.9	84.3 (47.1%)	26.2 (14.6%)	68.5 (38.3%)	0.0	158.2
4	173.2	56.0 (32.3%)	32.7 (18.9%)	74.3 (42.9%)	10.3 (5.9%)	131.8
5	183.8	86.4 (47.0%)	16.7 (9.1%)	80.8 (43.9%)	0.0	105.6
6	238.5	95.8 (40.1%)	26.9 (11.3%)	115.8 (48.6%)	0.0	157.6
7	331.1	107.4 (32.4%)	21.4 (6.5%)	201.3 (60.8%)	1.0 (0.3%)	210.8
8	274.5	113.9 (41.5%)	16.0 (5.8%)	144.6 (52.7%)	0.0	222.3
9	187.6	78.2 (41.7%)	19.5 (10.4%)	89.9 (47.9%)	0.0	142.0
10	186.8	71.1 (38.0%)	26.5 (14.2%)	89.3 (47.8%)	0.0	90.1
Mean	210.8	86.2 (41.7%)	21.6 (21.6%)	101.9 (47.0%)	1.1 (0.6%)	140.1

largest fraction among grass, forb, shrub and dead. The next highest fraction was green grass, averaging 41.7% and ranging from 32.3% to 51.2%. These two fractions composed nearly 89% of the total biomass.

Spectral Features:

NDVI values were in the range of 0.36 and 0.50 with an average of 0.44 in the study area. With a total possible range of -1 to +1 for NDVI, 0.44 indicated relatively high photosynthesis activity, contributed by the 41.7% green grass. The reflectance range was between 6.5% and 9.1% and the numbers were 17.7% and 21.1% for the NIR. LAI showed lower values, less than 1.28, with an average of 0.87 (Table 2).

Table 2: *Field measured LAI values and calculated reflectance of RED, NIR and NDVI based field level spectral measurements.*

SITE	LAI	RED (%)	NIR (%)	NDVI
1	0.77	7.35	19.38	0.45
2	0.56	9.11	19.36	0.36
3	0.84	7.58	21.05	0.47
4	0.68	7.50	19.96	0.45
5	0.72	8.65	19.22	0.38
6	1.05	6.95	17.77	0.44
7	1.09	6.98	17.69	0.43
8	1.28	6.48	19.32	0.50
9	1.06	6.73	19.53	0.49
10	0.66	8.09	18.09	0.38
Mean	0.87	7.54	19.14	0.44

Correlation between biophysical parameters and NDVI and between biophysical parameters and LAI:

The only significant correlation between NDVI and biophysical variables is for plant moisture content with r of 0.729 (Table 3). However, LAI showed a strong relationship with grass biomass (r = 0.761), dead material (r = 0.723), total biomass (r = 0.773) and plant moisture content (r = 0.903). Even though NDVI and LAI both are significantly related with plant moisture content, LAI showed a much stronger correlation (0.903 vs. 0.729). Subsequent regression analysis showed that LAI could explain 81.5% variation of plant moisture content and 59.8% variation of total biomass, while NDVI was not significantly related to biomass and could only explain 53.2% variation of plant moisture content (Figure 1). With Jackknife validation, the r^2 values dropped to 0.474 for NDVI and plant

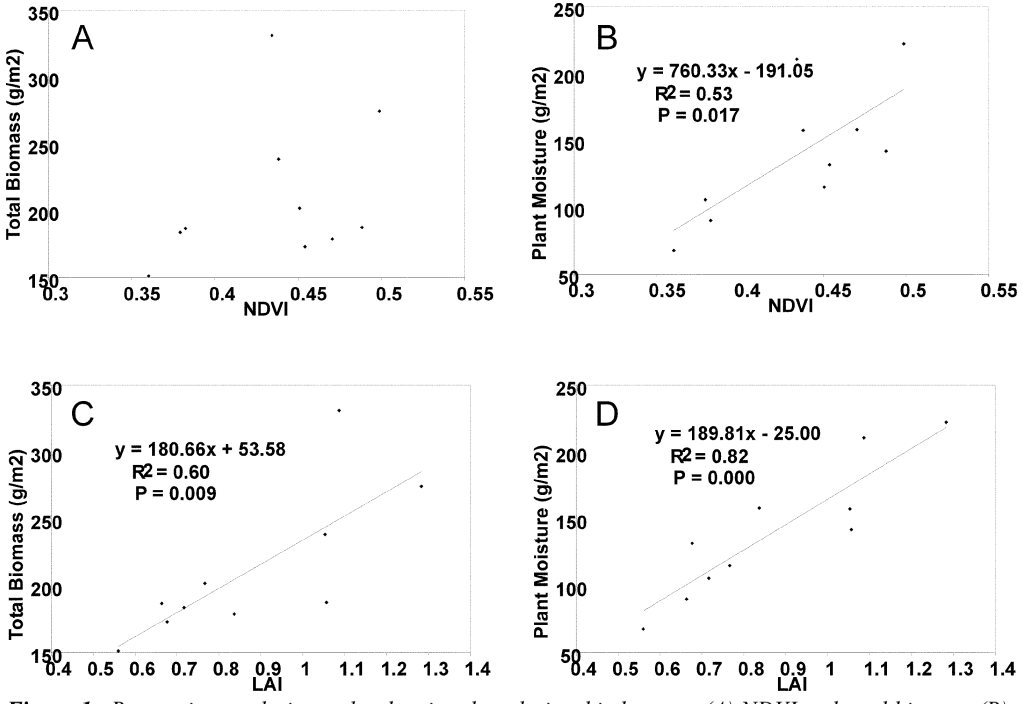

Figure 1: *Regression analysis results showing the relationship between (A) NDVI and total biomass (B) NDVI and plant moisture content (C) LAI and total biomass (D) LAI and plant moisture content. All measurements recorded in g/sqm.*

Table 3: *Correlation coefficient comparing biophysical parameters with NDVI and biophysical variables with LAI. Values in bold face indicate significant relationships.*

Variable		Grass	Forb	Dead	Total	Shrub	Moisture
NDVI	**r**	0.306	0.28	0.268	0.343	0.136	**0.729**
	Sig.	0.39	0.434	0.454	0.331	0.708	0.017*
LAI	**r**	**0.761**	-0.04	**0.723**	**0.773**	-0.259	**0.903**
	Sig.	0.011*	0.912	0.018*	0.009**	0.47	0.000**

Note: * - significant at 0.05; ** - significant at 0.01 level.

moisture content, 0.547 for LAI and total biomass and 0.792 for LAI and plant moisture content.

Discussion

Higher dead component is an obstacle for the performance of NDVI in the mixed grassland ecosystem:

NDVI works better when vegetation shows "typical" spectral responses, higher near infrared reflectance and lower red reflectance. Figure 2 illustrates the difference in spectral signatures of tall grass prairie (Kansas), wheat crop (Saskatchewan) and mixed grassland (this study). Grasses in the tall grass prairie showed a typical vegetation spectral curve with higher near infrared reflectance and lower red reflectance (Lillesand and Kiefer 1994). The wheat field showed a weaker response in the NIR region compared to tallgrass prairie, but was stronger than the mixed grassland. This is because the wheat was in flowering stage when the spectral readings were taken, which is on the down side of the vegetation phenology curve (Reed et al. 1994). The mixed grassland showed a much higher reflectance in the red and middle infrared wavelength regions and lower near infrared wavelength region. This is mainly caused by the higher dead material component which significantly reduced the sensed photosynthesis rate. Therefore, NDVI is a good measure of biomass and production for grassland in tallgrass prairie (Guo et al. 2000) and agriculture (Scotford and Miller 2003), but it doesn't show promise for the mixed grass prairie. A significant relationship between NDVI and plant moisture content indicated that NDVI is more sensitive to water absorption than photosynthesis when dead material is present. The subpixel unmixing method may improve the performance of NDVI if different component information is considered. Figure 3 showed the spectral response of isolated vegetation components for the mixed grassland in a laboratory setting. It

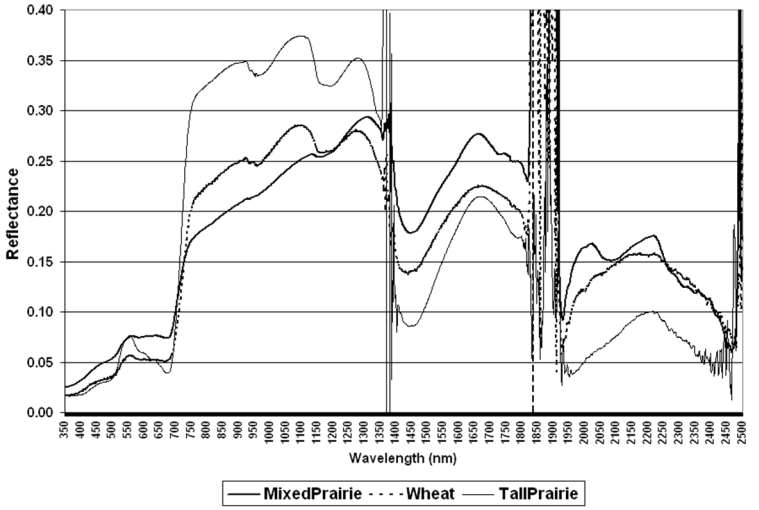

Figure 2: *Spectral response curves of grassland in tallgrass prairie, wheat field and mixed-grassland (mean of 30 samples). Spectral data for the tallgrass prairie were collected by Guo (unpublished data) at Douglas County, Kansas in June of 2000. Spectral data of wheat were collected by Guo (unpublished data) at the Agriculture and Agri-Food Canada Scott experiment field on July 18, 2003.*

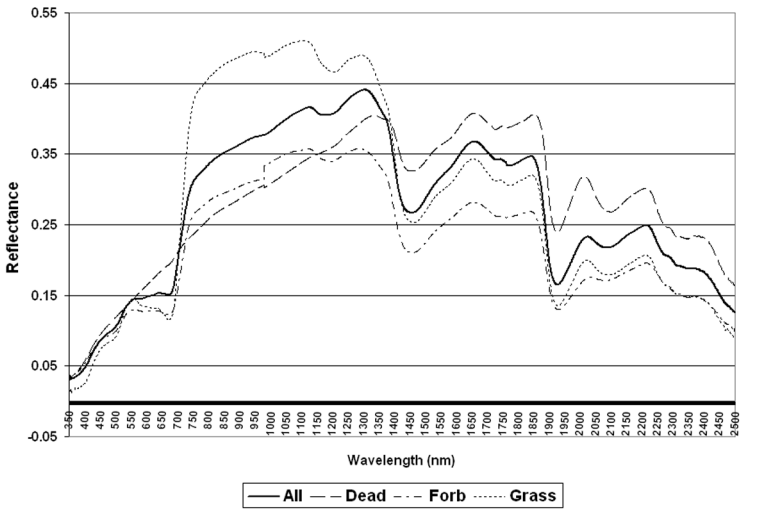

Figure 3: *Spectral response curves of different components of vegetation in the study area. Data were collected based on field collected samples after sorting in a laboratory setting with the same spectroradiometer as used in the field.*

is clear here that no single component of a complete mixed-grass sward dominates the total reflectance at all wavelengths. Indeed, the fact that the dead fraction has the highest reflectance in the visible range of red and the live fraction has the highest reflectance in the NIR range, suggests that the NDVI ratio is confounding the reflectance of two, distinct fractions.

LAI is an indirect method of estimating canopy structure in which the dead materials are counted:

LAI, defined as the total leaf area per ground area, is a direct canopy structure measure. Optical leaf area is measured indirectly via an instrument which detects gap fractions above and below the canopy. The LAI-2000 Plant Canopy Analyzer, used in this study, uses a fisheye light sensor that measures diffuse radiation simultaneously in five distinct angular bands about the zenith point. The sensor consists of five photodiodes whose active surfaces are arranged in concentric rings. The image of its hemispheric view is projected onto these rings, allowing each to measure the radiation in a band at the known zenith angle. In use, gap fractions at five zenith-angles can be measured by making a reference reading above the canopy and readings beneath the canopy both with sensor looking up. The below readings are divided by the above readings to obtain an estimate of the gap fraction at the five angles (Wells 1990). Since the measurement is based on the difference in diffuse radiation above and below a canopy, the measurement is not only for leaf area strictly, but a combination of whole canopy structure (e.g., stem and branches). Therefore, it incorporates a component of live and dead materials (standing dead). This explained why LAI was highly related with most biomass components and plant moisture content but forb biomass was not because a majority of forb component is at ground level.

Presence of moss and lichen enhanced the complexity of the mixed grass ecosystem:

Besides litter, moss and lichen cover the majority of ground which referred as soil crusts. The major species include Biological soil crusts serve a number of ecosystem functions that make them an important component of the biological diversity of many of the semiarid and environments of the world including breakdown humus and release nutrients (Kauffman and Pyke, 2001). These life form have significantly different spectral characteristics compared to bare ground since they are green (albeit, non-vascular) vegetation. Thus, while there is much exposed surface in an overhead image of mixed-grass prairie, little of this is exposed soil, but rather is a complex mix of materials that contribute independently to the spectral reflectance of the site.

Conclusion

NDVI, derived from remote sensing and applied to complete mixed-grass swards, is not suitable for mixed grassland ecosystem biomass estimations. It has marginal utility for plant moisture content prediction. Compared to NDVI, leaf area index (LAI) not only showed correlations with more biophysical variables, grass biomass, dead materials, total biomass and plant moisture content, but also could explain higher variability of total biomass and plant moisture content. An un-mixing model based on the components of grassland (grass, forb, and dead) should be further investigated.

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The evaluation of broadband vegetation indices on monitoring northern mixed grassland

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Abstract: The northern mixed grassland is characterized by its high amount of non-photosynthetic materials and low to medium green vegetation cover, which has proven to be a challenge for the application of remotely sensed data in a vegetation study. This study was conducted to evaluate broadband based vegetation indices and determine the most effective spectral vegetation index to be used in this ecosystem. The study area was Grasslands National Park (GNP) and surrounding pastures. Fieldwork was conducted from late June to early July 2003. Biophysical variables, including canopy height, cover, biomass, and species composition, and a corresponding Landsat 5 image on August 10, 2003 were collected. Thirteen vegetation indices were calculated based on at-surface reflectance. Texture analysis was conducted on these vegetation indices to study biophysical parameter variation. Pearson correlation and regression analysis were used to study the relationships between vegetation indices and biophysical parameters. Results showed that brightness, Adjusted Transformed Soil Adjusted Vegetation Index (ATSAVI), Transformed Soil Adjusted Vegetation Index (TSAVI), wetness, and Global Environmental Monitoring Index (GEMI) have medium to high correlation with biophysical parameters. This shows the success of applying these broadband based vegetation indices to study biophysical measurements in the northern mixed grassland.

Introduction

Broad band based vegetation indices, based on sensors with broad wavelength region bands (e.g. Landsat and SPOT), are the most frequently used indicators for monitoring ecosystem dynamics. Many vegetation indices have been developed and applied in vegetation studies since the first vegetation index, Ratio Vegetation Index (RVI) (Jordan 1969). These vegetation indices can be categorized as four groups: ratio, orthogonal, hybrid, and nonlinear (Chen 1996; Broge and Leblanc 2000). RVI and the Normalized Difference Vegetation Index (NDVI) are ratio vegetation indices.

NDVI is the most commonly used vegetation index in grassland study, which has been widely used to evaluate cover (Dymond et al. 1992), above-ground biomass (Tucker 1985), chlorophyll content (Tucker 1985), leaf area (Asrar et al. 1986; Curran et al. 1992), phenology (Markon et al. 1995), absorbed photo-synthetically active radiation (Prince 1991), and NPP (Ruuning 1989).

However, NDVI is influenced by many environmental factors such as topography, bare soil (soil fraction, soil type and soil moisture), atmospheric condition (Pinty and Verstraiet 1992), vegetation association, rainfall (Schmidt and Karnieli 2002) nonphotosynthetic materials and others (Gamon et al. 1993). Therefore, adapted vegetation indices, like hybrid, orthogonal, and nonlinear indices, have been proposed to deal with the influences of background information. Huete (1988) developed a Soil Adjusted Vegetation Index (SAVI) using soil adjustment factor, which is decided by percentage of green cover, to adjust for the influence of soil in the spectral features. Unfortunately, the requirement of knowing percentage vegetation cover beforehand is not met in many cases. As a result, Qi et al. (1994) improved the performance of SAVI by proposing Modified Soil Adjusted Vegetation Index (MSAVI) and the second Modified Soil Adjusted Vegetation Index (MSAVI2) with an additional dynamic soil adjusting factor. Baret (1989) introduced the Transformed SAVI (TSAVI) and Adjusted TSAVI (ATSAVI) by taking into account the soil line slope and intercept of the soil line. Pinty and Verstraete (1992) developed a Global Environmental Monitoring Index (GEMI) to correct for the atmospheric contribution in AVHRR data specifically. Generally, hybrid vegetation indices are good for vegetation canopy of low cover (Ray 1994).

Orthogonal indices are different from ratio indices for the position of the greenness isolines (Broge and Leblanc 2000). The Perpendicular Vegetation Index (PVI) and the Weighted Difference Vegetation Index (WDVI) are typical orthogonal indices. They are not sensitive to soil background because they are parallel to the principle axis of soil spectral variation. Because the relationship between vegetation indices and biophysical parameters is not necessarily linear, nonlinear indices, the Nonlinear Index (NLI) and the Renormalized Difference Vegetation Index (RDVI), were developed to linearize their relationships with surface parameters (Chen 1996).

In addition, the Tasseled Cap Transformation (TCT) is a basic spectral enhancement method aimed primarily at analyzing vegetation cover making use of all bands (except the thermal band) of Landsat (Kauth and Thomas 1976). Greenness, brightness, and wetness, results of TCT when applied to TM or ETM+ data, are used to indicate vegetation canopy, bare soil, and moisture respectively.

Remote sensing application in the northern mixed grassland are challenging because of its high amount of non-photosynthetic materials and low to medium green vegetation cover even though remote sensing has been used on other grassland ecosystems (Guo et al. in press), e.g. studies in tallgrass prairie (e.g., Asrar et al. 1986; Asrar et al. 1989), shortgrass prairie (Lauver 1997), and other grasslands in semiarid and arid environment (e.g., Wilson 1989; Lewis 1994; Dilley et al. 2004). Few studies have been conducted in the mixed grassland (e.g.: Davidson and Csillag 2000). And performance of these vegetation indices in the mixed grass ecosystem has not been evaluated yet. Therefore, this study aims to investigate the effectiveness of the above vegetation indices in the northern mixed grassland. The objectives are to find the best vegetation indices at detecting biophysical parameters and to evaluate the texture analysis method on spatial variation analysis.

Study Area

The study area included Grasslands National Park (GNP) (49° N, 107° W) and surrounding pastures, located in southern Saskatchewan along the Canada - United States border. This area falls within the mixed grassland ecosystem. The park is approximately 906.5 km^2 in area but in two discontinuous blocks, west and east. The first land was acquired for the park in 1984; as a result, some areas of the park have been under protection from livestock grazing for almost 20 years. The park area consists of upland grasslands and lowland grasslands. The dominant plant community in the upland grasslands is Needle-and-thread—Blue grama (*Stipa-Bouteloua*), which covers nearly two thirds of the park's ground area. The dominant species in this community include needle-and-thread grass (*Stipa comata Trin. & Rupr*), blue grama grass (*Bouteloua gracilis (HBK*) *Lang. ex Steud*.), and western wheatgrass (*Agropyron smithii Rydb. Selaginella Beauv.*) (Fargey et al. 2000). Apart from the Needle-and-thread—Blue grama (*Stipa-Bouteloua*) community, lowland grasslands contain higher densities of shrubs and occasional trees. The entire area consists of northern mixed grassland (Davidson 2002). The GNP area has a mean annual temperature of 3.8^0C and a total annual precipitation of 325 mm (Environment Canada 2003); approximately half of the precipitation is received as rain during the growing season.

Methods

Field work and data processing:

Field work was conducted in June and July of 2003. Ten sites were randomly selected within the park and surrounding pastures. Three 100 x100 m plots were set up in each site, and each plot was composed of two 100 m transects placed perpendicularly to each other with a north-west orientation. Twenty-one quadrats (20 x 50 cm) were placed in each plot at 10 m intervals. Percent cover of grass, forb, shrub, standing dead, litter, moss, lichen, and bare ground as well as species composition was collected at each quadrat. Biomass was collected at 20 m intervals using the harvesting method. Clipped fresh biomass was sorted into four groups: grass, forb, shrub, and dead materials. They were then dried in an oven for 48 hours. LAI was measured using a LiCor-LAI-2000 Plant Canopy Analyzer. At each plot, LAI is the average of four automatically calculated LAI values; each was the result of one above canopy reading compared with ten below canopy readings. These measurements were completed within two minutes to avoid atmospheric variation. The ten below canopy readings were set at five meter intervals. The sensor was shaded when observations were being taken to reduce the glare effect from direct sunshine.

All biophysical parameters were averaged by sites, composing 36 quadrats for biomass and 63 quadrats other parameters. Standard deviation was used to measure the variation of biophysical parameters within sites. Shannon's index (Rosenzweig 1995) and Heterogeneity index of height (HIH) (Wiens, 1974) were also calculated to stand for species diversity and the variation of canopy height inside sites respectively (Table 1).

Table 1: *Calculated parameters based on biophysical parameters.*

Parameter	Equation	Note
Shannon's index	$-\sum p_i \ln(p_i)$	p_i is the proportion of the total number of individuals occurring in species i
Heterogeneity index of height (HIH)	$\frac{\sum (Max - Min)}{\sum \bar{x}}$	Max=maximum value of the canopy height within quadrats, Min=minimum value of the canopy height within quadrats, N=the total number of quadrats, $\bar{x}$ the mean value of canopy height in a quadrat

Satellite image and preprocessing:

A Landsat 5 Thematic Mapper (TM) image was acquired for this study. The image was taken on 10 August 2003, approximately four weeks

after the field campaign. The image has a spatial resolution of 30 m except in the thermal band and contains seven bands. All bands except band six (thermal) were utilized in this study. Atmospheric and radiometric corrections were completed for the image, and digital numbers (DN) were converted to at surface reflectance. Because simple dark object subtraction can bring better results than more complex model (such as 6S model) (Song et al. 2001), an improved dark-object subtraction method (Chavez 1988) was applied during the atmospheric correction. The process of radiometric correction followed the procedure of Markham and Barker (1986). The image was registered to a Universal Transverse Mercator (UTM) projection and the nearest neighbour resampling method was used in geometric projection. Thirty GCPs were collected and the RMSE was less than 0.3 pixel (<10 m).

Vegetation indices and texture analysis:

In this study, we included indices evaluated by Chen (1996) and Peddle et al. (2001) plus TSAVI, ATSAVI, greenness, brightness, and wetness. Altogether thirteen vegetation indices were selected (Table 2). All vegetation indices were calculated based on at-surface reflectance with GEMI also calculated based on at-sensor reflectance. To investigate the

Table 2: *Methods of vegetation indices calculation in this study.*

Category	Vegetation index	Equation	References
Ratio Vegetation Index	Simple Ratio (SR) or Ratio Vegetation Index (RVI)	$\frac{TM4}{TM3}$	Jordan (1969)
	NDVI (Normalized Difference Vegetation Index)	$\frac{TM4 - TM3}{TM4 + TM3}$	Rouse et al. (1973)
Hybrid Vegetation Index	SAVI (Soil-adjusted vegetation index)	$\frac{TM4 - TM3}{(TM4 + TM3 + L)(1 + L)}$	Huete 1988
	TSAVI (Transformed Soil-adjusted Vegetation Index)	$\frac{a \times (TM4 - a \times TM3 - b)}{a \times TM4 + TM3 - a \times b}$	Baret,1989
	ATSAVI (Adjusted Transformed Soil-adjusted Vegetation Index)	$\frac{a \times (\mathrm{TM4 - a \times TM3 - b})}{\mathrm{a \times TM4 + TM3 - a \times b + 0.08 \times (1 + a^2)}}$	Baret and Guyot 1992
	MSAVI2 (Second Modified Soil Adjusted Vegetation Index)	$\frac{2 \times \mathrm{TM4} + 1 - \sqrt{(2\mathrm{TM4} + 1)^2 - 8 \times (\mathrm{TM4 - TM3})}}{2}$	Qi et al. 1994
	Global Environmental Monitoring Index (GEMI)	$eta \times (1 - 0.25 \times eta) - \frac{TM3 - 0.125}{1 - TM3}$ where : eta = $\frac{2 \times (\mathrm{TM4^2 - TM3^2}) + 1.5 \times \mathrm{TM4} + 0.5 \times \mathrm{TM3}}{TM4 + TM3 + 0.5}$	Pinty and Verstraiet (1992)
Orthogonal Vegetation Index	WDVI (Weighted Difference Vegetation Index)	$\mathrm{TM4 - a \times TM3}$	Clevers (1989)
Nonlinear Vegetation Index	RDVI (Renormalized Difference Vegetation Index)	$\frac{TM4 - TM3}{\sqrt{TM4 + TM3}}$	Roujean and Breon (1995)
	NLI (Non-Linear Index)	$\frac{TM4^2 - TM3}{TM4^2 + TM3}$	Goel and Qin (1994)
Tassled Cap Transformation Indices	Brightness	0.2909 * TM1 + 0.2493 * TM2 + 0.4806 * TM3 + 0.5586 * TM4 + 0.4438 * TM5 + 0.1706 * TM7	Crist et al. (1986)
	Greenness	-0.2728 * TM1 - 0.2174 * TM2 - 0.5508 * TM3+ 0.7221 * TM4 + 0.0733 * TM5 - 0.1648 * TM7	
	Wetness	0.1446 * TM1+ 0.1761 * TM2 + 0.3322 * TM3 + 0.3396 * TM4 - 0.6210 * TM5 - 0.4186 * TM7	

spatial variation of the forb component in the grassland ecosystem, a texture analysis of a 3 x 3 window size was applied to these three indices. GLCM texture analysis is a commonly used method for describing localized variation of surface features in grey scale. During the process of texture analysis, a grey level co-occurrence matrix or grey level co-occurrence vector is computed to describe the stochastic properties of spatial distribution of grey levels (Hall-Beyer 2000; He and Wang 1990). Results of these textural algorithms can be used to describe the heterogeneity within a landscape (Woodcock and Strahler 1987; Briggs and Nellis 1991; Anys and He 1995). Three textural parameters, GLCM standard deviation, contrast, and entropy, are used as indicators of heterogeneity or local variance (Zhang et al. unpublished).

Data analysis:

Vegetation indices and textural parameters were averaged using a 3 x 3 window size (90 m x 90 m), which was centered at each plot on every site. Pearson's correlation analysis was conducted for all biophysical parameters and vegetation indices. A linear regression analysis was run to identify indices or textural parameters best suited to estimate the biophysical parameters. Prediction models were developed for biophysical parameters and the results were validated with jack-knife cross validation method, which withdraws one sample each iteration and runs the model for (n - 1) iterations.

Results

Biophysical parameters:

The mixed grassland is noted for its low vegetation cover, large amount of dead material, and biological crust. The grass cover and forb cover are around 30% and 15% respectively. A large amount of dead material, including standing dead grass and litter, have been accumulated in northern mixed grassland, especially in the park area due to the protection from grazing. Dead materials account for about 50% of total biomass (Guo et al. in press) and cover 80% of understory. Biological soil crust is an important component of the semiarid and arid grasslands including the breakdown of humus and the release of nutrients (Kauffman and Pyke 2001). Moss and lichen are important components of the understory biological crust in the northern mixed grassland with about 15% cover. As a result, the northern mixed grassland has a low percentage of bare ground due to low grazing density (about 2.5%), which is different from other grasslands in semiarid and arid environments.

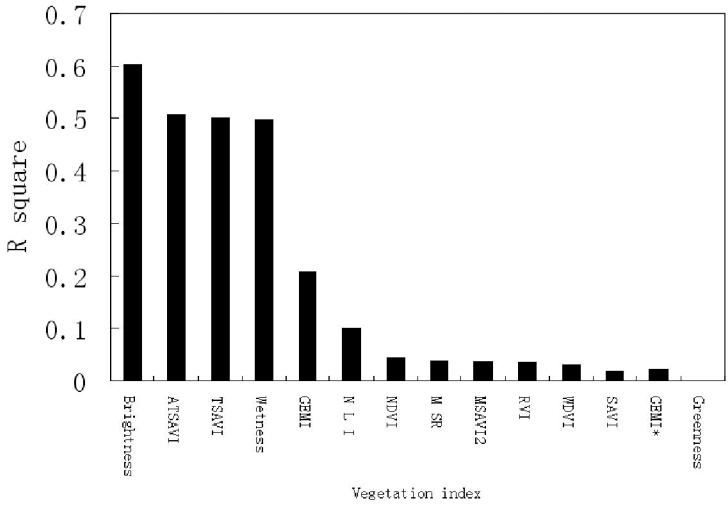

Figure 1: *Relationships between vegetation indices and LAI. While GEMI was calculated based on at surface.*

LAI and vegetation indices:

LAI is the total one-sided (or one half of the total all-sided) green leaf area, vertically projected, per unit ground surface area. It is an important vegetation structural parameter because it defines the area of leaf that interacts with solar radiation and provides the remote sensing signal. We have concluded that LAI is a good biophysical parameter in the mixed prairie region (Guo et al. unpublished). Therefore, the relationships between vegetation indices and LAI could be used to characterize the canopy directly. Results showed that LAI was moderately to highly correlated with brightness ($r = -0.77$, $p < 0.01$), ATSAVI, TSAVI ($r = -0.71$, $p < 0.05$), and wetness ($r = 0.71$, $p < 0.05$) (Figure 1, where r^2 values are shown). Brightness explains the variation of LAI better than ATSAVI, TSAVI, and wetness by nearly 10%. Brightness indicates non-photosynthesizing background information, such as dead materials, moss cover, lichen cover, and shadow. In northern mixed grasslands, the percentage of bare ground was very small and the amount of standing dead materials and litter (cover and biomass) was large (Guo et al. in press). Furthermore, spectral characteristics of dead materials are similar to that of bare soil (Baret and Guyot 1991). Decreasing LAI induced more background information in pixels, which resulted in negative relationships between LAI and brightness. Wetness, which indicates moisture, is positively correlated

with LAI. Adequate moisture normally corresponds to higher primary productivity due to the critical role of soil moisture in vegetation growth and LAI is highly related to production. Therefore, high moisture level is corresponded to high wetness values. It is interesting that ATSAVI and TSAVI, which take into account soil background information, are negatively correlated to LAI. It indicated that the information about the green canopy did not dominate the remotely sensed data. Therefore, these four indices provide an indirect measure of green canopy by measuring background information. Relationships between VIs and LAI can be predicted using linear regression (Table 3). Sixty percent of LAI variation could be explained by brightness, while the number dropped to 55% when the cross validation was applied. For ATSAVI, TSAVI, and wetness, they could explain 50% of LAI variation (43% with cross validation). There were no significant relationships between other vegetation indices and LAI. reflectance, GEMI* was based on at sensor reflectance.

Table 3: *Linear regression models for vegetation indices and LAI.*

Equation	r^2	Adjusted r^2	SE
LAI = -10.854 × Brightness + 4.3409	0.60	0.55	0.16
LAI = -10.855 × ATSAVI + 14.725	0.51	0.45	0.17
LAI = -12.644 × TSAVI + 15.733	0.50	0.44	0.18
LAI = 27.06 × wetness + 5.22	0.50	0.44	0.18

Biomass and vegetation indices:

GEMI based on at surface reflectance correlated well with grass, forb, and total biomass by explaining about 45% of the variation (Table 4). The number dropped to around 40% when the cross validation was applied, but the negative relationships showed again that information contained in GEMI is not only green vegetation.

Table 4: *Linear regression results for GEMI and biomass (Biomass=s*GEMI+ i, where s means slope and i is intercept).*

Equation	r^2	Adjusted r^2	SE
Grass biomass = -980.203 × GEMI + 520.185	0.47	0.41	13.1
Dead biomass= -2494.259 × GEMI + 1166.412	0.46	0.40	32.9
Total biomass = -3050.133 × GEMI + 1561.287	0.44	0.37	43.6

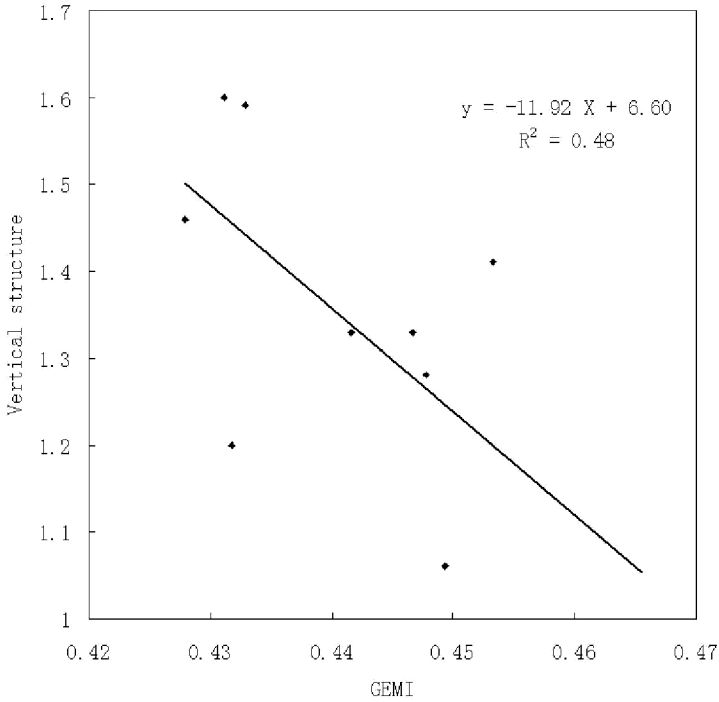

Figure 2: *The relationship between HIH and GEMI.*

Diversity and GEMI:

HIH is one of the indicators of within site variation. Results showed that only GEMI based on at-surface reflectance correlates well with HIH. GEMI based on at surface reflectance can explain about 48% of variation (Figure 2) and the value is 42% when validation was conducted. Shannon's index showed no significant relationships with GEMI calculated using at sensor reflectance ($r = 0.41$ and $p > 0.05$) and at surface reflectance ($r = -0.35$, $p > 0.05$).

Relationships between spatial heterogeneity and the spectral variation:

Variables of contrast, standard deviation, and entropy derived from texture analysis have proved to be an effective way to study grassland spatial variation (Zhang et al. unpublished). They are also correlated moderately well with standard deviation of LAI, percentage of bare ground, litter cover, and canopy height (Table 5). Approximately 50% of their

Table 5: *Coefficients of correlation between standard deviation of biophysical parameters and of textural parameters.*

		HIH	Average Height	LAI	Litter cover	% of Bare ground
	Contrast	-0.57	-0.52	-0.49	0.08	0.72*
ATSAVI	SD	0.74**	0.63*	0.55	0.16	0.65*
	Entropy	0.43	0.24	0.15	0.09	0.46
	Contrast	-0.72*	0.77**	-0.75**	-0.48	0.45
Brightness	SD	-0.67*	-0.69*	-0.72*	-0.47	0.41
	Entropy	-0.48	0.56	-0.73*	-0.33	0.42
	Contrast	0.41	0.30	0.27	0.45	0.10
Greenness	SD	0.52	0.39	´0.19	0.46	0.02
	Entropy	0.69*	0.57	0.05	0.75**	0.03
	Contrast	-0.57	0.52	-0.50	0.08	0.72*
TSAVI	SD	-0.74**	0.63*	0.55	0.16	-0.65*
	Entropy	0.43	0.24	0.15	0.09	-0.46

Note: *significant at 0.05 level. ** significant at 0.01 level.

variation (r^2) could be explained by the three texture analysis variables from the greenness, brightness, TSAVI, and ATSAVI. The positive correlation between greenness and litter cover and the positive correlation between TSAVI and percentage of bare ground also indicate that remotely sensed data for northern mixed grasslands contains more information than just green canopy. It can be concluded that ATSAVI and TSAVI are good for HIH, brightness is good for average height and LAI, while greenness is good for litter cover and percentage of bare ground in a reverse relationship.

A factor that should be taken into account is the time of image acquisition. There is about one month's discrepancy between field work and satellite image acquisition. It contributes to the low correlation between vegetation indices and biophysical parameters, especially variables that change dramatically temporally, such as forb cover. In the northern mixed grassland, late June and early July are the full growing season, which is our field data collection duration, while the image was acquired slightly after the maximum growing condition.

Conclusion

For northern mixed grassland, standing dead material, litter, and moss constitute the gaps of the vegetation canopy and contribute as background information. Therefore, indices either measuring background information (brightness and wetness) or hybrid indices (ATSAVI, TSAVI, and GEMI)

have relatively higher correlation with biophysical parameters. Brightness, ATSAVI, TSAVI, and wetness can be used to measure LAI, and GEMI can be used to extract biomass and diversity information. Other indices do not perform well in the northern mixed grassland, which imply the importance of background information. Vegetation indices can be also applied to study grassland heterogeneity. ATSAVI and TSAVI are good for HIH, brightness is good for average height and LAI. However, this study was based on one year's field data. Climate variation may have effects on the conclusions because 2003 was a dry year. Further field data will be collected to validate our results. Nevertheless, we believe that our sample scheme and sites selected are very representative in the mixed grassland ecosystem. Therefore, the results are reliable at least for the similar climate conditions.

Acknowledgements

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Bird populations and remote sensing

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Abstract: Bird populations are highly dependent on grassland structure, diversity and quality which, in turn, are disturbance dependent (e.g. grazing and fire). The reflectance differences in vegetation can be detected by satellite signals that are further analyzed through vegetation indices. Our purpose was to investigate the feasibility of applying remote sensing techniques to predict the breeding bird population in the northern mixed grasslands. Birding surveys were conducted in the summer of 2003 in Grasslands National Park (GNP), Saskatchewan, Canada. One Landsat Thematic Mapper (TM) image was acquired in the same year. Selected vegetation indices were calculated to investigate the relationships between spectral reflectance and the populations of four bird species. Results indicated that remotely sensed data could predict bird density with moderate accuracy: 53%, 51%, 43%, and 44% for Sprague's Pipit, Baird's Sparrow, Horned Lark, and Chestnut-collared Longspur, respectively. The ATSAVI spectral vegetation index showed the best results, followed by TVI and Wetness.

Introduction

Critical grassland habitat for species at risk (SAR) in the Canadian prairies is shrinking dramatically due to direct and indirect human influence. This has resulted in chronic population declines of species already at risk, such as Sprague's pipit, Baird's sparrow, and sage grouse. Loss, degradation and fragmentation of critical habitat due to human activities have impeded species recovery. While the characteristics of critical habitat for some SAR (e.g., sage grouse) are reasonably well understood (silver sagebrush, forbs in vegetation community), until recently it has been difficult, if not impossible, to measure these factors at a landscape scale. Remote sensing, with its advantages of large areal coverage and multiple spatial, spectral, and temporal resolutions, has been applied to predict avian populations

by linking remote sensing and habitat biophysical characterisitcs. Avery and Haines-Young (1990), for example, used satellite imagery to estimate the population of the dunlin *Calidris alpina* for the Flow Country of northern Scotland. The authors demonstrated that remotely sensed satellite imagery could be used to make accurate predictions of the dunlin population, and thereby assess the impact of forestry on this wading bird. The near-infrared band 7 of Landsat MSS, in addition to its sensitivity to green vegetation, is also sensitive to soil wetness. The habitat favored by dunlin is wet moorland interspersed with small pools, so that dunlin populations are significantly negatively correlated with a soil wetness index derived from the MSS band 7 reflectance values.

Palmeirim (1988) similarly mapped the habitat of several avian species using satellite imagery. The author combined the habitat classification derived from Landsat TM imagery and bird survey data to obtain habitat suitability estimates and produce maps reflecting the habitat needs of each individual species. One scene of TM imagery was used to produce a land cover map of a study area located in NE Kansas, USA, and then spatial algorithms were used to reclassify the land cover map to habitat classes for breeding birds. Bird surveys were conducted to obtain the composition and abundance of the required bird fauna at a number of points representative of all the major habitats present in the study area. Both the habitat map and bird survey results were input to a GIS to generate distribution, suitability and density maps, and to make crude estimates of population size. Other avian studies using remote sensing include predicting avian population, such as for ring-necked pheasant in Kansas (Houts et al. 2002), duck population and duck habitat (Cowardin et al. 1995), and linking landscape heterogeneity and bird population ecology with microwave remote sensing (Imhoff et al. 1997). Significant efforts have been made to map habitat, including relating bird abundance to forest stand structure (DeGraaf et al. 1998), modelling sage grouse winter habitat (Homer et al. 1993), modelling landscape-scale habitat use using GIS and remote sensing (Osborne et al. 2001), and evaluating breeding habitat for an African weaver-bird (Wallin et al. 1992). Previous studies have therefore demonstrated the effectiveness of using remote sensing to predict bird populations. However, there is limited study of the feasibility of remote sensing techniques to estimate the populations of any avian species in the mixed prairie ecosystem. Thus the primary objective of this research is to find the most suitable spectral vegetation indices for bird population estimation and to use these indices to develop bird population predictive models in a mixed prairie ecosystem.

Study Area

Our study area is located in Grasslands National Park (GNP), which has a geographical extent of 49.21N, 107.57W - 49.16N, 107.50W. GNP is located in southern Saskatchewan along the international border of Canada and the United States. The park is approximately 960 km^2 in total area over two discontinuous blocks, west and east. The first land was acquired for the park in 1984; therefore, some areas of the park have been under protection from livestock grazing for over 20 years. The park area consists of upland and valley grasslands. The GNP area has a mean annual temperature of 3.4^0C (Environment Canada 2003) and total annual precipitation of 325 mm where about half of the precipitation occurs as rain during the growing season of June to August. The dominant plant community in the uplands of the mixed prairie ecosystem is Needle-and-thread—Blue grama (*Stipa-Bouteloua*), which covers nearly two thirds of the park's area. The dominant species in this community includes needle-and-thread grass (*Stipa comata Trin. & Rupr.*), blue grama (*Bouteloua gracilis (HBK*) *Lang. ex Steud.*) and western wheatgrass (*Agropyron smithii Rydb.*). Spikemoss (*Selaginella Beauv.*) and June grass (*Koeleria macrantha (Ledeb*) *J.A. Schultes f.*) are present as well (Fargey et al. 2000).

The need to preserve habitat for the species at risk endemic on the Great Plains has stimulated much research of the ecosystem scale including land use, and landform habitat estimation and monitoring. The current understanding of relationships among ecological integrity, wildlife habitat, and disturbance is that some level of grazing and fire disturbance is an integral biological process of the mixed prairie ecosystem. Remote sensing appears to be the best tool to help restore the ecological integrity of grassland landscapes through advancing the knowledge of relationships between SAR habitats and disturbances caused by grazing and burning, as well as by developing a measuring and monitoring tool that can be used for SAR recovery strategy development.

The Canadian prairies are the northern range of the four species investigated in this study, Sprague's Pipit (*Anthus spragueii)* (SPPI), Baird's Sparrow (*Ammodramus bairdii)* (BASP), Horned Lark (*Eremophila alpestris)* (HOLA), Chestnut-collared Longspur (*Calcarius ornatus)* (CCLO) (Figure 1). The park area is located within the core habitat regions of these species.

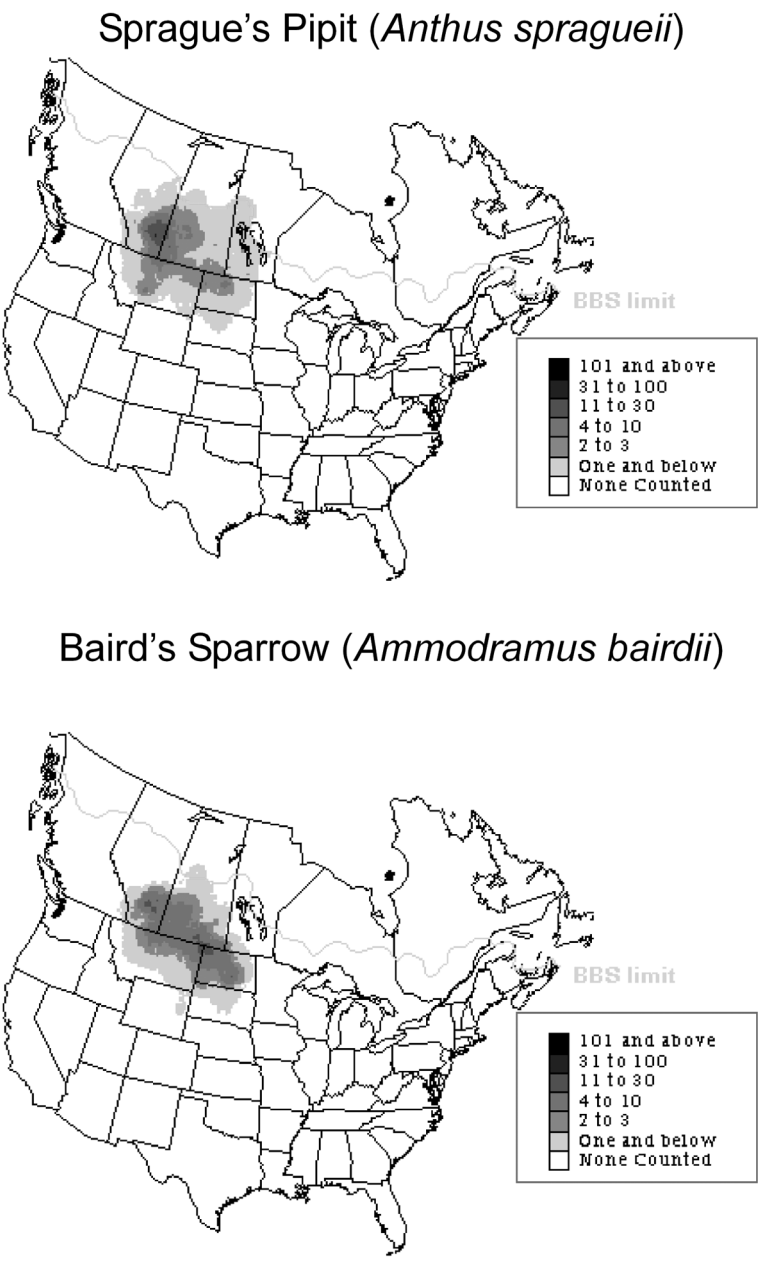
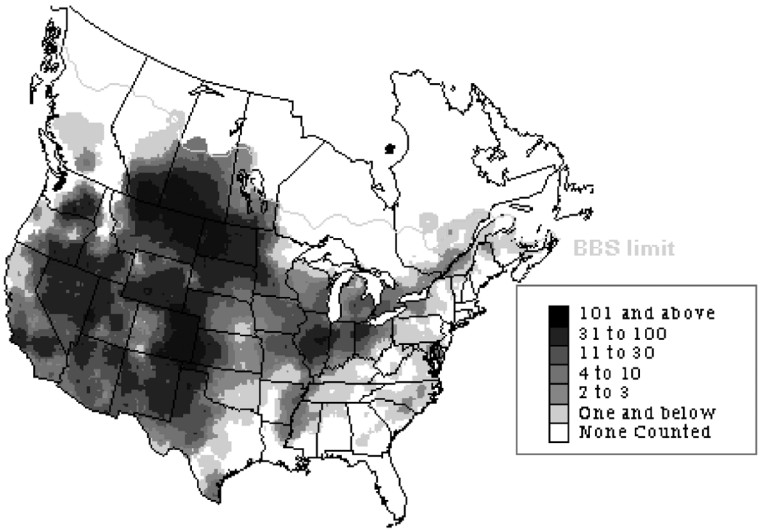


Figure 1: *Spatial distribution of the four bird species in North America. (Data sources: http://www.mbr-pwrc.usgs.gov/id/framlst/i5380id.html).*

Horned Lark (*Eremophila alpestris*)



Chestnut-collared Longspur
(*Calcarius ornatus*)

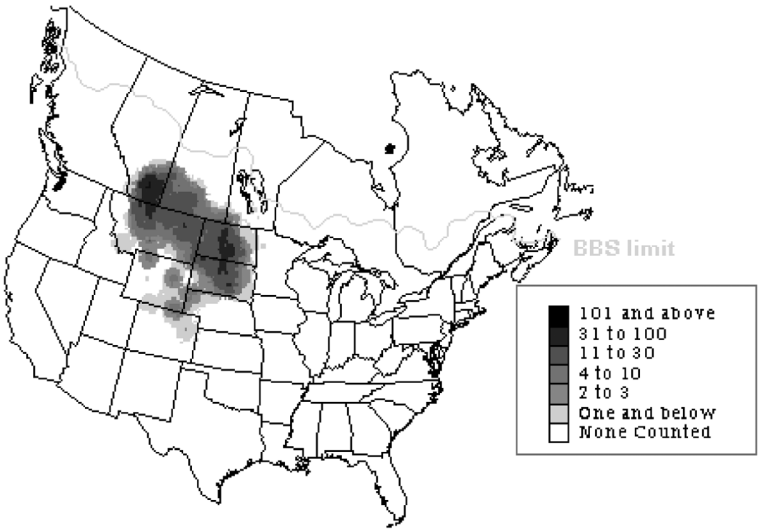


Figure 1: *(continued)*

Methods

Field data collection:

Field work was conducted in the summer of 2003 using a stratified random sampling method. Ten sites were selected from upland grasslands in the western block of GNP, as upland represents the mixed grass ecosystem. Five 100 x 100m plots were established in each site, and each plot was composed of two 100m transects placed perpendicular to each other with a north-west orientation. Point-count surveys targeting Sprague's Pipits, Baird's Sparrow, Horned Lark and Chestnut-collared Longspur, were conducted on the field sites during the growing season. Point counts were made at a 100m radius with a distance between closest survey points of at least 200m. At each point, the number of each species observed (aurally and/or visually) was recorded within a 5min interval, excluding flyovers. The survey methodology follows recommendations in the Canadian Land Bird Monitoring Strategy (Downes et al. 2000) and established protocols for GNP by Sutter (1997). This method permits quantitative sampling of breeding bird densities to be linked with habitat variables using song and visual recognition. Survey data were analyzed to species richness (no. species per hectare). Species diversity was calculated using Simpson's reciprocal index (Equation 1) (Feinsinger 2001).

$$D = \frac{1}{\sum_{i=1}^{S} p_i^{\,2}} \qquad [1]$$

Where S is the total number of species and *P* is the proportion of species *i*.

Satellite image acquisition and pre-processing:

One satellite image acquired on August 10, 2003 was used in this project. The image was pre-processed for atmospheric, geometric, and radiometric corrections. The digital numbers (DN) were converted to 'at surface' reflectance using the method described by Markham and Barker (1986). The pre-processed image was then transformed to selected vegetation indices and all layers stacked together. The vegetation indices (VIs) selected for this study include Adjusted Transformed Soil-adjusted Vegetation Index (ATSAVI), Modified Soil Adjusted Vegetation Index (MSAVI), Perpendicular Vegetation Index (PVI), Triangular Vegetation Index

(TVI), Normalized Difference Vegetation Index (NDVI), and the Brightness (BI), Greenness (GI), and Wetness (WI) indices from the Tassel Cap transformation. NDVI, BI, GI, and WI have been broadly used in vegetation studies, and ATSAVI, MSAVI, PVI, and TVI were selected because they showed promising results for semi-arid environments. Equations for these vegetation indices are listed in Table 1.

Statistical analyses:

The geographic locations of the 50 plots (five plots for each site with 10 sites) were overlain onto the TM image with all vegetation index layers using a GIS overlay procedure. At each location, the mean value of a square of 3 x 3 pixels (90m x 90m area) were extracted for each layer, which approximately matched the area for the birding survey. Both birding survey and spectral plot data were averaged to site level for further statistical analyses. The Pearson's correlation coefficient analysis was performed to test the relationships between bird populations and spectral vegetation indices. Based on the results from the correlation analysis, a linear regression analysis was run with each species population with the spectral variable that showed the highest correlation coefficient for the same species. The regression models were tested using a Jack-Knife cross validation approach. This approach was implemented by withholding the spectral data for one site and building the functions using the data from the remaining sites. The process of removing one site from the dataset was repeated until all sites had been withheld.

Results and Discussion

Birding survey species richness:

Comparing the four principal surveyed species, Sprague's Pipit has the highest number of individuals followed by Baird's Sparrow, and Chestnut-collared Longspur, with the Horned Lark the lowest. While overall diversity was low (4.2) compared to diversity in other habitat types (James and Rathbun 1981). Relative to the average number of individuals recorded at each site (7.1/hectare), this diversity value reflects reasonable spatial overlap among species (Figure 2).

Relationships between species density and vegetation indices:

Pearson's correlation coefficient showed that particular spectral vegetation indices could provide moderately accurate estimation of bird density (Table 2). ATSAVI, TVI, PVI, Brightness, Greenness, and Wetness were well correlated with bird population density. This suggests that

Table 1: *Equations for the vegetation indices used in this study.*

Vegetation Index	Equation	Reference
Adjusted Transformed Soil-adjusted Vegetation Index (ATSAVI)	$\frac{a(TM4 - aTM3 - b)}{aTM4 + aTM3 - ab + X(1 + a^2)}$, X=0.08	Baret *et al*. 1992
Modified Soil Adjusted Vegetation Index (MSAVI)	$\frac{1}{2}\left[2(TM4+1) - \sqrt{(2TM4+1)^2 - 8(TM4 - TM3)}\right]$	Qi *et al*. 1994
Perpendicular vegetation index (PVI)	$\frac{TM4 - TM3 - b}{\sqrt{1 + a^2}}$	Richardson and Wiegand 1977
Triangular vegetation index (TVI)	$60(TM4 - TM2) - 100(TM3 - TM2)$	Broge and Leblanc, 2000
Normalized difference vegetation index (NDVI)	$\frac{TM4 - TM3}{TM4 + TM3}$	Rouse *et al*. 1974
Brightness vegetation index (BI)	.1544*TM1*+.2552*TM2*+.3592*TM3*+.5494*TM4* +.549*TM5*+.4228TM7	Kauth and Thomas 1976
Greenness vegetation index (GI)	-.1009*TM1*-.1255*TM2*-.2866*TM3*+.8226*TM4* -.2458*TM5*-.3936*TM7*	Kauth and Thomas 1976
Wetness vegetation index (WI)	.3191*TM1*+.5061*TM2*+.5534*TM3*+0.0301*TM4* -0.5167*TM5*- 0.2604*TM7*	Kauth and Thomas 1976

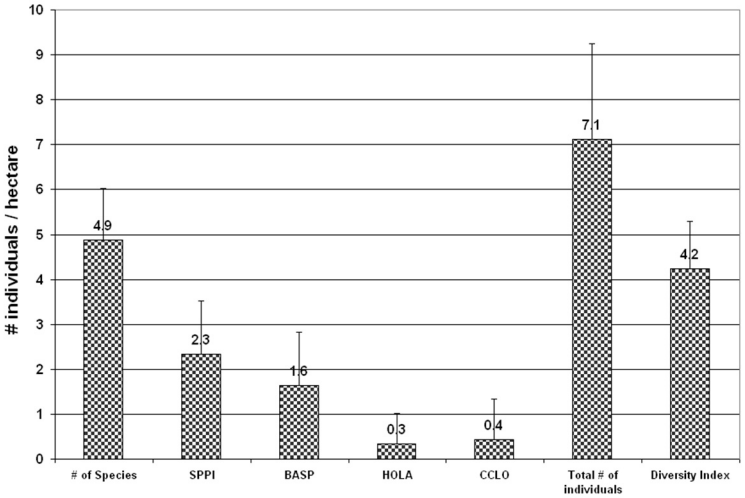


Figure 2: *Species richness of the surveyed birds in the study area with standard errors showing the variation among sites. (SPPI, BASP, HOLA, and CCLO are Sprague's Pipit, Baird's Sparrow, Horned Lark, and Chestnut-collared Longspur respectively)*

different bird species require different vegetation structures that are detected as different vegetation indices. The better results from ATSAVI, TVI and PVI are likely because they are developed for semi-arid regions and are thus more suited to low biomass vegetation land cover. The three indices from the Tasseled Cap transformation performed well because they are based on the principal component analysis, which represents the maximum variation from the canopy. NDVI, popularly used in other studies, did not perform well in the analyses, which is also consistent with another study in the same ecosystem (Guo et al., this issue). NDVI is not suited for detecting the vegetation canopy in the northern mixed grasslands due to influence from senescent materials.

Species density prediction model development:

Bird population density prediction models were developed based on the spectral vegetation indices derived above. Results showed that 43% to 53% variation in species density could be explained by a single vegetation index (Figure 3) when linear relationships were tested. ATSAVI is the best spectral vegetation index to predict densities of Sprague's Pipit and Horned Lark. The TVI and Wetness yielded the best results for Baird's Sparrow and Chestnut-collared Longspur respectively. Theoretically, there is an

Table 2: *Pearson's correlation coefficients between spectral vegetation indices and species population density. Bold numbers indicate significant results at p=0.05.*

VIs	Statistic	SPPI	BASP	HOLA	CCLO
ATSAVI	r	**-.730**	-0.089	0.064	**.662**
	P.	**0.017**	0.808	0.861	**0.037**
MSAVI	r	-0.218	**-.698**	-0.5	0.413
	P.	0.546	**0.025**	0.144	0.235
PVI	r	**.698**	-0.023	-0.15	-0.6
	P.	**0.025**	0.95	0.686	0.066
TVI	r	-0.137	**-.714**	-0.51	0.323
	P.	0.706	**0.02**	0.129	0.363
Brightness	r	-0.606	0.04	0.294	**.641**
	P.	0.063	0.914	0.41	**0.046**
Greenness	r	-0.204	**-.658**	-0.53	0.38
	P.	0.571	**0.039**	0.119	0.279
Wetness	r	-0.184	-0.394	**-.656**	-0.13
	P.	0.611	0.26	**0.039**	0.723
NDVI	r	0.198	-0.595	-0.49	0.002
	P.	0.583	0.069	0.155	0.996

optimal vegetation structure range for each species of breeding birds in the grasslands, and species-specific densities will decrease in vegetation communities where the structure is outside of this optimum range (Sutter et al. 2000). While there is clearly spatial overlap among species, as indicated by our diversity measure, optimal habitat utilization varied among species sufficiently to be detected by remotely sensed vegetation indices. We observed this trend for Sprague's Pipit and Horned Lark (less abundant in high density vegetation regions), and Baird's Sparrow and Chestnut-collared Longspur (more abundant with less vegetation cover). Unfortunately, the number of samples in our current study is not large enough to build a non-linear model.

Conclusion

Our study indicated that remotely sensed data could provide moderate accuracy of bird density prediction for individual species, but that no single vegetation index is suitable for all types of breeding birds in the northern mixed grass prairies. This is because each bird species appears to be selecting slightly different habitats. The variation of bird population can be explained by a single spectral vegetation index with accuracy of 53% for Sprague's Pipit, the highest. The accuracy measurements are 51%, 43%, and 44% for Baird's Sparrow, Horned Lark, and Chestnut-collared

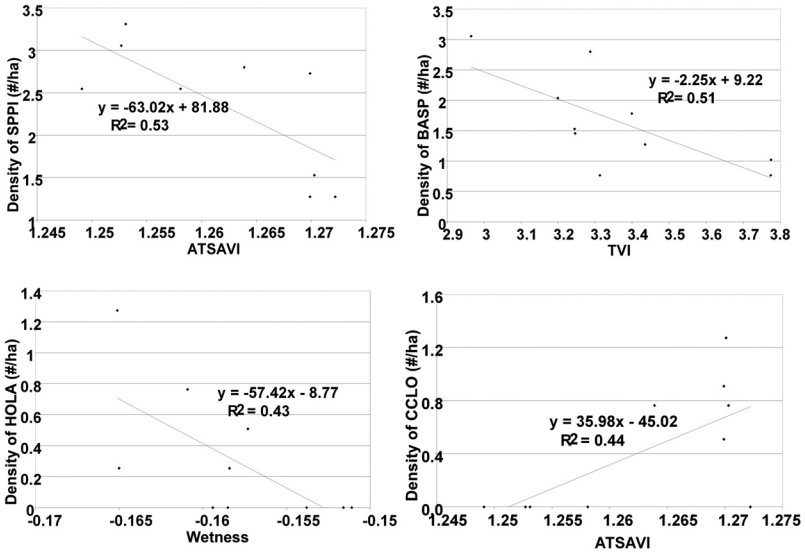


Figure 3: *The bird population prediction models for the four bird species within the study area.*

Longspur, respectively. Among spectral vegetation indices, ATSAVI was the best and followed by TVI and Wetness. This study showed the potential to use remote sensing techniques for species at risk recovery plan development. However, there are several limitations in this study. First, data used for analyses were from one year only. Even though birding data were available for 2004, the satellite imagery was not available and as a result we were unable to test our results. With additional satellite imagery in 2005, further investigation can be conducted in the near future. A second limitation was that the relationships were built on birding population and spectral vegetation indices directly. To understanding how remote sensing data can be used to predict bird populations, it is essential to understand the relationships between birding habitat and birding population, as well as between grassland biophysical and spectral characteristics.

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Impact of climate change with enhanced UV-B radiation on China's agricultural NPP

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Abstract: Global climate change may have adverse effects on the net primary productivity (NPP) of crops. Several studies have investigated the potential influence of future changes in temperature and precipitation on agricultural NPP, but the potential effects of UV-B radiation on agricultural NPP has received little attention. This paper describes an NPP model that can calculate the effects of climate change on agricultural NPP, and couples the impact of UV-B increase into this model. Results indicate that 1) in the case of a reduction in precipitation and ozone concentration, temperature increases will have a negative effect on agricultural NPP, 2) in the case of no changes to precipitation, any temperature increase will partially counteract the negative influence of UV-B increase, and 3) in the case of a precipitation increase, the negative influence of a UV-B increase will completely counteract any temperature increase, which will benefit agriculture NPP in China. In all three cases, the degree of effect that global change will have in each climate condition is in the order of semi-arid, humid, and arid regions from low to high.

Introduction

One component of global climate change is the loss of stratospheric ozone, which recently has received increased attention in assessing the potential damage to vegetation due to enhanced levels of Ultraviolet-B (UV-B, 280-320 nm) radiation (Grant 1990; Bornman 1991; Nunez et al. 1994). Satellite measurements have proven the expansion of stratospheric ozone losses, and ground-level measurements have detected significant UV-B increases (Kerr and McElroy 1993). Increased UV-B radiation caused by reduced stratospheric ozone is expected to continue into the 21st century (Madronich et al. 1998). A substantial number of studies have been conducted that have evaluated the potential consequences of an increase in UV-B radiation on many plants (Krupa and Kickert 1989; Zheng 2003),

and approximately 400 species of plants have been screened for sensitivity to UV-B radiation and of these, about two-thirds were found to be sensitive in some parameter (Sullivan and Rozema 1999).

The concern for producers and agricultural scientists is whether enhanced UV-B radiation reduces economic yields or the quality of field crops (Kakani 2003). Numerous studies evaluating the impact of enhanced UV-B on crop yields have been carried out in both field and greenhouse environments. Nearly half of these studies showed that enhanced UV-B radiation decreases crop yield (Kakani 2003). NPP of agriculture vegetation is important in estimating farmland carrying capacity, and the quantity of energy remaining after crops have satisfied their respiratory needs. Therefore, enhanced UV-B radiation must be accounted for in estimating the potential impacts of global climate changes on agriculture NPP (Caldwell et al. 1998; Madronich et al. 1998). In previous studies, however, the potential impact of enhanced UV-B radiation on NPP of agriculture vegetation has largely been ignored. In this paper, a method of adding the impact of UV-B radiation to a NNP model is developed, and the dependency of China's agricultural NPP on global changes, including the enhanced UV-B radiation, is examined under different scenarios.

Methods

Because this research adopts parameters derived by Zheng's (1997) study, the geographic focus is on the same areas of China; with the exception of Hainan province, Taiwan, and Hong Kong. Based on different humidity conditions, Zheng's study divided China area into three regions: humid region, semi-arid region and arid region (Figure 1).

NPP model:

At present, there are four models which can calculate NPP: the Miami model (Lieth 1975), the Thornthwaite model (Lieth 1972), the Chikugo model (Uchijima and Seino 1985), and the Synthetic model (Zhou 1996). The Miami model empirically derives correlation of net primary productivity with mean annual temperature and precipitation. The Thornthwaite model is similarly an empirical model for estimating potential evapotranspiration (Zhang 1989; Chang 2003). The Chikugo model is a regression model based on correlation between NPP and climate variables. Generally, the potential of application of empirical or regression models for future projection is limited as regressions may not necessarily be appropriate for climatic conditions that are novel to terrestrial ecosystems (Melillo *et al*.

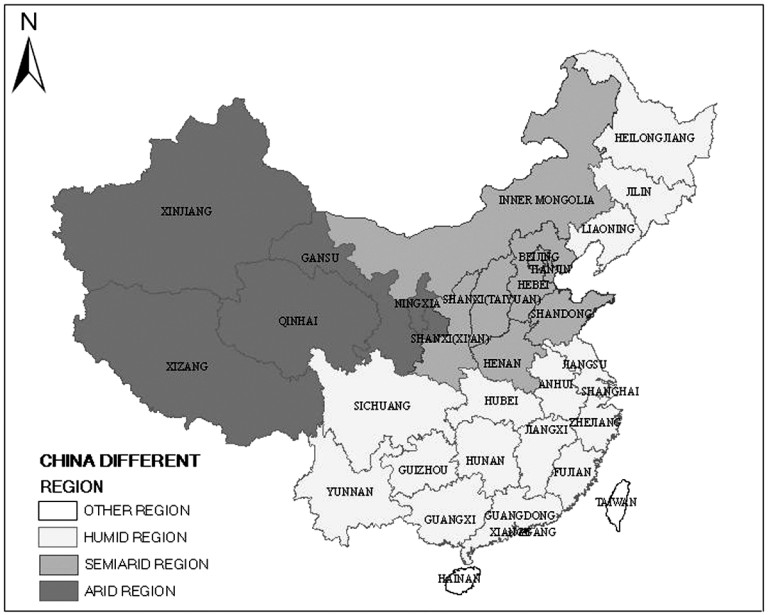

Figure 1: *Study area (humid region, semi-arid region and arid region)*

1993). Although the Synthetic model is based on the eco-physiological features of plants as well as climatic factors, it is known to better simulate NPP of natural vegetation in semi-arid and arid areas in China than other models (Zhou 1996). This paper adopts the Synthetic model to calculate the effect of climate change and UV-B increase on agriculture NPP in China. The calculating formula of the Synthetic model is expressed as follows.

[1]

$$NPP = RDI\frac{rR_n(r^2 + R_n^2 + rR_n)}{(R_n + r)(R_n^2 + r^2)} \cdot \exp(-\sqrt{9.87 + 6.25RDI})$$

Where R_n is net radiation, r is annual precipitation, unit of NPP is t DW·hm^{-2}·a^{-1}, and RDI is aridity.

Based on the result of Zhang (1994), RDI in formula [1] can be expressed as:

[2] $$RDI = (0.629 + 0.237PER - 0.00313PER^2)^2$$

Where PER is potential evapotranspiration rate which can be expressed as:

[3] $$PER = PET / r = BT \cdot 58.93 / r$$

Where PET is annual potential evapotranspiration (mm) and BT is Mean annual biology temperature (ºC). BT can be expressed as:

[4] $$BT = \sum t/365 = \sum T/12$$

Where *t* is daily mean temperature, which ranges from 0°C to 30°C. and T is monthly mean temperature, which also ranges from 0°C to 30°C. Rn in formula [1] can thus be represented as:

[5] $$R_n = RDI \cdot r$$

Based on the above derivation, NPP of agriculture vegetation can be calculated from biology temperature and precipitation.

Modified model:

Equation [1] does not allow for the role of UV-B. In order to add the effect of UV-B to the model, equation [1] was modified by multiplying it by a coefficient 'Cuv.' In this way, the influence of the enhanced UV-B (i.e., the reduced Ozone) on the NNP is estimated in the model. Based on experimental data of Zheng et al. (2000), the coefficient Cuv can be expressed as:

[6] $$Cuv = 1.9716 \times x + 0.9763$$

Where Cuv is the percentage of NPP decreasing, and x is percentage of UV-B increasing.

If the percentage increase in UV-B is available, NPP can be calculated under the enhanced UV-B modified model. Some researchers have predicted ozone depletions of 0 - 4% in the tropics and 4 - 12% at high latitudes by

about 2050 (TOLBA 1992). For consistency, this study adopts the assumption of ozone reducing 5% in China by about 2050 (Xiong 1993). The increment of UV-B radiation can be derived from the ozone reduction by using the technique developed by Xiong (1993). A decreasing percentage of NPP is thus calculated using equation [6]. Table 1 indicates that decreased Ozone produces enhanced UV-B radiation and reduced NPP. The increment of UV-B and the reduction of agricultural NPP in China vary by region. The reduction of NPP ranks first in the humid region, second in the arid region, and last in the semi-arid region.

Table 1: *Increment of UV-B and decrease of NPP when ozone reduces 5% in different area of China.*

Region	Province	summer	winter	average	Decreasing to percent of NPP
Semi-arid Region	Inner Mongolia	3.40%	5.80%	4.60%	88.56%
	Beijing	3.35%	5.25%	4.30%	89.15%
	Tianjing	3.35%	5.25%	4.30%	89.15%
	Hebei	3.35%	5.25%	4.30%	89.15%
	Shanxi(Taiyuan)	3.25%	5.25%	4.25%	89.25%
	Shandong	3.25%	4.90%	4.08%	89.60%
	Henan	3.15%	4.80%	3.98%	89.79%
	Shanxi(Xi'an)	3.15%	4.65%	3.90%	89.94%
Humid Region	Liaoning	3.35%	5.30%	4.33%	89.10%
	Jilin	3.50%	6.00%	4.75%	88.26%
	Heilongjiang	3.35%	6.00%	4.68%	88.41%
	Shanghai	3.05%	4.40%	3.73%	90.29%
	Zhejiang	3.10%	4.10%	3.60%	90.53%
	Anhui	3.15%	4.80%	3.98%	89.79%
	Fujian	3.10%	3.70%	3.40%	90.93%
	Jiangxi	3.10%	4.50%	3.80%	90.14%
	Hubei	3.10%	4.30%	3.70%	90.34%
	Hunan	3.10%	3.90%	3.50%	90.73%
	Guangdong	3.10%	4.10%	3.60%	90.53%
	Guangxi	3.05%	4.10%	3.58%	90.58%
	Sichuan	3.05%	4.05%	3.55%	90.63%
	Guizhou	3.00%	3.90%	3.45%	90.83%
	Yunnan	3.00%	3.75%	3.38%	90.98%
Arid Region	Gansu	3.20%	5.00%	4.10%	89.55%
	Qinhai	3.20%	5.00%	4.10%	89.55%
	Ninxia	3.15%	5.00%	4.08%	89.60%
	Xinjiang	3.50%	5.50%	4.50%	88.76%

Source: Xiong 1993

Results

This study calculates agricultural NPP under different scenarios of global climate change. Three common assumptions are adopted: 1) precipitation increases by 20 percent, temperature increases by two degrees Celsius, ozone reduces by 5%; 2) similar to (1), but precipitation does not change; and 3) similar to (1) but precipitation is reduced by 20 percent (Zheng 1997). Table 2 gives the input parameters of the model. NPP variations for different regions in China under each of the three cases are shown in Figure 2 and Table 3. From Figure 2, it can be seen that different global changes produce different variations and trends of NPP. In the first case NPP decreases sharply, which indicates that when both precipitation and ozone are reduced, temperature increases will have a negative effect on agriculture production. In case 2 the average NPP also decreases but the reduction is obviously smaller compared to case 1, which indicates that when precipitation does not change, a temperature increase will

Table 2: *Input parameters of model.*

Region	Province	Precipitation mm	Biology temperature °C	aridity	NPP of agriculture vegetation t DW·hm^{-2}·a^{-1}
Semi-arid Region	Inner Mongolia	351.6	3.3	1.11	2.4
	Beijing	644.2	11.5	1.22	7.9
	Tianjing	566.9	17.5	1.66	8.7
	Hebei	573.9	10.8	1.5	4.9
	Shanxi(Taiyuan)	497	9	1.73	3.9
	Shandong	769.8	12.7	1.28	12.6
	Henan	763.8	14.3	1.49	6.2
	Shanxi(Xi'an)	630.6	11.6	1.448	7.3
Humid Region	Liaoning	723.9	8.3	1.02	5.5
	Jilin	645.3	4.9	0.88	4.3
	Heilongjiang	485.5	3	0.84	4
	Shanghai	1123.7	15.7	1.05	20.4
	Zhejiang	1441.1	17	0.86	10.6
	Anhui	1056.9	15.3	1.06	19
	Fujian	1490.6	21.6	0.94	7.7
	Jiangxi	1550	17.8	0.79	11.8
	Hubei	1097.8	16.1	1.01	5.8
	Hunan	1395.7	17	0.83	11
	Guangdong	1673.7	22.5	0.9	14.4
	Guangxi	1597.8	21	0.83	13.2
	Sichuan	975.1	13.3	1.11	9.6
	Guizhou	1199	15.5	1	10.1
	Yunnan	1037.7	14.9	1.26	8
Arid Region	Gansu	325.7	8.3	2.47	4.5
	Qinhai	420.2	7.1	2.06	3.4
	Ninxia	287.4	7.7	2.86	4.2
	Xinjiang	106.1	9.4	5.84	3

Source: Zheng 1997

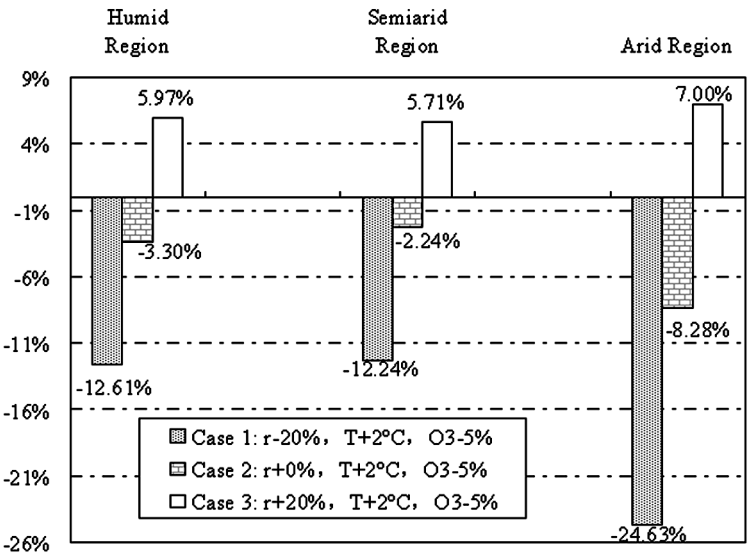

Figure 2: *NPP average variations in different regions under three cases.*

partially counteract the negative influence of UV-B increase. Case 3 benefits agriculture, and NPP increases. This implies when both precipitation and temperature increase, the negative influence of a UV-B increase is completely counteracted. That being said, the degree of influence in each climatic region is different. In case 1 the average NPP in the arid region reduces by about 25 percent. The reduction is almost twice as much as that in other regions. Humid and semi-arid regions have similar results, but the reduction in the humid region is slightly larger than the semi-arid region. In case 2 the dependence of reduction on the humidity conditions is similar to case 1. In case 3 the differences of NPP increments are not significant across different humidity regions, but we still can draw a conclusion that the increment is largest in the arid areas and the least significant in semi-arid areas. Table 3 gives the maximum and minimum NPP variations in China for the different regions and under the three cases. From this table, it can be seen that the magnitude of NPP variation ranks first in the arid area, second in the humid area, and last in the semi-arid area.

Table 3: *The maximum and minimum NPP variations in different regions under three cases.*

Regions	Case 1: r-20%, T+2°C, O3-5%		Case 2: r +0%, T+2°C, O3-5%		Case 3: r+20%, T+2°C, O3-5%	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Humid	-14.19%	-9.91%	-4.89%	0.85%	3.31%	11.62%
Semi-arid	-9.63%	-19.59%	-6.66%	0.37%	2.90%	10.37%
Arid	-57.01%	-12.37%	-24.34%	-2.18%	4.45%	6.51%

Discussion and Conclusion

This paper described an NPP model capable of calculating the effect of climate change on agricultural NPP, and coupled the impact of UV-B increase into the NPP model. The impact of UV-B increase on agricultural NPP is remarkable in different climatic zones in China. The reduction of NPP ranks first in the humid region, second in the arid region, and last in the semi-arid region. The results indicate that it is necessary to include a UV-B parameter in NPP models in order to improve the accuracy of prediction under different scenarios of global change. The results of the modified NPP demonstrate that: 1) in the case of reducing precipitation and ozone, a temperature increase will have a negative effect on agricultural production; 2) in the case of no change in precipitation, a temperature increase will partially counteract the negative influence of a UV-B increase; 3) in the case of precipitation increase, the negative influence of a UV-B increase will be completely counteracted with a temperature increase, which will benefit agriculture in China; 4) in all three cases, the nature and magnitude of the effect that global change will have in each climatic region is different: with only minor effects in semi-arid regions, but large effects in arid regions.

These results demonstrate that the effects on plants will be different for each region depending on the pre-existing climatic conditions and the adaptation potential of local cultivated species (Chartzoulakis 2004); and that arid regions are the most sensitive to global change. Previous research has reported that plants can change form under increased UV-B radiation and thus capture more sunlight for photosynthesis (Barnes 1988; Barnes 1995). Therefore, plants are presumably adapted to more UV-B radiation and better buffered against increasing UV-B. Because there is less cloud cover in the arid regions of China, crops in this region might adapt to increased UV-B and the decrement of agricultural NPP in this region might be less than in other climatic regions. The NPP model results, however, are not in agreement with this notion; agricultural NPP in humid and semi-arid

areas are potentially less affected by increased UV-B, possibly due to greater cloud cover.

In conclusion, there are a number of limitations to this research that need to be noted in future studies. First, global change will most likely result in different behaviors across different areas; but the model assumes a rather homogeneous pattern within each climatic region. Second, changes in temperature, precipitation, and UV-B were included in evaluating the effect of global change on the agricultural NPP, but the responses of these changes to ecology and environment were ignored and the interaction between temperature, precipitation, UVB, and agriculture in climatic zones not considered. Third, this paper only identified UV-B input at a fixed value, and it would be very instructive to vary the UV-B model input to measure sensitivity to this parameter. Finally, the expression used to calculate NPP decrement with increasing UV-B was derived based on the experimental data of previous research in this region, but the data only spanned three years and results thus need to be tested by future experimental research.

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Circuit-riding students and professors: higher education in the United States military

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Abstract: The virtual university (i.e., a university with no fixed geographical location) preceded the internet age. For almost sixty years the United States military has provided undergraduate and graduate courses on overseas bases. A free education is indeed a major selling point for the military; however, little has been published concerning the quality and structure of this higher education system. Faculty on overseas bases typically have less status and influence than at stateside universities, are socially and intellectually isolated, and have few traditional academic resources. Course textbooks and syllabi are generally decided on by remote committees. Students are highly mobile, overworked, and often not prepared for higher education. The role of student is subordinate organizationally and psychologically to that of soldier, sailor, or airman. These factors often adversely affect the quality of education in the military, blur the distinction between "education" and "training," and influence what can and cannot be taught.

Introduction

The US military has a long working relationship with universities (Abrams 1989). One unique association is with contracted educational institutions that provide tuition free classes to overseas service members and dependents. Reasons for taking classes include earning degrees, gaining promotions, improving morale, bolstering self-esteem, pursuing intellectual interests, and relieving boredom. This focus on a free education is an important recruiting strategy and helps to prepare service members for the civilian economy. Since the 1950s the US military has contracted with various educational institutions to provide courses and to grant associates, bachelors, and graduate degrees. Because of the military's geographically scattered operations, military education providers employ

a faculty with diverse backgrounds, including full-time and adjunct faculty who live in countries hosting bases, traveling faculty, and distance education faculty.

Operating an accredited, worldwide university that provides a quality education meeting both the needs of students and the military is a daunting endeavor. With no permanent campus and few local staff the issues faculty face are not usually encountered in standard educational institutions: students deployed or reassigned, canceled or relocated classes, and poor maintenance of AV and other essential equipment. Near active deployment zones, classes usually are also conducted under tight security, with no or limited access to off-base services. One of the most challenging issues facing faculty who teach courses for military personnel is the wide array of educational backgrounds and interests that students bring to the classroom. Although a high school diploma is the minimum standard for acceptance, many students have rudimentary writing, math, and study skills. Further, as most are full time service members, their main focus is not on coursework or student activities.

Curiously, there are few recent descriptions of how higher education on overseas US bases operates. Hays (2003) discusses teaching psychology and English courses on a ship in the Persian Gulf. This is in sharp contrast to numerous examinations of higher education for officers (e.g., Kennedy and Neilson 2002; Stiehm 2002) and of specific officer training programs (e.g.: Garraway 2002; Schumm et al. 2003) and pleas from within the military for increased educational opportunities for enlisted personnel (Kime 2004; Murphy 2003).

Most face-to-face and distance education courses are currently provided by University of Maryland University College (UMUC), an adult education component of the University System of Maryland. In 2004, UMUC had 50,234 students in face-to-face classes on bases in 23 countries outside the U.S. and 126,341 enrolments for online courses (see http://www.umuc.edu/ip/umucfacts_02.html). While UMUC's headquarters are in Adelphi, Maryland, overseas programs are largely administered from Heidelberg, Germany (Europe and the Middle East) and Tokyo, Japan (Asia). Other contracted education providers include Embry Riddle Aeronautical University, Central Texas College, University of Oklahoma, University of Phoenix, and Troy State University.

To investigate UMUC's current efforts to provide quality university education, Radenbaugh (an earth and environmental scientist) and Morse (a psychologist) draw upon their experiences working for UMUC on military bases in Belgium, Germany, Italy, Kosovo, Kuwait, and Turkey and upon the experiences of fellow faculty members. This paper discusses how this

educational system works and compares the military's notion of education with that of a typical U.S.-based undergraduate institution.

Case Study — University of Maryland University College

The UMUC started in 1920 as the College of Special and Continuation Studies in Adult Education, offering evening courses in Maryland. In 1947 the college became part of the University of Maryland system and, under a U.S. Department of Defense contract, expanded into six European locations. In 1956 it began programs in Asia and was renamed "University of Maryland University College."

Despite its large enrollment, UMUC has no "campus," except for a combination office building, hotel, and conference center in Adelphi, Maryland. Classes are usually offered in other institutions' classrooms (overseas, mostly in the classrooms of the base Education Center). This lack of campus provides only limited opportunity for students to experience a typical academic environment, to participate in extracurricular activities, or to have ready access to such facilities as a research library. It also does not allow participants to feel part of an academic, let alone scholarly, community. To promote an academic atmosphere faculty must thus make extra efforts to hold discussions, study sessions and workshops for students.

Given its focus on non-traditional students, UMUC emphasizes practical and career-related skills. The most popular degrees awarded are in communications, computer science, history, legal studies, and the social science, but UMUC offers Bachelors degrees in five arts and nineteen science fields (UMUC 2004). At the Masters level, UMUC offers a number of "executive programs," including an MBA and certificates in counseling, technology management, information technology, and public administration. The school also provides many short courses such as three to five-day business and leadership seminars.

The learning environment:

In 2004, about 70% of the courses offered at UMUC took place in traditional classroom settings. However, distance or online education is booming (Noble 2001), and military providers are part of this trend (Heeger 2000; Patterson Lorenzetti 2004). The likely result is a decrease in face-to-face courses (particularly at small, geographically isolated, potentially dangerous, locations) and in the number of overseas faculty.

The military generally has the responsibility of providing and maintaining classroom space, which is a significant cost saving for education providers. The quality of classrooms thus varies widely, as does the availability of audio-visual and other educational aids. Further, courses that require a lab, such as geography, biology, chemistry, and geology, become problematic because there are rarely adequate facilities or necessary equipment. Library services at most military instillations are restricted to small base libraries with few academic resources. To supplement this, UMUC offers a standard set of online research databases. However, effective use of these databases is challenging. Since classes are usually only eight weeks long and enrollment is a complex, lengthy activity, students may not have access to the databases until well into the semester. While a student can request the mailing of books and articles from the University System of Maryland library system, this will normally take longer than six weeks. Material is unlikely to arrive before the end of the semester.

The shortage of labs and libraries makes access to the internet vital. Although UMUC has computer labs at most military instillations where it holds classes, the times they are open and the quality of equipment vary greatly. For example, in Brussels (NATO) and Kosovo (Camp Bondsteel) the UMUC computer lab was well maintained and well run while in Kuwait, one base had a small computer lab that was only open on weekdays between 5 pm and 8 pm, if a lab supervisor was available and no classes were scheduled. On another, newer and larger base in Kuwait, the computer lab had not yet opened even though courses were being offered. At the Incirlik Education Center in Turkey, students could not use the UMUC computer lab outside of class because of unspecified security concerns.

To develop library skills, students take a special course. This course is supposed to be taken early in a student's program, but is often not available when it should be taken. When available, it requires considerable work for only one academic credit. Many students therefore avoid taking this course until they are almost finished with their degrees. Although this course often provides valuable information, it is usually taught entirely in the computer lab (with no visit to the library) by an English teacher who often is unfamiliar with databases in other fields. It is therefore not surprising that most students lack minimal skills in using libraries and online databases.

Educational quality:

In traditional universities, faculty and administers have at least the potential of working together to assure a quality education (hopefully in a cooperative endeavor). Administrators are responsible for ensuring that

the institution runs efficiently and effectively in terms of enrollment and finances. Faculty members are accountable for the curriculum and the quality of the program and courses within their disciplines. Forces outside these two constituencies usually do not play any formal role in the process.

A core faculty is usually non-existent in overseas military education because of geographical dispersion, high turnover, and very limited communication among persons within the same academic discipline. To compensate for this, military education providers allow (and may require) the administration (with perhaps some perfunctory faculty consultation) the final say in the curriculum and the choice of textbooks. At present, faculty members are given standard syllabi. Changes must be approved by the academic director of the discipline in question. This supposedly guarantees standardization of course content and ensures that syllabi will be available (on the web) before registration. Faculty then must often endorse or stand behind impenetrable, jargon-filled syllabi at times replete with spelling and grammatical errors or tell students to ignore the online syllabi.

As a whole, UMUC faculty members in Europe and Asia have less formal education than faculty at other Maryland universities. Comparison with the University of Maryland in College Park is salient because many students believe that they will receive degrees from this institution since they do not distinguish between UMUC and College Park. This is a distinction that UMUC personnel have a clear incentive to blur, as in advertisements and literature that depict UMUC as "Maryland in Europe."

Table 1: *Highest degree earned by instructional staff at UMUC by region.*

	Stateside		Asia		Europe		Total	
2003								
Highest Degree	#	%	#	%	#	%	#	%
BA/BS	2	0.2	16	5.4	29	6.6	47	2.5
Master's	349	31.4	163	55.1	255	57.8	767	41.5
1st Professional	52	4.7	2	0.7	0	0.0	54	2.9
Doctoral	648	58.2	115	38.9	157	35.6	920	49.7
Oth/Unk	62	5.6	0	0	0	0	62	3.4
Total	1,113	100	296	100	441	100	1,850	100
2002								
BA/BS	1	0.1	11	4.0	26	5.4	38	2.1
Master's	363	35.5	151	54.9	309	64.1	823	46.2
1st Professional	46	4.5	1	0.4	0	0.0	0.0	
Doctoral	595	58.2	112	40.7	147	30.5	854	48.0
Oth/Unk	18	1.8	0	0.0	0	0.0	18	1.0
Total	1023	100	275	100	482	100	1780	100

Source: UMUC Factbook, 2003

Even comparing UMUC overseas and stateside faculty is instructive. As Table 1 shows, there were about 18% more faculty with Ph.D.s stateside than overseas in 2002-2003. Over 50% of overseas classes were taught by faculty with a Masters degree or less. Scholarly productivity is also lower among UMUC overseas faculty, as UMUC does not provide funding or opportunities for research and indeed often discourages research on military bases.

One possible indicator of educational quality, or at least of the effective use of educational resources, is graduation rates. Not surprisingly, overseas graduation rates are low: 13% for UMUC and 7% for the University of Phoenix, which offers only online courses (US News and World Report 2004). These figures are well below other US educational institutions (Table 2). Table 3 compares the ratio of students enrolled at UMUC in a given year with the total number receiving degrees in that year. Assuming that an average student takes four to five years to receive a Bachelors degree and two to three years to receive a Masters degree, the expected ratio should be below five for a Bachelors degree and three for a graduate degree. However, while the UMUC stateside program comes close to this ratio, the average for both UMUC's European and Asian programs is over thirteen. There are good reasons for this. Changing priorities, duty stations, and needs of their service interrupt courses. Most service members in a one-year overseas tour take one or two classes per term and earn less than one year of college credit (Rubin 1997; Chernitzer 2003).

A low graduation rate may trivialize education and undermine academic quality. Complaints by faculty concerning the quality of some courses and concerning student performance and expectations are, for example,

Table 2: *Comparisons of universities using US News and World Report indicators.*

Indicator	**Maryland**			**Other**		
	UMUC	**College Park**	**Eastern Shore**	**Univ. of Phoenix**	**U North Dakota**	**Harvard**
Acceptance Rate	100.0%	43.0%	58.0%	100.0%	74.0%	10.0%
Graduation Full Rate	13.0%	70.0%	42.0%	7.0%	50.0%	98.0%
Ratio Student:Faculty	24:1	18:1	17:1	10:1	18:1	8:1
Full-Time Faculty	10.7%	75.1%	94.5%	0.0%	63.8%	79.7%
% with Doctorates	38.6%	94.0%	95.0%	NA	NA	99.0%
Classes <20 Students	40.0%	35.0%	94.0%	NA	35.0%	73.0%

Table 3: *UMUC graduates degree level and division - ratio of enrolled students (headcount) to graduates in given year.*

FY	Stateside		Asia		Europe	
	Bachelor	Graduate	Bachelor	Graduate	Bachelor	Graduate
1998	4.9	5.0	15.5	2.4	14.1	4.1
1999	5.8	5.1	13.2	2.7	12.6	2.5
2000	6.4	6.8	12.3	6.3	12.2	2.4
2001	7.5	8.1	13.0	8.7	14.4	9.2
2002	7.6	6.8	11.3	10.5	14.5	7.8
2003	8.5	6.4	15.5	2.5	15.1	--
Ave.	6.8	6.3	13.5	5.5	13.8	3.3

often dismissed by administrators with the comment that this issue is not of major importance because most students will take only one or two courses and are not expected to graduate.

Idiosyncrasies:

A major influence on the local quality of military higher education is the staff of the base education center, who often interprets the purpose and nature of higher education differently than do academic faculty. This staff includes administrators, trainers, counselors, and testers as well as one or more "field representatives" from the education providers. Staff often chose to have limited contact with teaching faculty. The number of center personnel can range from one part-time person at small bases to over 20 at the largest. All of these people are under the supervision of the Educational Services Officer (ESO), a civilian employee of the Department of Defense. The ESO's relationship with university staff, including instructors, is important. Each ESO has different rules. An effort to inform faculty of these rules is necessary for a successful learning atmosphere.

The success in teaching and learning on military bases (and on self-esteem and feeling of psychological comfort and utility) largely depends on the local staff's understanding of, and commitment to, education. This is not the same as commitment to maintaining satisfactory statistics on course and enrollments courses offered, although seemingly mistaken for such by many administrators. Field representatives and other base personnel in effect serve as local deans, department chairs, bursar, and academic advisors. Personal agendas and relationships (about which distant administrators and traveling instructors normally know little and care even less) may thus largely determine what faculty can and can't do and what students are likely to expect and actually encounter.

Good relationships are not always maintained between ESOs and education providers. For example, we found that the Spangdalham Education Center (in Germany) ran efficiently with education in mind. However the Incirlik Education Center (in Turkey) did not foster a good learning environment. The quality of classes at each location was therefore not the same, even though the instructors were. Another issue concerns staff members that are actively pursuing their own degrees through UMUC. This creates inherent conflicts of interest and boundary problems between instructors and field representatives. In a particular class, for example, the field representative may see his or her role as a representative of the students, as an agent of the instructor, or as in some ways the instructor's boss. We have seen field representatives deciding what classes will be offered based upon their own degree needs rather than upon student needs, faculty availability, and overall curriculum considerations.

Course modularization:

Standardization of curricula and courses raises the risk of courses becoming too modularized. Such a path limits the faculty's ability to respond to varying educational backgrounds. Perley and Tanguay (1999) argue that modularization threatens three defining features of universities: academic freedom; collegial governance; and the presence of scholars and students engaged not only in teaching and learning, but in advancing knowledge. Risk of modularization is a major concern for distance education programs.

Controversial topics:

Many students come from small towns in the South and Great Plains states, where religious and political views tend to be more conservative than elsewhere in the country. This creates a situation where they may feel threatened by the views of fellow students from more cosmopolitan backgrounds. It also may reinforce the psychological and intellectual distance between students and professors, assuming that most faculty are more critical and less tied to prevailing religious and political viewpoints than are these particular students (which is, of course, not always the case).

Education providers want to appeal to as many students as possible as tuition is reportedly their only source of income. Complimenting this, the military wants statistics showing that many service members are actively and successfully pursuing higher education. While the military may want to foster learning, self-development, and critical thinking, these outcomes may conflict with the need to retain enlisted personnel and to

guarantee discipline and order in the ranks. This creates an inherent difficulty for faculty who encourage thinking about viewpoints some students may find novel, alien, or even distasteful (Mednicoff 2003). In a multifaceted but generally conservative and authoritarian setting such as the military, it can be difficult to encourage and reward critical thinking and tolerate unconventional or unpopular ideas. Three persistent ideas present inherent difficulties: (a) the Theory of Evolution, (b) the notion that homosexuality is not a matter of free choice, and (c) the idea that different people can legitimately behave and think differently; one culture is inherently no better than another (i.e., cultural relativity).

Cultural relativity may easily jar one's self-assurance and commitment to policies believed to be morally 'right' simply because they are endorsed by political or military authorities and because most of one's peers may have similar views. It is, of course, possible to steer clear of discussions touching on cultural relativism unless one teaches anthropology or sociology. With more difficulty sexual orientation may be avoided, even in a course on interpersonal relationships (where it should be discussed). The teaching of evolutionary theory poses perhaps greater difficulties because it is essential to understanding biology and geology. Although there is no explicit military policy against teaching evolution (and thereby not endorsing Creationism), the military actively encourages the teaching of many sacred scriptures and promotes a religious worldview. We need look no further than the conspicuous role of base chaplains as religious advisors as well as counselors, therapists, and mentors to understand the influence exerted by traditional religious belief systems. While systems of traditional (usually Christian) religious beliefs and practices may provide comfort to soldiers in hostile locations, the suppression of contrary ideas would not be tolerated at secular universities.

Conclusions

University courses on military bases overseas offer many positive benefits to service members and dependents. Education providers supply needed courses at overseas bases, including isolated locations like the Balkans and the Middle East, an accomplishment that is appreciated by service members. There are however always ways to improve the student experience. It is difficult to maximize student learning on U.S. military bases because of structural constraints that include poor libraries, syllabi prepared by faceless committees, time constraints, generally poor academic skills, lack of continuity in instructors and offerings, and vague and

incompatible goals on the parts of all participants. While many faculty members try to promote critical thinking, facilitate inter-cultural understanding, and teach the latest developments in their fields, education administrators often want the educational enterprise to maintain a low profile in order to reduce conflict and guarantee renewal of the university's contract with the military. As in other educational institutions faculty and educational administrators are often at odds about how to educate. But the military education system gives most decision-making power to administrators. This power stems from contracts which equate quality with statistics on the number of students enrolled, with the date by which a syllabus should be posted on a web site, by the number of courses to be offered per term, and so on. This leads to a 'by any means necessary' mentality. Faculty who equate quality with student learning rather than with bureaucratic outcomes, who ask for more faculty involvement in decision-making, or who criticize current textbooks and other curricular materials are often encouraged to quit or their contracts are not renewed. The result seems to be an increasingly passive, disinterested, out-of-date teaching faculty with ever lower credentials.

Although the military is concerned about the quality of education and is watchful of enrollment in courses from unaccredited "diploma mills" (Robson 2004), it needs to also remain vigilant of its contract institutions. Many of these issues are summed up by an anonymous student/airman:

> "...While they may not be diploma mills as some schools are, I do feel they push too many students through who do not meet current standards." Incirlik Turkey 9/2004.

"They" refers to UMUC and other contract providers of higher education to the military.

So how can the military improve its higher education system? First education providers need to hire and retain (for more than one year) qualified faculty with Ph.D.s and interests in both scholarship and student learning. A reduction in the number of transient faculty will strengthen academic standards. Faculty members with extended experience interacting with enlisted personnel will have better appreciation of how they live and the problems they face, leading to a better educational experience. This will also reduce conflicts between faculty and education center staff as a closer working relationship can be maintained. The education providers also need to allow a core faculty to establish curricula, develop courses, and select reading materials. Prepackaged curricula created by committee often have little to do with military life and with the concerns of students.

This is especially true and problematic in such fields as psychology. For example, standard textbooks in social or clinical psychology used in UMUC courses are appropriate for full time traditional undergraduates living at home in a predictable and familiar environment. However, relating to such textbooks is difficult when situations are starkly different psychologically, socially, vocationally, and politically. These textbooks don't cover issues of immediate day-to-day concern such as group living in an overseas environment often perceived as alien and hostile. Relating more to military concerns and experiences will help to promote self-development and critical thinking in the classroom. This in turn will lead to better appreciation and understanding of basic psychological processes, research, and theory. Students will then be able (and should be encouraged) to apply such learning to the reality in which they find themselves. In the long run this should benefit everyone: students, teachers, and the military.

To maximize learning, institutions must make better use of valid and reliable placement tests in English and math to counsel students and, if necessary, steer them toward remedial courses. More comprehensive exposure to research methods and the use of libraries and database is needed, perhaps within each specific discipline. This will make it possible to increase rather than constantly decrease the amount of information covered in courses and to raise expectations for student performance. A way must also be found to systematically evaluate short-term and long-term educational outcomes, both in courses and beyond. Public statistics on issues such as how many students take courses at and eventually graduate from other universities is, for example, is lacking.

There is also a need to improve the educational infrastructure. Each education provider needs its own audiovisual equipment and other instructional supplies so that instructors needn't rely upon (and be supplicants to) Education Center personnel, the military high school, or other individuals. For courses that require labs (geography and geology for example), exercises and materials should be developed that can travel to remote locations, while being flexible enough to be used in the context of the geographical region in which the course is being taught.

In conclusion, the teaching of unscientific creeds and the setting of curricula by those who are not educators may make good soldiers, but is this really how we should be teaching the military students, who generally spend fewer than four years in the service and want a standard university education. As U.S. military personnel expand into new geo-political areas, we must ask what sort of education we are currently providing. Is this the type of education we want to support and in which we want to participate?

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An exploration of recreation and tourism in Brandon, Manitoba

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Introduction

Over the past few decades industrial societies have seen a dramatic increase in leisure time and disposable income resulting in an increased demand for recreation and tourism facilities. According to Krotz (1996), tourism is widely recognized as the world's largest industry. Due to the current popularity of tourism, understanding why humans engage in recreational and tourism activities is an increasingly important and complex area of research for social scientists. Historically, geographers have played a limited role in the development of literature concerning various aspects of tourism and peoples' use of leisure time, which means that recreation and tourism has only recently made an impact on the wider geographical community.

Although disposable income and leisure time have increased over the past forty years, individual social aspects such as occupation, income, material wealth, car ownership and mobility, time available, duties and obligations, social roles, and education, all have a significant impact on participation in recreational activities (Rural Development Institute 2003). More specifically, those with skilled occupations, high incomes, ready access to private transport and higher education tend to lead more active lives involving more leisure activities. Hall and Page (1999) indicate that 53% of those surveyed in their study stated money to be the number one constraint on recreation. Clearly socio-economic status is a powerful determinant in the volume and pattern of current recreation and tourism activity. An indicator of increased travel in Canada is the growth of average disposable income by 4.7% in the year 2000 and 3.2% in 2001 (The

Conference Board of Canada n.d.). As incomes continue to grow travel should increase as well.

The World Tourism Organization provides the main source of data for international tourism and their statistics show that travel rates have consistently increased over the past forty years. The recreation and tourism industry's "age of discovery" took place during the 1960s as travel steadily grew for many developed nations. As new technology in air travel developed in the late 1960s, international travel expanded tremendously. "International travel has maintained strong growth rates, often in excess of 5% per annum" (Hall and Page 1999). Aside from improvements in transportation technology, global media and communication development have also led to an increase in travelers. Growing use of the Internet has remarkably affected the amount of information available to tourists regarding travel destinations, accommodations, and the availability of entertainment (The Conference Board of Canada n.d.). According to the Canadian Tourism Commission (2002a) 25% of Canadians use the Internet to research and/or book travel and these people have been appropriately classified as "iTravellers". Although Canadian iTravellers use the Internet predominantly for research and planning purposes at present, it is suggested that its role within the tourism industry will become increasingly important. As the total amount of time spent on the Internet each week increases and as the Internet comes to be understood as a reliable source, it is clear that its importance within the tourism industry will be noticed (Canadian Tourism Commission 2002a).

This research project has four main objectives. The primary focus of this study is to understand the leisure behaviour of Brandon, Manitoba residents: the destinations and activities they are selecting to meet their recreational needs on local, regional, national, and international scales. The second objective is to measure the supply and demand for recreational facilities and tourism events in Brandon and the surrounding area. By understanding the relationship between supply and demand, predictions can be made about Brandon's recreational future. Thirdly, this project compares results of "Outdoor Recreational Participation Rates and Destinations of the Population of Brandon, Manitoba" (Costanza 1981) to explore the similarities and differences in Brandon residents' recreation and tourism habits today from twenty years ago. The fourth focus of this study is to investigate whether the Internet plays a role in the planning and booking of recreational experiences by Brandon residents.

Recreation and Tourism in Manitoba and the City of Brandon

Tourism is an important industry to Manitoba and a potential future growth generator. The industry is composed of thousands of small and large enterprises spread widely across the province. Manitoba residents make up the largest percentage of travelers and are the source of the majority of tourist expenditures. Tourists from other parts of Canada, primarily from Ontario and Saskatchewan make up the next largest share of travelers followed by Americans and foreign visitors. "Manitoba's tourism industry is a major contributor to the provincial economy, generating approximately $1.13 billion in annual tourism expenditures, or approximately 3% of Manitoba's Gross Domestic Product. The industry creates some 60 000 jobs with employment primarily within the sectors of accommodation, transportation, food and beverage. Thus, about one in ten people employed in Manitoba work in a tourism-related job" (2001/02 Marketing and Opportunities Guide n.d.).

The city of Brandon, nestled in the Assiniboine River Valley in southwestern Manitoba, is surrounded by flat landscapes, rolling hills and enormous skies. Brandon is Manitoba's second largest city with nearly 40,000 inhabitants (Statistics Canada 2001) and is central to the surrounding towns with ample parks, festivals, sporting events, historic sites, and shopping. It has also been named one of the top 10 cities in Canada in which to live (Manitoba Tour Manual: An Adventure in Nature n.d.). There are many activities in Brandon, ranging from botanical garden tours to spending a night out on the town at one of the city's bars. Brandon has earned an outstanding reputation for organizing and hosting world-class events such as the World Curling Championships, Canada's 1998 Olympic Curling Trials, and Canada's 1997 Summer Games.

The city has many appealing services for the outdoor recreation enthusiast with the Assiniboine Riverbank walking trails, golf courses, tennis courts, recreation parks and the newly developed beach volleyball courts. One of the most prominent attractions in Brandon is the 17 kilometres of paved walking and cycling paths (Brandon Riverbank Discovery Centre). The city of Brandon offers a wide variety of special events that are aimed towards entertaining the general public. Some of the city's arts and entertainment events include: Brandon's Folk Music and Art Festival, Brandon Wheat Kings hockey, Manitoba Fall Fair, Manitoba Summer Fair, Royal Manitoba Winter Fair, Canada Day Celebrations, the Art Gallery of Southwestern Manitoba and Prairie Showcase.

Brandon's streets and avenues are laid out in a grid like pattern making it relatively easy for people to navigate the city. The city-operated transit bus service provides service to most points in the city within forty minutes

driving time. There is also transportation service for those with special needs. Greyhound and Grey Goose bus lines serve Brandon along with Via Rail train passenger service. There are 19 hotels and motels in Brandon ranging from economy to family to luxury. Bed and breakfast homes are also available. There are more than 100 restaurants to choose from, with a range of ethnic specialty, family fare, fast food and fine dining. Recreation and convention facilities also exist: Brandon University, Keystone Centre, Riverbank Discovery Centre, Western Manitoba Centennial Auditorium, Brandon Sportsplex, The Victoria Inn and The Royal Oak Inn are Brandon's leading centres for hosting large events (Manitoba Tour Manual: An Adventure in Nature n.d.). Brandon is located within an hour's drive of some of Manitoba's most scenic areas including Riding Mountain National Park, the International Peace Gardens, Spruce Woods Provincial Park and the Souris Swinging Bridge.

In terms of regional tourist attractions, Brandon is central to a wide variety of travel destinations within the province of Manitoba. The Brandon Hills Wildlife Management Area is one of the most popular destinations for Brandon residents to visit for recreational purposes. In general, southwestern Manitoba is a region that has an interesting mix of relief, topographic features and vegetation cover. These physical aspects combined create focal points for tourism and outdoor recreation in the province (Wardrop et al 1980). The area surrounding Brandon offers excellent opportunities for camping, cross-country skiing, fishing, and hunting. The region has an abundance of facilities providing tourist services. Southwestern Manitoba is home to numerous provincial parks, such as Clearwater, Duck Mountain, Spruce Woods, Turtle Mountain, and Riding Mountain National Park.

Methodology

Very little information pertaining to Brandon's recreational facilities and tourist events exists. More specifically, literature concerning how Brandon residents are spending their leisure time and where they are going to meet their recreational needs on a local, regional, national, and international level is not readily available. As a result, a questionnaire was designed to elicit the required information. Using Costanza's (1981) and the City of Brandon (2003) studies as guidelines, "Brandon's Recreation and Tourism Assessment Survey" was developed (herein referred to as 'the survey'). The questionnaire consisted of six major areas of concern: 1) local, 2) regional, 3) provincial, and 4) international recreational interests,

5) socio-economic make-up of the household, and 6) the relationship between the Internet and travel.

The section of the survey that dealt with Brandon's local recreational activities consisted of questions regarding: frequency of dining out, types of dining establishments visited, the usage of the city's various modes of transportation, familiarity, participation and satisfaction rates for Brandon's arts and entertainment events, museums, recreation/convention facilities, and sporting facilities. An open-ended question was designed to discover if there were any specific types of attractions or events that the participant thought were needed in the city of Brandon. Questions pertaining to the participant's local tourism interests were created so it would be possible to analyze the supply and demand of Brandon's recreational facilities.

The second section of the survey focused on the participant's regional recreational interests. The idea behind this section was to discover what people were doing for pleasure outside of Brandon yet within Manitoba's limits. Questions dealing with the availability of vacation residences (i.e., cabins or trailers), winter and summer single day, over-night, or multi-day trips to outdoor recreation sites (e.g., Brandon Hills, Riding Mountain National Park) were also asked. For the latter of these questions, the respondents were provided with a list of 14 commonly used outdoor recreation sites as well as three time periods with varying lengths of day, over-night, or vacation of a week or longer. Another sub-component of this section was concerned with the frequency of participation in selected summer and winter outdoor recreational activities (e.g., berry picking, snowmobiling, swimming). Respondents were given six frequencies of participation and asked to indicate which category most suited their participation in each of the 23 activities listed. In order to allow a respondent the freedom to select any activity or area, a section entitled "other" was added at the end of each list of questions. The types of outdoor recreational activities used in this study as well as the outdoor recreation areas were based on Costanza's (1981) study to allow for comparison tests to be made.

Another section of the questionnaire dealt with recreation and tourism on a provincial level. Respondents were asked whether or not any of their household members had traveled outside of Manitoba yet within Canada throughout the past three years. The resident that went, the purpose of the trip (i.e., pleasure, work, or visiting family and friends), length of holiday, and the provinces that were visited were the points of interest. The fourth section was concerned with obtaining information on who, where, why, and how long the members of a household had traveled to foreign countries within the past three years. Discovering tourism interests on an

international scale was especially important, as statistics have proven that more younger people are traveling on a global scale than ever before.

To obtain background information on the socio-economic parameters of the household questions pertaining to: the length of stay in Brandon, age, gender, marital status, number of people in household unit, ownership of residence, and levels of education were asked. These personal questions were primarily situated at the end of the survey so as not to discourage respondents from answering the questionnaire (Kitchin and Tate 2000). Lastly, two questions dealing with the role of the Internet in researching potential travel destinations and booking plane flights, accommodations, or tickets to a particular event or show were asked. The idea behind this section was to observe whether or not the Internet had any influence in peoples' recreational and travel habits. In order to obtain a representative picture of the recreational behavior of Brandon's 40,000 residents, five different groups of people were investigated. Brandon's north and west regions represent residents' with higher socio-economic status as compared to the average standing of Brandon. The "average value of dwelling" in Brandon's north and west dissemination areas are $153,222 and $184,406 respectively. These values are considerably higher than the "average value of dwelling" in Brandon, which is $100,892. The "percentage of the population 20 years and over holding university graduate certificates" is also much higher in the city's north and west ends as compared to Brandon's overall average. The south represents the general population of Brandon reasonably well. Its "average value of dwelling" and "percentage of the population 20 years and over holding university graduate certificates" are comparable to those of Brandon. The city's downtown and east dissemination areas are regions of Brandon with slightly lower socio-economic status. The "average value of dwelling" in the east end and downtown are $73,219 and $84,129 respectively. These values are considerably lower as compared to the "average value of dwelling" for Brandon. The "percentage of the population 20 years and over holding university graduate certificates" in these two dissemination areas is also lower than the percentage for Brandon (Census Data 2001). Surveying two enumeration areas with higher, two of lower, and one similar to the socio-economic standing of Brandon, Manitoba, suggests that overall, a representative sample of Brandon's population was achieved. One hundred fifty households in each of Brandon's north, south, east, west, and downtown regions were surveyed throughout June and July 2004 (Figure 1).

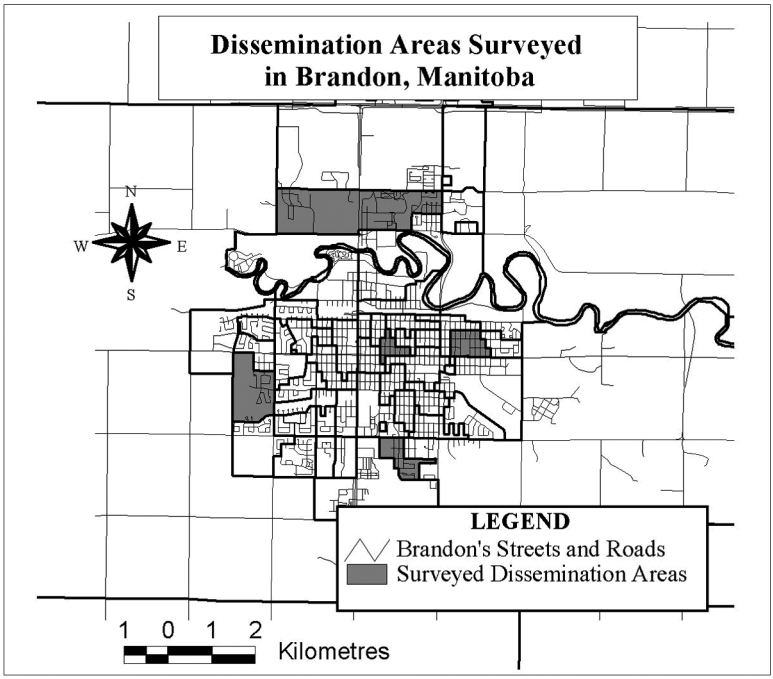

Figure 1: *Dissemination areas surveyed in Brandon, Manitoba.*

Results and Discussion

Brandon residents' dining habits:

Table 1 shows the response rate for each region surveyed. Brandon's north and west enumeration areas were areas of relatively high response rates as compared to the other three dissemination areas. This was to be expected because Brandon's north and west dissemination areas consist of well-educated upper-class residents. These residents are likely to complete a university student's questionnaire because at one time they were attending university and so they understand the importance of survey participation (Mosset 2005a). A less co-operative attitude exists from those living in the city's south, east and downtown areas where income and education levels are much lower than levels in Brandon's north end and west end.

"Brandon's Recreation and Tourism Assessment Survey" dealt primarily with the recreation patterns that exist within the city of Brandon

Table 1: *Survey response rate*

Dissemination Area	Response Rate (%)
North End	49
South End	51
East End	44
West End	55
Downtown	33

and one question dealt with the types of restaurants most frequently visited by Brandon residents (Figure 2). The most common type of restaurant that participants' visit (44%) are those eating establishments that fit under the category heading "Family Fare". Some examples of Brandon's "Family Fare" restaurant chains include "Applebees", "Gullivers", "Pizza Hut", and "O'Kelley's". (Manitoba Group Tour Manual: An Adventure in Nature n.d.). These types of restaurants are geared towards families who desire an upbeat atmosphere, good food and reasonable prices. The second most popular types of eating-place are Brandon's "Fast-Food" restaurants. Examples include "Wendy's", "A&W", "Burger King" and the most popular of them all, "McDonalds". The results show that 37% of respondents most often choose fast-food restaurants when they decide to eat out. Fast-food restaurants provide low prices and quick service. The fact that they serve millions of people in the world every day shows how familiar these sorts of places are to the general public.

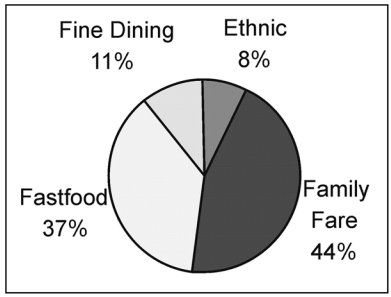

Figure 2: *Types of restaurants most frequently visited by Brandon residents.*

Eleven per cent of respondents indicated that they most frequently visited Brandon's "Fine Dining" facilities. Three of Brandon's fanciest restaurants are "Remingtons" the "34th Street Bar & Grill" and "Rhapsody Grill" located in downtown Brandon. These dining facilities are relatively expensive in comparison to other types of restaurants, a formal atmosphere is apparent at these eating-places and generally the food is prepared by the finest of cooks. The least frequented type of restaurant according to Brandon's general public is "Ethnic Dining" facilities. Only 8% of those surveyed indicated that they most frequently visited this type of eating-

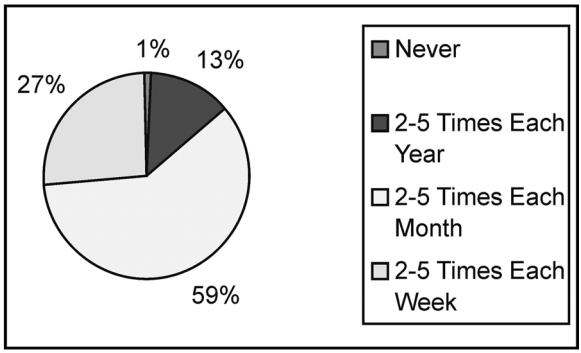

Figure 3: *Eating out habits.*

place. Examples of Ethnic Restaurants in Brandon include "Kam-Lung's", "Albert's" and "Kim's Chinese Restaurant". The city of Brandon does not host a lot of ethnic restaurant variety, which could in part be the reason why so few people eat out at these sorts of dining facilities. In fact, one of the questions in the survey asked if there were any specific types of attractions or events that the respondents' believed were needed in the city of Brandon and many replied saying they wished there were more ethnic restaurants. This suggests that although "Ethnic Restaurants" are less frequented by Brandon residents, if the quality and quantity of these eating places were to improve, some people would be willing to try out these new dining establishments. The frequency of the general population in Brandon that is eating out (Figure 3) was also researched. More than half the population of Brandon eats out between two and five times each month. Twenty seven per cent of respondents dine two to five times each week and 13% eat out between two and five times each year. One per cent stated that they never eat out and no respondents indicated they eat out daily.

The affects of socio-economic status on recreational habits of Brandon residents:

As previously mentioned, one of the initial hypotheses of this study was that a resident's socio-economic status would determine his/her participation in recreation and tourism activities. Throughout most recreation literature, cost is recognized to be one of the main recreational constraints (Mosset 2005b). Hall and Page (1999) state that "those with more skilled and responsive occupations, with higher incomes, with ready access to private transport and with a longer period spent in full-time

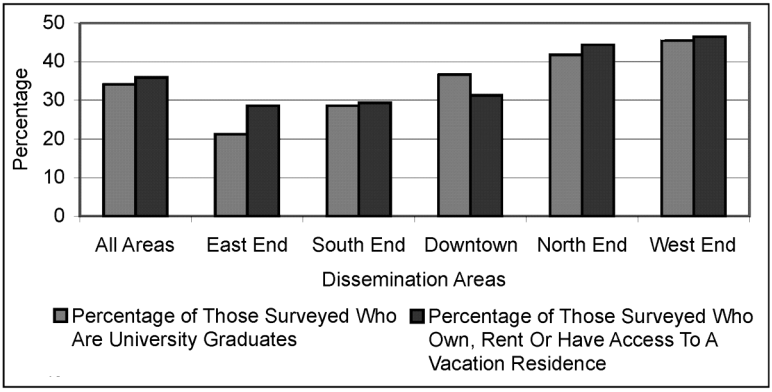

Figure 4: *Level of education vs. owning a vacation residence.*

education tend to lead a more active and varied leisure life, with less emphasis on passive recreations both within and beyond the home."

For some recreational activities, such as walking on the city's paved bike paths, cost is negligible. In these instances money or disposable income has little impact on recreation participation. On the other hand, cost can be a significant barrier to undertaking those activities that are major consumers of money, such as owning, renting or having access to a vacation residence, whether it be a cottage, cabin, or trailer (Everitt 2002). Results showed a strong correlation between those who hold a university degree and those who have access to a vacation residence (Figure 4). With respect to Brandon residents, the highly educated and more wealthy north and west end citizens of Brandon have greater access to vacation residences than those with less education and lower incomes residing in Brandon's east and south ends.

Comparing Brandon residents' recreation rates from 1981 to 2004:

As the tourism industry has grown to become the world's largest industry, the actual number of people travelling has also dramatically increased. To measure the rate of recreation increase of Brandon residents over time, results from this study were compared to a similar undergraduate study by Costanza (1981). Figure 5 presents a comparison of outdoor recreation use between 1981 and 2004. It is evident that the percentage of respondents making day trips to recreation areas in the Brandon regions has dramatically increased. For some recreation areas such as Riding Mountain National Park, Minnedosa Beach, Spruce Woods Provincial

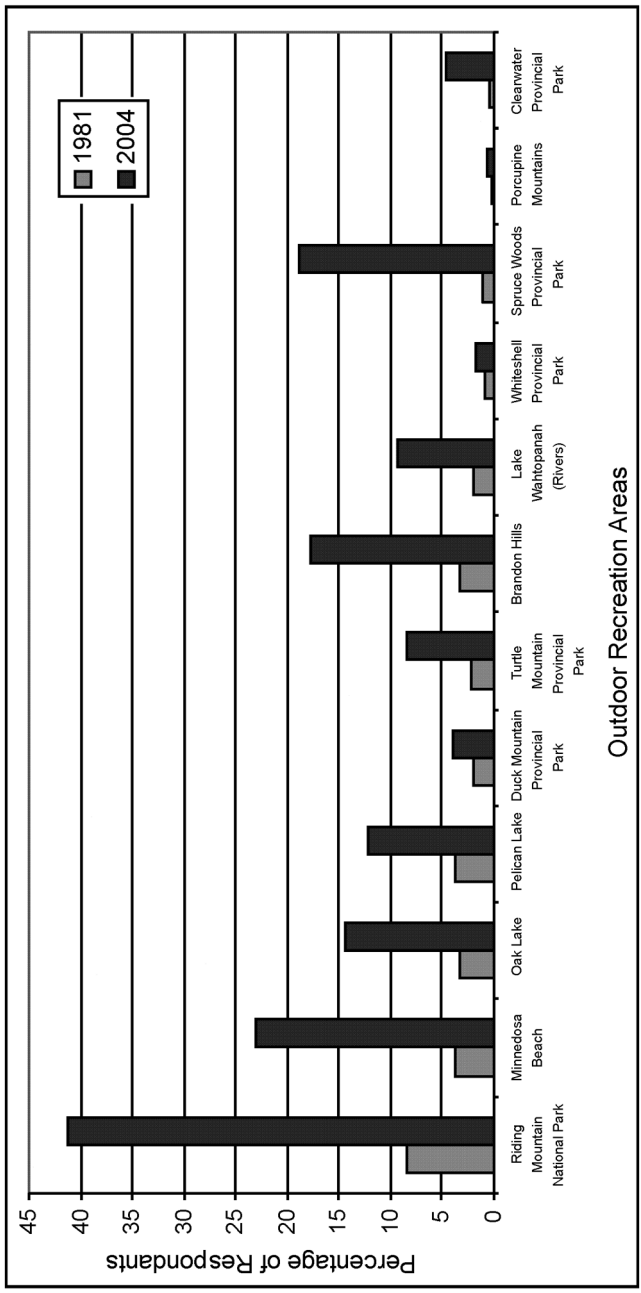

Figure 5: *Residents going to select outdoor recreation areas in 1981 vs. 2004.*

Park, and the Brandon Hills, 2004 percentages triple and in some instances quadruple the 1981 percentages of residents going to recreation areas.

There are many reasons that could explain this augmentation in leisure participation. Primarily, as our standard of living has improved and people have had more disposable income and leisure time available to them, it is possible for more people to take time out of their lives to visit these parklands. Mobility and transportation greatly affect the rate of tourist participation so as more people have access to their own car, more people have been able to drive to these recreation areas. Also, in the past twenty years these recreation areas have undergone massive development. More walking, biking and ski trails have been cleared, more campsites have been allotted and parking lots, restaurants, accommodation and entertainment facilities have also expanded. This improvement in the quality and quantity of facilities has dramatically increased the percentage of people who travel to these sorts of outdoor recreation areas (Tourism in Canada: Past, Present, Future n.d.).

As these tourist locations continue to grow and become more attractive, it is reasonable to assume that recreation participation rates will continue to rise. In the year 2000, Manitobans made more than 5.26 million personal visits within Manitoba and spent $607.3 million in tourism expenditures. This represents 53.8% of total expenditures. More than half the trips taken by Manitoban's in-province are same-day trips and three-quarters of the remaining overnight trips are for one or two-night-stays only. Therefore, Manitobans' per trip expenditure is $116. These trips remain vital to tourism, supporting many festivals, events, attractions, shops and restaurants (2001/02 Marketing and Opportunities Guide n.d.).

Influence of the internet:

Another development that has dramatically affected the tourism industry is the Internet. Internet use in Canada has grown from 29% of households in 1997 to 42%in 1999 (The Conference Board of Canada n.d.). Canadians use a wide range of information sources when planning a vacation trip but according to a study conducted by the Conference Board of Canada (n.d.) "the advice of friends and family and the Internet are most important." The Internet and its power to access global information and entertainment opportunities has affected the decisions of tourists regarding places to travel, methods of travel, and booking accommodations and entertainment while on vacation. "The Internet is now the main source of information for Canadians planning an outbound trip" (The Conference Board of Canada n.d.).

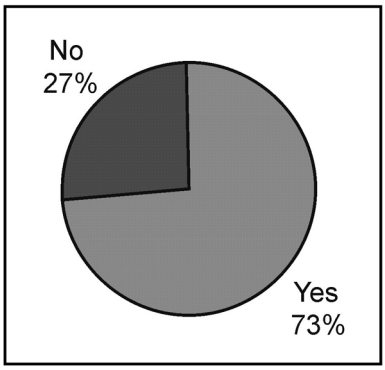

Figure 6: *Percentage of residents who use the internet to research potential travel destinations.*

Seventy-three per cent of respondents in this study indicated that they used the Internet to research potential travel destinations (Figure 6). Only 60% indicated that they booked plane tickets, accommodations, or tickets to particular shows or events over the Internet (Figure 7). Clearly the Internet is playing an important role when Brandon residents are researching and planning their recreation and tourism activities. These findings coincide with those of the Canadian Tourism Commission (2002a), which states, "the Internet continues to be a medium for gathering information as opposed to buying a travel product." Nine per cent of Internet users actually made a purchase of a travel product on the Internet in the year 2000; this percentage rose to 14% in 2001 (The Conference Board of Canada n.d.). Clearly we are observing a shift in website use from content-only use to booking on websites that also have content. As Canadians become more comfortable with booking on-line, it is reasonable to assume that booking sites may have an edge over destination sites without booking capability.

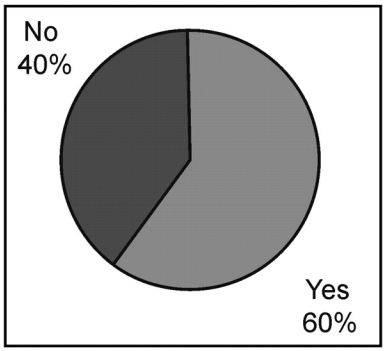

Figure 7: *Percentage of residents using the internet to book plane tickets, accommodations and/or show tickets*

Provincial recreational habits:

Eighty-six per cent of Brandon residents indicated they had traveled outside of Manitoba but within Canada over the past three years. Alberta, Saskatchewan, Ontario, and British Columbia were the top four provinces that were visited by respondents. In terms of "Time-Distance Decay" (Hall and Page 1999) it seems reasonable that the provinces closest to Manitoba are the provinces that most Brandon residents choose to visit

while on vacation. These findings match closely to those of the Canadian Tourism Commission's "Domestic Tourism Market Research Study of Manitoba and Saskatchewan" (1996). The only difference was that the CTC states the province of British Columbia is more frequently visited than Ontario. The majority of Brandon respondents indicated that the length of their trip was less than one week and the primary purpose of the trip was for pleasure as well as visiting family and friends. In terms of who went on the trip, 70% of those surveyed stated that those travelling in their party were only adults. Thirty per cent of respondents stated that those vacationing out of province were adults and children.

International recreational habits:

Over the past few decades more people have begun travelling the world for business purposes, to visit family members who live in foreign countries, and for personal enjoyment. A section of "Brandon's Recreation and Tourism Assessment Survey" dealt specifically with international travel destinations, namely: United States, Mexico, Caribbean, Central America, South America, Europe, Africa, Asia, and Australia. Seventy-two per cent of those surveyed indicated that the purpose of their trip was for personal enjoyment. After the data was analyzed it became obvious that the majority (65%) of Brandon residents who are travelling outside of the country are vacationing in the U.S. This coincides with the Canadian Tourism Commission's Manitoba/Saskatchewan Regional Report, which states that the vast majority of trips that are taken to international destinations are to the U.S. (Domestic Tourism Market Research Study Manitoba and Saskatchewan Report 1996).

Another country that many "Brandonites" are visiting is Mexico. In fact, more generally, the Caribbean as a whole seems to be an attractive place for Brandon residents (19%) to travel. This could, in part, be due to the high value of our Canadian dollar as well as the "cheap get-a-way Caribbean vacation" packages that travel agencies are currently selling to customers. It is also interesting that 75% of all Mexican travelers have a strong interest in visiting Canada (Tourism: Canada's Tourism Monthly 2003). This emerging Mexican market demonstrates the potential to evolve into one of Canada's tourism growth markets in the future.

Brandon's recreational future:

The city of Brandon is currently undergoing massive expansion as new hotels, restaurants, shopping places and businesses are being established in Manitoba's second largest city. A lot of people believe Brandon to be on the verge of an economic explosion and this gives way to much opportunity for the recreation and tourism industry. With the

aging baby boomer generation, Brandon's tourism industry is also heading toward expanded long-term market opportunities. "It is estimated that, over the next twenty years, baby boomers will retire from the workplace at an average rate of 500,000 per year (in Canada)" (Canadian Tourism Commission 2002b). The resulting increase in leisure time and discretionary income will lead to an even larger market than currently exists. The challenge facing Canada's tourism industry will be to entice baby boomers to travel within the country.

Some of the reoccurring suggestions respondents made in "Brandon's Recreation and Tourism Assessment Survey" in terms of specific types of attractions or events needed in the city of Brandon were as follows. Many respondents wish the city would book comedians, singers, and famous entertainers on a more regular basis. Secondly, a lot of people wrote how they felt the city needed a new swimming pool or wave pool along with more zero-entry children pools operating during the summer months. Ethnic restaurants, bars, casinos, fairs, festivals, skateboard parks, and gatherings for teenagers were also programs and facilities that were requested. Many respondents gave praise towards the walking paths around the Riverbank Discovery Centre but stated they hoped that there would be more paths created in the future.

The Brandon Riverbank's strategic plan has been put into motion and recreational development in the City is currently taking place. Pathway construction has continued as promised alongside 1st Street North pleasing many residents and lights have been placed along some of the walking paths that currently exist. The Riverbank's Strategic Plan also includes a building expansion along with a new restaurant facility that has not yet been constructed (Brandon Riverbank Discovery Centre 2004). In terms of other recent developments in the city, a new "Home Depot", "Future Shop" and "Mark's Work Wear House" just moved into the corner of 18th Street North and Kirkcaldy Avenue. Businesses and restaurants such as Safeway, Montana's, Subway and Starbuck's are also scheduled to be constructed in this area in the future. This past summer the city funded a beach volleyball court situated on Lorne Avenue. In terms of hotel accommodations, a Canad Inn has just recently been erected on the Keystone Centre grounds and within this new hotel a family restaurant called "Altos" along with a piano bar, a pub (The Tavern) and a new nightclub (The Country Roadhouse) have opened.

Manitoba's recreational future:

The Canadian Tourism Commission is committed to increasing awareness of and interest in Canada as a four-season tourist destination. One of the Canadian Tourism Commission's main objectives is to sustain

a vibrant and profitable tourism industry by marketing Canada as a desirable tourist destination (Canadian Tourism Commission 2002b). In recent years Manitoba has been showing steady growth in tourism. Based on the greater number of people paying visits to Manitoba's travel destinations each year, the province's tourism industry has good future growth potential (Welsted et al 1996). It is an industry that can provide employment and development opportunities in areas which, because of their location or limited resource base, have few economic development alternatives. Tourism is an industry that can benefit residents of Manitoba by providing attractions, facilities, services and infrastructure that meet the resident recreation needs while generally increasing economic activity by attracting non-residents (Wardrop et al 1982).

Given the fact that Manitoba has one of the lower populations in Canada, its primary Canadian target market should not remain its own residents as "there is extremely large market potential in the rest of Canada that must not be ignored" (Domestic Tourism Market Research Study Manitoba and Saskatchewan Report 1996). However Manitoba seems to have problems attracting those who have never visited the province because while "nearly half (47%) of non-visitors to Manitoba regard Manitoba as a destination option among many, nearly as many (43%) have little interest in ever visiting this province" (Manitoba Travel Market Survey Final Report 2000). A mere 10% of those surveyed regarded Manitoba as a likely future destination. This information tells us that if the province of Manitoba wishes to increase its total number of visitors, it must come up with a management strategy that will not only keep Manitoba residents travelling, but will also attract people from other provinces, states and countries to vacation in Canada's prairie region. By attracting these non-residents, Manitoba's tourism industry has even greater potential to grow. New money will be introduced rather than simply circulating "old-money" around the province (2001/02 Marketing and Opportunities Guide n.d.).

A general consensus of survey respondents agreed that Manitoba has beautiful scenery, has abundant natural lakes, has lots of things for families to see and do, is very clean and well cared for, has mild summertime weather, and is a very safe place for visitors (Manitoba Travel Market Survey Final Report 2000). These positive qualities of Manitoba need to be better publicized and expanded on so more people learn of the features and amenities associated with the province. A strong awareness campaign and partnership with industry will ensure continued success. The government has been working on a tourism development strategy for Manitoba and a host of marketing techniques have been researched in an attempt to attract more visitors to the area. It is important for the province to expand its traveling audience by attracting non-residents so they can

see for themselves what sort of natural beauty and unique recreational experiences can be had while traveling Manitoba.

Conclusion

Clearly Brandon residents are choosing a wide variety of destinations and activities to meet their recreational needs on local, regional, national, and international scales. Within the city of Brandon it was discovered that ethnic and fine dining facilities are not as popular as family fare and fast-food restaurants. It was also determined that the majority of the population ate out between two and five times each month. Our study shows that socio-economic status plays an important role in peoples' recreational lives as a much larger percentage of residents from Brandon's wealthy north and west ends have access to vacation residences as compared to those people living in the city's south, east, and downtown areas. The study also shows that as the tourism industry has grown over time so have the participation rates of Brandon residents traveling within the province. Comparing our study to Costanza's study, it is clear that present tourism participation rates are higher than what they were twenty years ago. Many reasons can be given for this increase. Certainly improvements in industrial standard of living have contributed to this increase in recreation. Another contributing factor is the Internet and the influence the World Wide Web has had on assisting travelers in their research as well as booking entertainment, transportation and accommodation services. Comparing these results to Costanza's (1981) it was concluded that (i) recreational demand and opportunities have increased both within and outside the City; (ii) there are spatial variations in the recreational behaviour of Brandon residents, and (iii) that facilities and programs should take account of these variations.

In terms of provincial recreational habits, Brandon residents visit the provinces of Alberta, Saskatchewan, British Columbia and Ontario most when they travel within Canada. Hall and Page's (1999) "Time-Distance Decay" model corresponds well to these results as "Brandonites" most frequently visit the provinces closest to Manitoba. With regards to international recreational habits, the United States is the country most often visited by Brandon residents. Due to the connectedness between Canada and the U.S. this result is not surprising. Mexico is also a very popular travel destination according to the survey results. In fact, the Caribbean in general attracts 19% of Brandon residents who are traveling internationally.

Brandon's recreational future looks bright as the city's economy is progressing and the population is growing. With the development of the Riverbank Discovery Centre in 1999, the city of Brandon now has an established tourist information facility (Brandon Riverbank Discovery Centre). This building also serves as a starting point for the trail system and the interpretive programming events that go on in the area. Survey respondents indicated the attractions and events they felt were needed in the city of Brandon. Recurring suggestions included more arts and musical entertainment, a new swimming pool, more fairs, festivals, parks, restaurants and socializing facilities. The Brandon Riverbank Discovery Centre's strategic plan involves funding and expanding the city's recreational base. More of the city's money is being spent to develop new restaurants, hotels, shopping places and recreational facilities. The province of Manitoba could become a more popular travel destination if the province instigated better marketing strategies and if more advertising and public funds were made available. Manitoba is scenic with diverse physical landscapes and the abundance of lakes, streams and rivers. The existence of several provincial parks and one national park provide a strong basis for the recreation and tourism industry. The provincial government is currently working on a tourism development strategy for Manitoba in order to make the province more attractive to travelers.

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Healthy places? Service provision for seniors in small towns on the Prairies

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Abstract: This paper presents the results of a research project that was designed in part to investigate and evaluate the provision of services for seniors in selected smaller settlements in Manitoba and Saskatchewan. These results are part of a larger country wide study, known as the *Aging across Canada* project, funded by CIHR. Census of Canada data indicate that some of these communities can be seen as relatively service rich and others as relatively service poor. Some are more northern and others southern. The purpose of the study was, in particular, to look at the effects of place and scale upon service provision. It was hoped that this would enable us to explain how and why communities are aging differently. Key informants from the government, private, and voluntary sectors were interviewed. In this paper results from Neepawa, Dauphin and Thompson (MB) are discussed along with data from Prince Albert (SK). These results suggest that "service richness" and "service poorness" cannot be seen as absolutes, but are related to location and scale of settlement, and to the perception of those living and working in these places. Clearly the provision of services for seniors has to be seen as a much more complex issue.

Introduction

This paper introduces a research project that was designed in part to investigate and evaluate the provision of services for seniors in selected smaller settlements in Manitoba and Saskatchewan. These results are part of a larger country wide study, known as the *Aging across Canada* project, funded by the Canadian Institutes of Health Research (CIHR). The study reported on in this paper, applies aspects of the geographic viewpoint to the issues of service loss and community retention. It looks at, in particular, the effects of two well established geographic concepts, scale and location, upon service provision (Broek and Webb 1973, 8-12; Johnston et al. 1994),

and investigates their relationship to a more recently developed concept, place, which focuses on the values attributed to a location by the people living there (Norton 2004, 56). It is hoped that this helps us to explain how smaller communities are behaving, and why some small communities are behaving differently to others and to larger urban centres, and thus becoming more successful. The results are based upon a study of service provision for seniors that used interviews with key-informants from local governments, chambers of commerce, health and social care institutions, voluntary organisations, and seniors' groups from four communities located in Manitoba and Saskatchewan. The paper discusses a series of issues about belief in community, and we conclude with a reflection on the results as they relate generally to understanding service provision for seniors in smaller settlements in these two provinces.

Conceptual Basis

Census of Canada data indicate that some communities are relatively service rich, and others are relatively service poor. Many reasons can be postulated for these variations, but we are particularly concerned with how these differences are related to location, scale, and place – that is to say, the geography of our study regions. To put it another way, communities may be different from one another in many ways, but have a commonality of problems (Troughton 1995). Thus we are arguing that geography, as Allen et al. put it, "turns up everywhere" (in Massey et al. 1999, 323), geography does matter (Massey and Allen 1984; Johnston 1991, 246-249).

Location is perhaps the fundamental concept of concern for geographers (Johnston et al. 1994; Norton 2004, 56), as it is inextricably tied to 'where' questions, which are arguably the basic questions that a geographer poses in order to organise his or her experiences (Abler et al. 1971, 11). A major challenge to service provision in rural areas is that the needs of a small and sparsely distributed population frequently lack the critical mass necessary for providing some services and particularly the more specialised services that are needed by the elderly (Joseph and Hallman 1996; 1998). Thus, in the context of service provision for seniors, we are concerned with how location (including the relative location of a community *vis à vis* other communities, as well as its absolute location) is important in creating service rich or service poor communities.

Second, we can ask how important is scale (e.g., the size of the community, and its level within the urban hierarchy) to the manner in which a community functions in terms of the organisation and delivery of services by service centre (Johnston et al. 1994, 543). Is it the "crucially

important dimension of geographical differentiation" that Brenner has suggested it can be (Brenner 2001, 604)? Is it "central to the research agenda of the entire discipline of geography" as Marston (2000, 220) proposes? That is to say, is the scale of a community a major factor in determining its selection of services? Scale is closely related to location when the provision of services is to be considered, as Christaller made clear many years ago (Carter 1995). A settlement of a particular size that is a long way from competing centres may be expected to have a larger bundle of services than a similarly sized settlement close to a metropolis. However, not all communities of a similar size and similar relative location have the same bundle of services, and this may be related to their place characteristics.

More recently, place effects have been emphasised within human geography (Johnston 1991, 179; Johnston et al. 1994, 442). These are the non-quantifiable characteristics of communities – for instance, the way in which social relations and identities are constructed to give one location a unique character that is different from that of others. The importance of attachments to place ('a sense of place') in our discussion is closely tied to the concept of community as place as a concept within cultural geography involves being known and knowing others (Norton 2000, 274). It is likely that communities with a strong sense of place will be able to maintain themselves despite having a poorer location and a smaller size than other settlements. Similarly a community with a strong sense of place may be better positioned to retain its services – that is to say, 'place matters'. Place is also related to (in particular) health care and health services in other ways (Kearns 1993). For instance, peoples health may be better if they live in a place they know and like, and to which they have an emotional attachment. As Perry (2001, 66) suggests, "For most there's no place like home". Health may suffer if they are removed from this place. Thus many seniors prefer to age in place, even if that place has inferior services, to migration to another settlement, because it is their home (Everitt and Gfellner 1994; 1996). The distress that a spatial dislocation can cause was nicely summed up in one interview:

> *People have to leave the city [Thompson, MB] to go to Winnipeg near the end of life to get services. (It is) tough leaving their community and then once they are very ill the hospital in Thompson won't take them back. People end up dying in an unfamiliar place.*

Smaller Canadian cities and towns have long been seen as places with closer ties between people, and a greater shared understanding of

the notion of community, than many larger urban areas. Consequently, although rural areas and settlements have been evolving in recent years as a response to the challenges of agricultural restructuring and rural depopulation, they are still seen as communities by their inhabitants (Ramsey et al. 2002; 2003). In many, perhaps most cases, the elderly in these communities prefer to 'age in place', or at least 'age near place' (Everitt and Gfellner 1994; 1996), often leading to "naturally occurring retirement communities (NORCS)" (Perry 2001: 66). But, the loss of services (in health, education, and business) continues to put stresses and strains on rural people and their dwelling places, and key debates within academic and public policy discourses have raised important questions about the conventional wisdom surrounding service provision for seniors in smaller settlements town settings (Everitt 1994; Gfellner and Everitt 1997; Hallman and Joseph 1998; 1999; Wenger 2001; Fast et al. 2004).

In addition, these communities may have higher rates of some health problems, because of the large number of seniors in these places (Furuseth 1998). Indeed, within the service provision environment, there is a sense of uncertainty surrounding the capacity of these communities to cope. It may be, however, that they *can* cope because they are communities that believe in themselves, believe in their futures, and believe in their abilities to function despite the challenges to their very existence. That is to say, what small towns lack in terms of formal community services they make up for in terms of the closer ties of people within the community, and particularly family, friends and volunteers who are concerned with the care of the elderly. Thus community can be seen as a social construct that is fluid and constantly evolving.

Thus it is argued that the integration of place, scale and location provides a useful point of departure for the analysis of the provision of services for seniors. To demonstrate the utility of our argument, results from a study of service provision for seniors in four communities within Manitoba and Saskatchewan are reported. Out of this analysis a series of issues are raised regarding the role that place, scale, and location, play in the provision of services for seniors and our understanding of communities.

Research Design

In this research the provision of public services for seniors was analysed through an in-depth comparative study of four smaller urban communities. More particularly, the provision of services to seniors at the local level was considered, and put this in the context of a comparative

study of four different communities. Two are small towns that serve their local agricultural regions; one is a larger mining town in northern Manitoba; the fourth is a larger urban centre in northern Saskatchewan that serves both an agricultural population as well as a forest-product economy on the Canadian Shield. This approach is designed to explore the changing service provision environment for seniors in different urban settings in order to shed light on the effects of place, scale and location.

Four major analytical questions guided the research design: (1) Do service providers view their communities as places and if so how? (2) Do service providers see the scale at which they operate as having positive or negative effects upon service provision? (3a) How do service provider responses compare with respect to the provision of services for seniors and (3b) Are the differences and similarities in responses a function of service provider notions of place and scale? And, (4) Does the location of the community affect its package of services, or its service providers' perceptions of the 'richness' of this package?

Methodology

The methodological approach is qualitative and uses in-depth interviews to understand service provision of seniors (Limb and Dwyer 2001). Although the interviews are carried out among key informants in four small towns in rural Manitoba and Saskatchewan, the purpose is to construct a composite view of *healthy places*. In other words, we are not trying to compare the four towns or argue that each town falls on some continuum of service rich or service poor, but to take the perspectives of key informants from the four towns to draw lessons about the nature of service delivery for seniors. Thus, the primary data for this research represents the knowledge and perceptions of service providers from a variety of organisations and institutions within our target communities.

A series of in-depth interviews with fourteen key-informants from the study communities were completed in the summer of 2002. In order to capture the complex dimensions of change and various sectors involved in providing services for seniors in Manitoba and Saskatchewan, interviews were conducted with senior officials and administrators from a broad range of government, public, private, and voluntary agencies across the health care, housing, social services, transportation, and recreation sectors. These included local government departments (economic development; parks and recreation; and public transportation); public health institutions (community care access centres, hospitals, and long-term care facilities); public and non-profit housing corporations; seniors'

associations; private for-profit providers (e.g. 'We Care') and voluntary and non-profit service agencies (health care, home care, transportation).

In the in-depth interviews, the key-informants were asked a series of structured and open-ended questions related to the formal service environment for seniors in the community. In each case particular reference was paid to (a) the strengths and weaknesses of the current situation, and (b) the constraints on becoming service-rich, or at least service richer. The information gathered from these key-informants enables us to gain an invaluable 'insider view' of the complex and dynamic ways in which services for seniors are discernible at the local level. The emphasis on local decision-makers and circumstances is crucial, especially given the downloading of responsibilities for direct service provision in Manitoba and Saskatchewan, as has been the case elsewhere in Canada (Halseth and Williams 1999).

Analytically, following the advice of Hay (2000), the interview transcripts were read by all three authors independently. What is reported in the following section is where there was a convergence among the authors on key themes that come out of the interviews. To provide the reader with a sense of the wealth and nuance of the interviews, quotations are used for illustrative purposes.

The Study Communities:

Two more southerly, Neepawa (MB) and Dauphin (MB), and two more northerly communities, Thompson (MB) and Prince Albert (SK), were selected for study. Although located in what is, in many ways, a 'Christaller-like' central place landscape, the locations of these settlements did not evolve naturally over time, but were imposed by the policies of railway companies. Neepawa is an agricultural service centre of 3,300 people located 175 km west northwest of Winnipeg, and 75 km northeast of Brandon. It was chosen to represent the smaller urban places within the Manitoba urban system. Dauphin is an agricultural service centre in Manitoba of some 8,300 people located about 167 km north of Brandon, and 304 km northwest of Winnipeg. It represents one of the larger urban places within agro-Manitoba, and one that is more remote from the largest cities in the province.

Both Neepawa and Dauphin have struggled in recent years reflecting changes that have occurred in agriculture in Manitoba, and the related rural depopulation of large parts of the province. Both towns reached their peak populations in 1976 and have declined since that date. In recent years, again reflecting regional trends, the percentage of elderly (65 years old +) in these towns has risen considerably, and is now almost 30% in each centre. Recognising this demographic transformation towards what were identified earlier as NORCS (Naturally Occurring Retirement

Communities), the towns have tried to capitalise upon this trend and sell themselves as retirement centres. At the same time it is recognised that the populations in and around Dauphin and Neepawa may once again get younger as the 'bulge' of elderly people disappears or at least declines in significance. Thus the elderly must be planned for, but not to the exception of all other cohorts. A good example of this new direction is given on the Dauphin website (*http://www.city.dauphin.mb.ca/lifestyle.htm*) where the emphasis on services for seniors is made quite clear:

> Retirement Dream
> Whether your view of retirement is a quiet and comfortable setting to spend your golden years in relaxation, or your view is an active and event-filled lifestyle that keeps you constantly busy, Dauphin is the ideal setting to realize your dreams. Services for seniors are plentiful in Dauphin. Health care needs are available from a modern 90-bed hospital and the Dauphin Clinic which boasts 13 practitioners. Four fully stocked pharmacies provide medicines and a full range of health care products. Mobility service for those with needs, are readily available in Dauphin. Dauphin Seniors' Centre offers the opportunity for seniors to get involved with your peers. Dauphin is in the centre of an outdoor recreational playground. Fishing, hiking, skiing, bird-watching, sight-seeing, and countless other activities await.

Thompson is a nickel-mining community (INCO Ltd.) of about 14,500 people, with a trading area of about 40,000, located in northern Manitoba, 750 km north of Winnipeg. Incorporated in the 1960s, it is now the largest centre in northern Manitoba (the 'Hub of the North'), and the third largest provincial urban centre after Winnipeg and Brandon. Originally the population was characteristically quite youthful and migratory, but over time the population structure has stabilised, and become more elderly: as one key informant put it:

> *It's only in the 1990s that you're starting to see senior citizens in the city, mostly because workers / miners that originally came to Thompson to work for a few years ended up settling in the city. Now, they're getting old and retiring.*

As a consequence the health services of the city are learning to cater to an increasingly family-oriented population, and one that is becoming more elderly (only 2.5% over 65, but 14.5% over 55 years old), although it cannot be termed a retirement community. A large proportion of the

population of the city is aboriginal, reflecting the ethnic structure of its catchment area. Although this means that the city continues to have a significant proportion of younger in-migrants, First Nations people are starting to retire into the city. However, the city web site still promotes local and regional recreation and tourism as attractions ("The biggest attraction to Thompson is the area itself."), not the city's possibilities as a retirement centre (*http://www.thompson.ca/*).Prince Albert is the third largest city in Saskatchewan with a population of some 41,500 people. It lies on the North Saskatchewan River, about 141 km west northwest of Saskatoon, and is near the boundary of 'agro-Saskatchewan' and the forest belt of the Canadian Shield. Prince Albert acts as a service, retail and distribution centre for northern Saskatchewan's resource industries - mining, forestry and agriculture. Like Thompson, it does not bill itself as a retirement centre. Although just under 13% of its population is over 65 years old, about 21% is over 55 years old, and seniors' services are thus likely to become a greater concern in the future. Along with Thompson it may assume many of the characteristics of a NORC within a decade or two.

Study Results

Our results will be summarised by referring to the 'four major analytical questions' referred to earlier: (1) Do service providers view their communities as places and if so how? (2) Do service providers see the scale at which they operate as having positive or negative effects upon service provision? (3a) How do service provider responses compare with respect to the provision of services for seniors and (3b) Are the differences and similarities in responses a function of service provider notions of place and scale? And, (4) Does the location of the community affect its package of services, or its service providers' perceptions of the 'richness' of this package? A number of direct quotes from our interviews will be used to illustrate these responses.

First, with reference to our suppositions about 'place' - communities in southwestern Manitoba (as elsewhere) have been developing their separate identities since they were founded in the late nineteenth century. These separate identities have been reinforced over time by 'Christaller-like' central place economic activities that concentrate the actions of the people in a region on their local central communities. In addition, the decline of many smaller towns in the local central place hierarchy and resultant increase in significance of the dominant community has increased the nodality of these communities. The key informants also commonly saw their communities as offering a superior quality of life to their

neighbouring settlements, and even to the larger centres such as Brandon, Winnipeg, or Saskatoon. It is not surprising then, that place emerges as a major theme in the perceptions of service providers in the study settlements.

> *Dauphin is a community (that is) attractive for seniors. Dauphin offers small town living plus good services which attracts people from surrounding areas. Some seniors (are) leaving Dauphin for other centres to be closer to children, but don't think it's very common.*

Interestingly, but not surprisingly in context, each place was seen by key informants from that place as being better than others around it. That is to say, place was seen as an absolute concept, but also as a relative concept that was connected to scale and location. In addition it was a concept that implies inclusion – people were attached to a place – but also reflected exclusion, with 'outsiders' having some difficulty attaching themselves to that place. And while each respondent indicated that they recognise their communities as distinct locations, a wide range of features are used to equate their communities to different 'notions of place', although these can be summarised within a five-part taxonomy: amenities; role within local and sometimes regional or provincial communities; diversity and culture; sense of community; and quality of life.

> *The community is attractive for seniors. If you move here when you are already old, it might be difficult to break into the social network, but for people native to Dauphin and surrounding area, [it is a] good place to live.*

> *Prince Albert probably is not attracting seniors from Regina and Saskatoon. The catchment area for Prince Albert is probably about a 50 - 80 km radius. Farmers migrate into the city.*

> *People have to leave the city to go to Winnipeg near the end of life to get services. (It is) tough leaving their community and then once they are very ill the hospital in Thompson won't take them back. People end up dying in an unfamiliar place.*

Second, the scale of service provision also plays a significant role in the perceptions of the services for seniors. Several scale effects were highlighted by the respondents with respect to the provision of services for seniors in their communities. These were related to the absolute size of

the community as well as to its position within the local, regional, and provincial urban hierarchy. These included the size of community; the level of services; jurisdiction; flexibility; and comprehensiveness. Interestingly, in each community we found key informants who felt that their community was 'service rich'. However, it was clear that they also recognised that they were occasionally short of physicians, and particularly specialists, as well as equipment (such as a Nuclear Magnetic Resonance machine [NMR]) that might be found in Winnipeg.

There was also the fact that the smaller settlements are just one part of a larger Regional Health authority (RHA) and thus one part of a regional health system. Several of our key informants, in both our larger and our smaller study settlements, saw their communities as large enough to have adequate services – even though they might be deficient compared to the largest provincial centres. That is to say 'service richness' and 'service poverty' were also relative concepts, in some cases being compared to what was reasonable to expect given their size vis-à-vis larger centres such as Winnipeg or Brandon or Saskatoon, and in other cases being compared to smaller local settlements.

> *If you have two communities of similar size, but one is service rich and one is service poor, it might be related to a number of factors. First, geographic location might be important. A community that is relatively close to a large centre will probably have fewer services, but a community that is similar size but a little bit more remote from a larger centre will have more in order to minimize travel time. Second, politics has something to do with it. For example, politics heavily influenced where hospitals were constructed in Saskatchewan. Third, political will. Some communities are just better at lobbying government or other people to get or maintain services. Finally, the demographic of the community is important. Obviously, a community that has more seniors will have more services than another community even if their total population sizes are the same.*
>
> **Q:** *So the RHA, sort of implemented those changes*. **A:** *Yeah. We were sort of given a choice I think when they came in, whether to be a part of them or be separate. But, I think we thought at that time it seemed the most sensible thing to everybody to be a part of them so that they ... everybody knew what was going on. But um, like you said, other than the money coming directly*

from them they don't take a lot of responsibility for our program anyway.

Third, service providers recognise that they might provide good services, but there is always room for improvement. At the same time they recognise that the package of services available is related to their community size, money available, and the availability of services and other attractions elsewhere, and in some instances the willingness and ability of other community members to volunteer their time to improve the service package. For the most part the services provided in Neepawa and Dauphin are better developed and more varied than those provided in the other centres, reflecting the larger proportion of seniors in these settlements, and the greater length of time that seniors have been numerically more significant.

Dauphin has more seniors than Thompson so it has more services for seniors. Dauphin is service rich relative to a community like Thompson

I think we have a very good, wide range of services available, I'm sure there are always more that could be added, but you know I think that we do very well for what we have and why I looked at this question and I was trying to decide what the right answer for that would be and I just think we have a very wide range of services and if we need things then we look at adding them. Like we did the adult day program when it started back a few years ago and we would like to, we could probably run that program five days a week but there's not the funding for it and so that's unfortunate. You know, funding is all over us. The congregate meal could probably be run seven days a week but we don't have someone who can, you know, who can do. So, but I think, I think overall we've got excellent, excellent services for people.

Long winters that can be tough but it depends on the person. If you are a senior that likes winter activities then Thompson is okay, but the longer winter months relative to southern Manitoba can be difficult.

Fourth, the location of the community affects its package of services, or its service providers' perceptions of the 'richness' of this package. This in turn affects the attractiveness of the community and thus its viability. At

the same time it is clear that the service providers do care, and do believe that they can provide a fulfilling community for their seniors.

> **Q:** *Is (your package of services) attractive to seniors…?* **A:** *I think so we have, because of some of the services that we have in our um, in our EPH, which is our elderly person housing unit I do know that we do have people who have moved from McCreary. From smaller areas they come to Neepawa. I do know that people come in because we, you know, certainly we encourage some of them to come because we can provide a service for them that they may not get out in some of the outlying areas around Neepawa, you know.*
>
> ***Q:*** *And they'd rather come here than Brandon?* ***A:*** *I think so. Because they like small and this is compact and local and maybe they have family around you know. We have had people come from Portage and uh, in fact I know that we have two couples moving here because their children are here.*

Conclusions

We had proposed that location, scale and place would be important concepts that enabled us to understand the existence of service rich and service poor settlements, and this proved to be the case. But it was not a case of simply using these geographic concepts in their 'dictionary definition form' – for instance, scale being the size of the community. These terms have to be seen in a wider framework. For in addition to recognising these as important variables per se, they were also seen to be important within a service provider context that is more than local in nature. Thus it was recognised that the relative differences are important here, as (1) absolute scales are not agreed upon, and (2) people in our study communities commonly view their pattern of services in a relative context ('how do we compare to 'x' community?') rather than an absolute one. Thus while they *are* concerned with the absolute number of services available, they realise that what they have has to be viewed in a regional or provincial context. In addition, some of the communities investigated in the larger study are more northern and others southern and this division is also reflected in our results.

> *Dauphin is service rich, but it's relative: relative to Winnipeg or Brandon, Dauphin has less.*

Thus our results suggest that 'service richness' and 'service poorness' cannot be seen as absolutes, but are related to location and scale of settlement, and to the perception of those living and working in these and other places. And these variables evolve over time and space as the social, political and economic environments also evolve. Indeed it could be argued, although not a focus for this paper, that public policy has also been responsible for disrupting the relations between scale, place, and location. Thus it is not a simple issue of larger places being better off and smaller places being worse off. Because distance (location) and amenity (place) come into play as well as absolute size (scale) then some settlements might be viewed as more or less attractive than others for less obvious reasons (e.g. climate). Clearly the provision of services for seniors has to be seen as a much more complex issue.

> *Thompson is service poor but it is developing…(and) adjust(ing) to these new realities.* **Q:** *I hear you're comparing yourself to competing communities, to put it that way. Do you think Neepawa is better off than, uh, the others at a similar size?* **A:** *Yeah, yeah I do. But smaller, tighter communities people are more willing to bend over backwards for you, you know. They phone me at home and tell me that things aren't working [laughs], this is a good thing or this is a bad thing. But that's one of the things that happens and you know, so you try and help them plan.*

It was suggested earlier that the notion of community "can be seen as a social construct that is fluid and constantly evolving". A major question is, how far has this evolution gone, and can this process of development continue into the foreseeable future? When will the demand for community to take up the slack left by declining government input exceed its capacity to do so? Our service providers were for the most part positive about their roles and about their communities as healthy places. And although our research indicates that the social capital of even the smallest communities studied has not yet been depleted, it leaves open the question as to whether this reliance upon community can continue indefinitely, or whether the stresses and strains of the continual demands that are made upon individuals will eventually reach a breaking point. These communities might be healthy places today, but this question will need to be revisited on a regular basis.

Acknowledgements

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The plebiscites of Regina's 1985 civic election

I never vote for anyone; I always vote against
W.C. Fields (1880-1946)

Bernard D. Thraves, University of Regina

Abstract: The Regina civic election of 1985 was unusual insofar as it included three plebiscites. Electors were asked to vote on proposals to fluoridate the municipal water supply, and to sell light beer at Taylor Field and low alcoholic beverages at Exhibition Park. Results of the plebiscites indicated clear rejection of each proposal. Nevertheless, rejection was unevenly expressed across the city and some neighbourhoods voted in favour of the proposals. Generally, votes for and against the proposals contrasted inner city with suburban areas and northern suburbs with southern suburbs. This paper explores the background to the plebiscites, interprets the voting patterns associated with each and comments on their outcome in the longer-term.

Introduction

Canada is a federal state in which political power is shared by the national and provincial governments. A third level of government, namely that of civic or municipal administration also exists but remains relatively neglected as a field of academic study. Such neglect is surprising in view of the impact and immediacy of municipal decision-making on the lives of citizens (Sancton 2000). In Regina, studies of civic governance have been mostly confined to ones defining the city's electoral history and comparing the merits of alternative electoral systems (de Vlieger 1980; Brennan 1989). Studies by geographers or with predominantly geographical themes are not found. Consequently, the city's electoral geography remains largely unexplored. In addressing this topic, the following discussion focuses on the background to and outcome of three plebiscites conducted as part of Regina's 1985 civic election. These plebiscites are selected for review for

two reasons. First they focus on selected issues in public health and safety and, second, they were conducted at the same moment in time and thus the 'mood of the electorate' can be viewed as neutral when drawing comparisons between the plebiscites.

The Plebiscites

In 1985, Regina's electorate was asked to vote on two bylaws and one question. Bylaw 8034 proposed fluoridation of Regina's municipal water supply. If the majority of voters voted in favour of the Bylaw, City Council would proceed with final passage of the same within four weeks of the election. A second bylaw, Bylaw 8081, sought approval for the City to apply for a license to sell light beer at Canadian Football League (CFL) games at Taylor Field, home of the Saskatchewan Roughrider Football Club. In this case the result of the plebiscite would not be binding. Instead, if the majority of voters voted in favour of the Bylaw, City Council could choose to pass the Bylaw at its discretion. The third proposal was presented as a question rather than a bylaw, but it also concerned the sale of alcohol and was similarly framed. It asked electors whether they were in favour of the sale of low alcoholic beverages at Exhibition Park during sporting events attended primarily by adults. Again, a vote in favour of the question would not be binding on City Council.

Data and methods:

The background to the plebiscites was established through a search of City Council records for 1985 and from examination of feature articles, editorials and letters to the editor appearing in *The Leader Post* in the one month preceding and one week following the election. On Election Day, October 23 1985, polling took place in 113 polls spaced across ten wards and in 26 special polls located in hospitals, care facilities and retirement homes. In addition, the votes from an advance poll were allocated at the ward level. Approximately 50% of 113,721 persons on the voter list recorded eligible votes. Results of polling were obtained from City of Regina Archives and are summarized in Table 1. A base map showing poll boundaries was provided by the same source. This was digitized and used in presenting poll-by-poll results for each plebiscite. The following interpretation of the plebiscites and their long-term outcome is guided by informal interviews conducted with city councillors, primary stakeholders and leaders of advocacy groups associated with the plebiscites where these could be identified. The discussion is necessarily speculative in places. Privacy of the ballot box plus the absence of exit polls and the records of formal

Table 1: *Results of plebiscites by poll type.*

Poll type	Number and proportion of votes cast for and against					
	Fluoridation of the municipal water suppy (Bylaw 8034)		Sale of light beer at Taylor Field (Bylaw 8081)		Sale of low alcoholic beverages at Exhibition Park	
	Yes	No	Yes	No	Yes	No
Advance	583	619	390	798	415	799
	(48.5%)	(51.5%)	(32.8%)	(67.2%)	(34.2%)	(65.8%)
Special	490	1,012	288	1,104	353	1,270
	(32.6%)	(67.4%)	(20.7%)	(79.3%)	(21.7%)	(78.3%)
Election day	24,558	29,895	21,526	31,881	22,155	32,918
	(45.1%)	(54.9%)	(40.3%)	(59.7%)	(40.2%)	(59.8%)
Total	25,631	31,526	22,204	33,783	22,923	34,987
	(44.8%)	(55.2%)	(39.7%)	(60.3%)	(39.6%)	(60.4%)

Source: City of Regina Archives

political parties makes questions pertaining to voting behaviour difficult, if not impossible, to answer with complete certainty.

Fluoridation of the Water Supply

Great controversy surrounds the issue of fluoridation of public water supplies. Proponents of fluoridation point to its beneficial effects on dental health, and especially on the dental health of children (Health Canada 2002). They argue that community fluoridation is safe, inexpensive, practical and effective. In Canada, endorsement of this view is expressed by the Canadian Public Health Association, the Canadian Medical Association, the Canadian Dental Association, and in Saskatchewan, by Saskatchewan Health (SaskHealth 2003). Opponents of fluoridation point to its association with a long list of health risks including dental fluorosis, skeletal fluorosis, thyroid problems, immune disorders, heart disease, various cancers and infertility (Groves 2001). In addition, some opponents argue that fluoridation is undemocratic and violates basic human rights and specifically the Canadian Charter of Rights and Freedoms (Graham and Morin 1999; Millership 2001). The purpose of the current discussion is not to pronounce

on the relative merits of these arguments, but rather to describe the context of the 1985 plebiscite and to interpret the voting patterns it produced.

The 1985 plebiscite was not the first time Reginans had been asked to vote on fluoridation. In 1954, a plebiscite on fluoridation was defeated quite decisively with 59.6% of voters voting against the proposal. Despite this, a similar question was put before the electorate in 1958. This time the margin between those voting 'no' (51.3%) and 'yes' (48.7%) was quite narrow. The closeness of this vote provided support for a further plebiscite in 1965. This too was defeated with 57.9% of voters voting against the proposal. In April 1985, Regina Citizens for Fluoridation (RCFF) presented a petition to City Council requesting that a bylaw be submitted to electors. As the petition contained 6,825 valid signatures it fulfilled the 5% requirement of the Urban Municipality Act and was accepted by Council in anticipation of a plebiscite being included in the October election (Regina City Council 1985a).[1]

Introduction of the petition caused heated debate. First, the Pure Water Association of Canada (PWAC) and the Regina Council of Women (RCW) objected to what they considered was obscure and misleading wording of the proposed bylaw (Regina City Council 1985b, 1985c, 1985d). Specifically, the bylaw proposed:

> That the fluoride ion content of water supplied to the residents of Regina by the Corporation of the City of Regina shall be adjusted to a level between 0.8 mg/l (milligrams per litre) and 1.2 mg/l (milligrams per litre).

Objection focused on the word 'adjusted' when in reality an 'increase' was being proposed, and on the use of metric units and scientific terminology. Still greater controversy attended City Council's decision to grant $28,451 to the City's Health and Public Affairs Departments to provide the public with 'information and education about fluoridation.' The PWAC, RCW and others claimed that the 'information' provided by the Departments was biased in that it presented only arguments in favour of fluoridation (Regina City Council 1985c, 1985d). Amidst accusations of misspending of public funds and undemocratic behaviour they called for a balanced presentation of the arguments and/or financial support for groups opposing fluoridation. In reply, the City's Board of Health and Social Planning argued that no funds would be used to "support any citizens group, pro or anti" and recommended to City Council that the public education program should proceed (Regina City Council 1985e). Undaunted, the PWAC asked City Council to rescind the motion granting funds to the Health and Public Affairs Departments, and should it fail to

do this, that it grant the PWAC a similar amount (Regina City Council 1985f).[2] Set against this highly charged background Regina's daily newspaper, *The Leader Post*, urged voters to settle the issue (*The Leader Post* 1985a). However, in a clear attempt to steer public opinion in favour of a 'yes' vote, the newspaper charged opponents of fluoridation with resorting to "scientifically unsubstantiated claims" and engaging in "excessive scaremongering."

In the lead up to the election the RCFF was backed by the Saskatchewan Dental Therapists Association and the Regina Health District. The RCFF mounted an extensive campaign which included information displays in four shopping malls, advertising on four large billboards at locations around the city, the printing and distribution of 60,000 fluoridation facts sheets, several television and radio presentations and an Election Day telephone canvass (Saskatchewan Archives Board no date).[3] The PWAC was supported by Mothers Against Fluoridation and Dr. Morris Schumiatcher, Saskatchewan's highest profile lawyer. Among other strategies, the PWAC invited renowned American biochemist Dr. John Yiamouyiannis to address a public meeting at the Saskatchewan Museum of Natural History (*The Leader Post* 1985b).[4] Pro and anti fluoridation supporters conducted a lively debate in the pages of *The Leader Post*. The RCFF ran a series of advertisements inviting the electorate to "Turn on to Fluoride!" and argued that millions of Canadians including the residents of Ottawa, Toronto and 57 Saskatchewan communities drank fluoridated water (*The Leader Post* 1985c). To counter this, the PWAC advised voters that fluoridation was forbidden in many European countries, and was not practiced in many of Canada's largest cities including Calgary, Montreal, Quebec City and Vancouver, or in the overwhelming majority of Saskatchewan communities (*The Leader Post* 1985d).

The two mayoral candidates, Larry Schneider and Henry Baker, aligned themselves with the opposing campaigns. As the incumbent mayor, Schneider gave low-key support to proponents of fluoridation. Baker, who had served as Regina's mayor from 1959-1970 and 1974-1979, was unapologetic in his opposition to fluoridation which he likened to the use of sodium fluoride to kill infestations of rats on farms in the 1930s (*The Leader Post* 1985e). Somewhat ironically, whilst Baker's opposition to fluoridation seemed to strike an accord with much of the electorate, on other issues his campaign had much less appeal and he was defeated decisively in his bid to regain the mayorship.[5]

Results of the plebiscite produced a clear if not overwhelming victory for the anti-fluoridation campaign with the size of the 'no' vote (55.2%) being similar to that recorded in 1965 (*The Leader Post* 1985f). Nevertheless, rejection of the proposal was not expressed evenly across all polls or in all

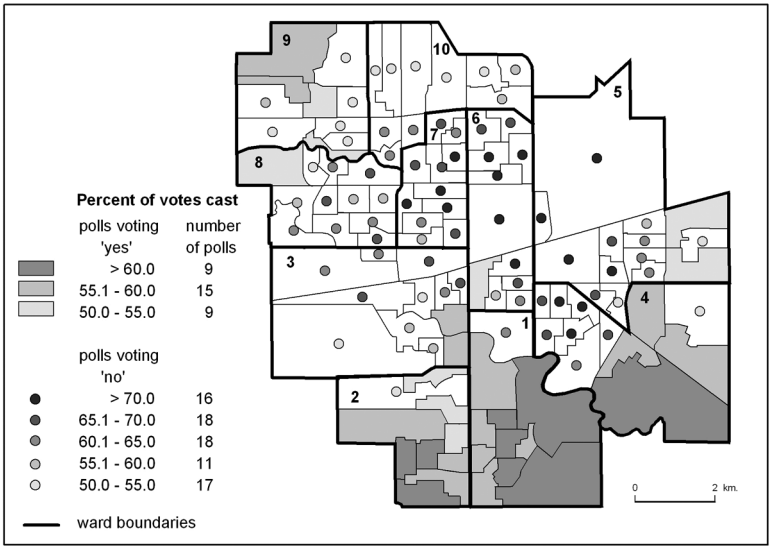

Figure 1: *Result of plebiscite on fluoridation of municipal water supply. (Source: City of Regina Archives)*

parts of the city. Greatest opposition (67.4%) was registered in the 26 special polls, 17 of which rejected the proposal. In total, the special polls accounted for 2.6% of voter turnout, but 3.2% of the 'no' vote. An obvious explanation for this phenomenon is not available. However, as most persons participating in special polls were elderly, it is tempting to attribute the large 'no' vote to the wisdom or conservatism that reputedly accompanies age, or to the possibility that dental health is not the most pressing health care priority of elderly persons. Results of the advance poll were more balanced with just over half (51.5%) voting against fluoridation. Presumably the two campaigns were able to muster approximately equal numbers of their most committed supporters. However, on Election Day itself the proposal was rejected by a clear majority (54.9%) of voters.

Despite the overall victory of the 'no' vote, fluoridation was rejected by a majority of voters in only 80 of the city's 113 electoral polls (Figure 1). This feature of the plebiscite reflected the greater spatial concentration of the 'yes' vote. On Election Day, half (50.7%) of the 'yes' vote was drawn from just 37 (32.7%) of 113 polls. Polls voting 'yes' were largely confined to suburban areas of the city and particularly to large parts of Wards 1 and 2 and smaller parts of Wards 4 and 9. Together these four wards accounted for 52.0% of the 'yes' vote. By and large voters in the inner city opposed fluoridation. The 'no' vote was particularly strong in Wards 6 and 7 where

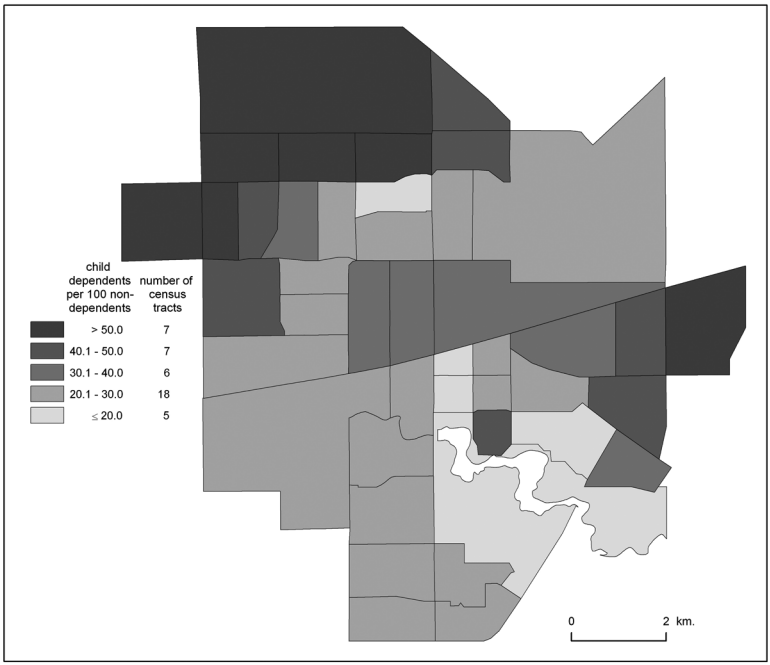

Figure 2: *Variation in child dependency ratios, 1986. (Source: Statistics Canada, 1988a)*

it exceeded 70% in nine of 22 polls. In the same wards only one poll voted in favour of fluoridation and did so by the narrowest of margins (50.2%).

Three factors are suggested to account for the voting pattern. Of these, the first recognizes that the greatest benefits of fluoridation are reputed to accrue to children. Thus, notwithstanding the initiatives of Mothers Against Fluoridation, it seems reasonable to assume that the strongest 'yes' vote would be registered in areas of the city with large numbers of children, and conversely, that the 'no' vote would peak in areas with relatively few children. However, dependency ratios for children aged 0-14 fail to support this view (Figure 2).[6] Specifically, areas (census tracts) with high dependency ratios in the northern and eastern suburbs generally opposed or offered weak support for fluoridation whilst areas with lower dependency ratios in the southern suburbs exhibited strong support. At best a weak positive correlation between support for fluoridation and child dependency is suggested. Unfortunately, differences in both the number and geometry of electoral polls (Figure 1) and census tracts (Figure 2) prevent measurement of a correlation statistic.[7]

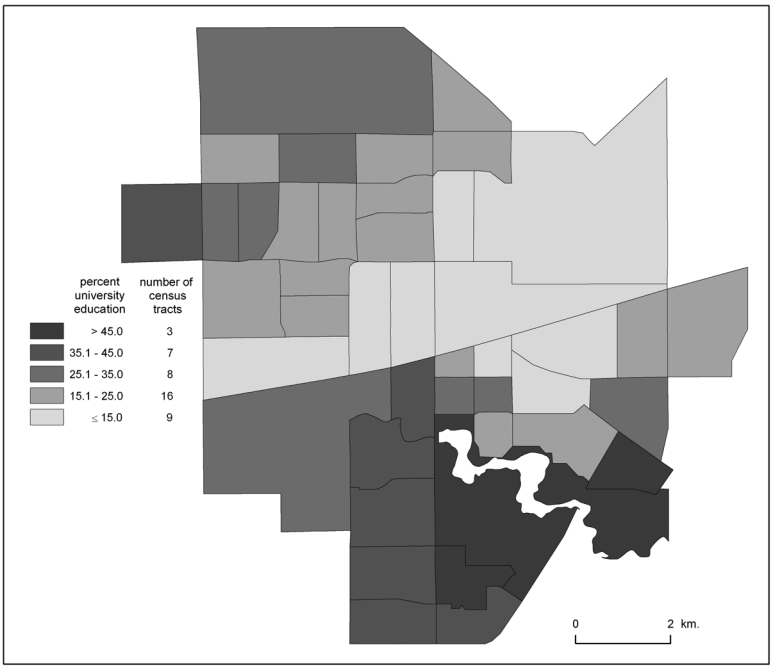

Figure 3: *Variation in population 15 years and over with some university level education, 1986. (Source: Statistics Canada, 1988b)*

A second explanation of the voting pattern is found in the educational status of Regina's population. Here the argument is made that the pro-fluoridation campaign drew most of its support from persons with high educational status (Nelson 2004). In 1986, educational status exhibited distinct zonation (Figure 3). High educational status in the suburbs was contrasted with comparatively low educational status in most inner city neighbourhoods. In addition, educational status tended to be slightly higher in southern than in northern suburbs. Comparison of the distributions in Figures 1 and 3 seems to support the claim of pro-fluoridation campaigners. Polls that voted 'yes' tend to match with census tracts showing high-educational status, and polls that voted 'no' match tracts with low-educational status. Again, a precise statement of the association is not possible as the different geographies of the polls and tracts preclude correlation analysis. Also, some caution is warranted in comparing the distributions. One cannot assume that all of the most educated voters in high-education tracts voted 'yes' and, conversely, that all of the least educated voters in low-education tracts voted 'no.' Despite

this, the association between voting preferences and educational status seems strong and provides a credible explanation of the voting pattern. At the same time, this explanation is not meant to imply that a vote in favour of fluoridation represented a 'preferred' or 'correct' outcome to the plebiscite.

The third, and perhaps the most intriguing, explanation for the voting pattern is based on the nature of Regina's water supply and distribution system in the 1980s. In 1985, Regina's potable water was derived from two sources: Buffalo Pound, a large lake 55 km west-northwest of the city, supplied most of the city including the southern suburbs; local wells supplied the inner city and some neighbourhoods in the east of the city. Local well water was much harder than water from Buffalo Pound. It contained high levels of iron and manganese and, as drinking water, it was generally less desirable than water from Buffalo Pound where recent upgrading of the treatment plant had eliminated problems of odour and taste. Based on these conditions it is suggested that residents of areas receiving well water might have been less trusting of or willing to accept the addition of another chemical, namely sodium fluoride, to their water, and hence were more likely to vote 'no' (Calam 2005). Of course, the association between water source and voting preference may simply be coincidental.

Long-term outcomes:

Since 1985 the issue of fluoridating Regina's water supply has not returned to the forefront of the political arena. However, the issue has not disappeared completely. Opponents of fluoridation claim success in preventing the question of fluoridation being re-introduced during the 1997 civic election (Bryde 2004). Currently, approximately 50% of Saskatchewan's urban municipalities, including the cities of Saskatoon, Prince Albert, Moose Jaw and Swift Current, fluoridate their water. In 2002, the Regina Urban Environment Advisory Council noted that children in Moose Jaw had a lower incidence of tooth decay than children in Regina, and attributed this difference to fluoridation of Moose Jaw's water supply (RUEAC 2002). Although plebiscites on fluoridation have been defeated four times it is not inconceivable that a fifth plebiscite might be presented at some future date.[9] Irrespective of the merits of arguments for and against fluoridation, a plebiscite might be justified simply on the grounds that it is already 20 years since the last one. Since 1985 the composition of Regina's electorate has changed considerably as part of wider changes in the city's social geography and demographic structure. Arguably, a decision made

in 1985 should not be binding on a substantially different population in 2005.

Beer Sales at Taylor Field

Taylor Field is located in Regina's North Central neighbourhood on a two-block site approximately 0.5 kilometres northwest of the central business district. It is bounded on the south by extensive areas of open space that are used for parking during sporting events and by the mainline of the Canadian Pacific Railway (CPR). On its remaining sides the Field is surrounded by an area of predominantly low-income single-family dwellings most of which were built before 1930.

In 1985, Taylor Field, unlike the other stadiums in the CFL, was dry…or was at least 'officially' dry. Furtive drinking in the stands was *de rigueur* and unquestionably some fans arrived at games already more fortified to brave the elements than was generally deemed acceptable in a public place. Despite this, or perhaps in order to quell disruptive behaviour stemming from illicit drinking, a proposal to sell beer at Taylor Field was presented by City Council under the terms of the Liquor Licensing Act. Specifically, the Act required that a question be addressed to the electorate in the form of a proposed bylaw.

Approval of the bylaw was unlikely from the start. Early in the election campaign *The Leader Post* carried a feature article alerting readers to the negative aspects of alcohol consumption (*The Leader Post* 1985g). Similarly, the Saskatchewan Safety Council expressed concern over alcohol-related accidents and advised citizens to vote against the proposal (*The Leader Post* 1985h). Even the Roughrider's management were divided on the proposal as they feared approval of the bylaw might alienate some season ticket-holders (*The Leader Post* 1985i). Then on the eve of the election *The Leader Post* expressed the view that the plebiscite had been "introduced to Regina City Council through the back-alley of secrecy – the council legislative committee" and "got its impetus, not from a cross-section of the community asking, but from the desire for an added revenue source" (*The Leader Post* 1985j). Set against this background it is hardly surprising that the proposal was rejected by a margin of three (60.3%) to two (39.7%).

Rejection of the proposal was not evenly expressed. Greatest opposition (79.3%) was registered in the 26 special polls, only one of which (Extendicare Parkside) voted in favour of the proposal. This feature of the plebiscite is somewhat curious insofar as the residents of retirement

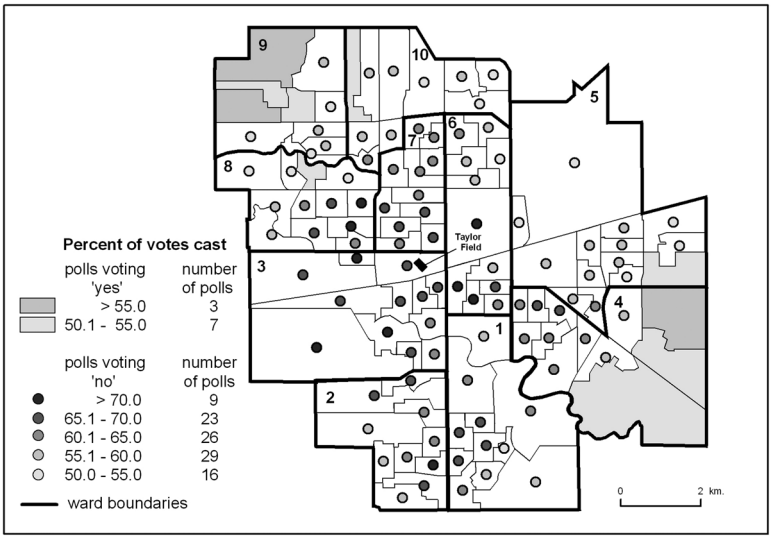

Figure 4: *Result of plebiscite on sale of beer at Taylor Field.* ***(****Source: City of Regina Archives)*

homes and care facilities would be relatively isolated from the any negative consequences stemming from the introduction of beer sales at Taylor Field. The proposal was also rejected by over two-thirds (67.2%) of persons voting in the advance poll. On Election Day itself the proposal was rejected by three out of five (59.7%) voters, and in 103 of the city's 113 electoral polls. Rather predictably, the 'no' vote was generally strongest in inner city polls close or adjacent to Taylor Field (Figure 4). Residents of these polls could expect to be more affected than residents of more distant polls by any anti-social behaviour stemming from the sale of alcohol at Taylor Field. Significantly, the few polls that voted 'yes' were located at great distance from Taylor Field in suburban areas in the northwest and southeast of the city.

Despite the apparent explanation of the voting pattern provided by distance from Taylor Field, an equally satisfactory explanation is provided by differences in household income. In 1985, median household income exhibited distinct zonation in which high income suburbs were contrasted with low-income inner city neighbourhoods (Figure 5). Comparison of Figures 4 and 5 shows that greatest support for beer sales tended to be in high-income neighbourhoods, whilst greatest opposition was frequently associated with low income areas. It is possible that the voting pattern also reflected the distribution of Roughrider season ticket holders. Here it is assumed that, because of their high cost, most season tickets would be

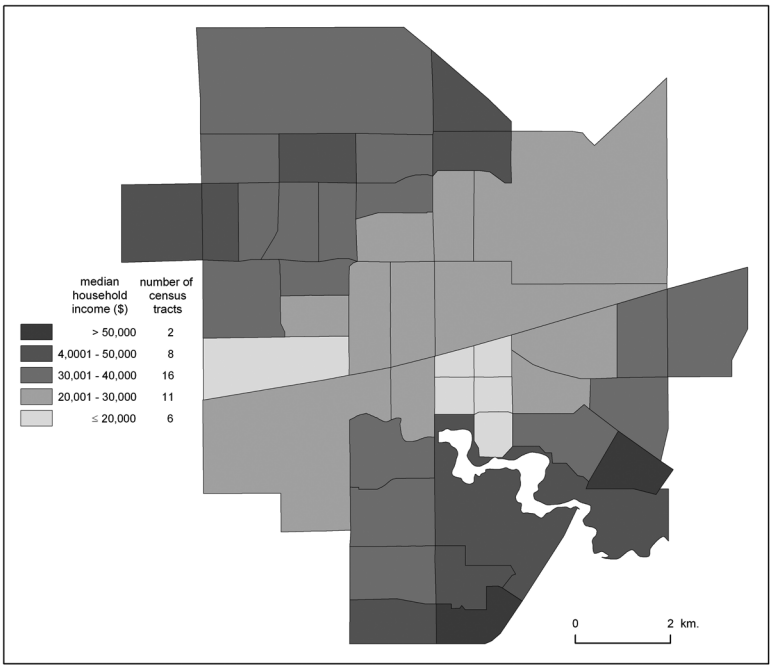

Figure 5: *Variation in median household income, 1985.* ***(****Source: Statistics Canada, 1988b)*

purchased by high-income suburban residents. However, in the absence of data showing the distribution of season ticket holders in 1985 and a retrospective survey to ascertain their then views with respect to alcohol sales, this conclusion must remain speculative.

Alcohol Sales at Exhibition Park

Regina Exhibition Park is located on a 41.3 hectare site four blocks west of Taylor Field. Like Taylor Field its southern boundary is marked by the right-of-way of the CPR mainline. However, except for a three-block area immediately north of the Park, it is otherwise surrounded by non-residential land uses. These include Pasqua Hospital to the northwest of the Park and the Royal United Services Institute Armouries to the northeast. Much of the rambling site is devoted to livestock and exhibition barns, and parking lots. In 1985, a trotting course and stadium (Queensbury Downs) and sports arena (Agridome) were located at the centre of the site.

In September 1985, a delegation from the Regina Exhibition Association approached City Council and requested that a question regarding the sale of low alcoholic beverages (beer, wine, cider) at the Park be included in the forthcoming election (Regina City Council 1985g). The delegation stressed that the primary intent of the proposal was to permit alcohol sales at horse racing events, but asked that legislation be written in such a manner that it would cover other sporting events (e.g., motor racing and rodeo) attended primarily by adults if and when the Association developed these. By their very nature these events would take place at Queensbury Downs. Events at the Agridome, including hockey, were not specifically mentioned in the proposal.

In contrast to the well publicised debate over beers sales at Taylor Field, the proposal to sell low alcoholic beverages at the Park was rarely mentioned in the printed media or at City Council during the lead up to the election (*The Leader Post* 1985k). Rather curiously, voter support for the proposal was not sought by the Association and, although it recognized that alcohol sales might help secure the position of horse racing at the Downs, it had little sense of the potential revenues such sales might generate. Yet despite the low-key introduction and apparently non-controversial nature of the proposal it was firmly rejected at the polls. As with the fluoridation and Taylor Field plebiscites, greatest opposition (78.3%) was registered in the special polls all of which voted against the proposal (Table 1). Almost two-thirds (65.8%) of persons voting in the advance poll also rejected the proposal. On Election Day the proposal was rejected by three out of five (59.8%) voters, and in 104 of the 113 electoral polls. Opposition tended to be greatest in inner city polls adjacent to Exhibition Park and least in suburban areas especially those in the southeast of the city (Figure 6). On a poll-by-poll basis the voting pattern closely resembled that of the Taylor Field plebiscite ($r_s = 0.905$).

In explaining the voting pattern the same distance bias and social (income) status relationships are suggested as proposed for the Taylor Field plebiscite. However, in view of the untroubled manner in which the Exhibition Park proposal was introduced, it is possible that it became inseparable from or confused with the Taylor Field proposal in the minds of the electorate and was rejected simply for being 'guilty by association.' Taken together the outcome of the two plebiscites are surprising in at least one respect. Popular belief views suburban areas as bastions of conservative values where liberalization of laws pertaining to alcohol consumption might be least expected. In 1985, this was not the case in Regina.

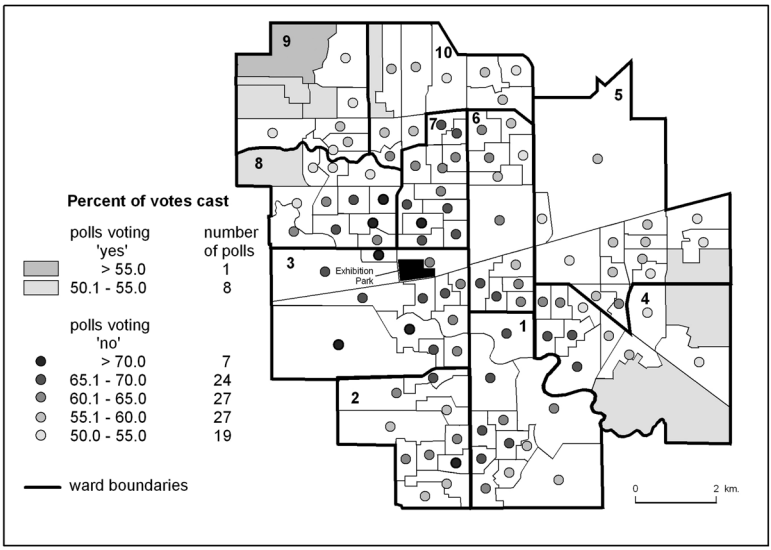

Figure 6: *Result of plebiscite on sale of alcoholic beverages at Exhibition Park. (Source: City of Regina Archives)*

Long-term outcomes:

In June 1988, the provincial government passed the Alcohol Control Act. The Act replaced the existing Liquor Licensing Act and provided new provisions under which alcohol could be sold at sports stadiums. Most importantly, it nullified the results of the plebiscites on sales of alcohol at Taylor Field and Exhibition Park and provided the City with powers to enact bylaws pertaining to the sale of alcohol at sports stadiums without first submitting such bylaws to the electors. In 1989, upon the request of The Regina Exhibition Association, City Council passed Bylaw 8852 to allow the sale of beer and wine at all events held in the Agridome (Regina City Council 1989a, 1989b).

Successful implementation and operation of Bylaw 8852 paved way for the introduction of alcohol sales at Taylor Field. Under the terms of the Act, City Council passed Bylaws 9361 and 9482 in 1992 and 1993 Regina (City Council 1992, 1993). These permitted the progressive introduction of light beer sales at Taylor Field for games and special events involving the Roughriders. Passage of the Bylaws brought Taylor Field into line with other stadiums in the CFL where beers sales were allowed. Arguably, in passing the Bylaws the City acted in the interest of the general (tax paying) public. Beer sales were expected to improve the profitability of the Roughriders and thereby increase the prospect of a financial return to the

City under the terms of the Club's lease agreement. Also, beer sales fitted with the City's strategy to expand and improve its hospitality service industry in anticipation of Regina (Taylor Field) hosting the Grey Cup in 1995.[10]

So the question remains: were the fears of those who advised against the introduction of alcohol sales justified? More specifically, did the introduction of beer sales at Taylor Field result in negative impacts on the local neighbourhood? Such evidence as exists suggests that it did not. In its 1993 report to City Council recommending passage of Bylaw 9482, the Executive Committee (of Council) noted that "Experience at Taylor Field during the 1992 season showed no negative impacts from the issuance of the licence….Your Administration is not aware of any concerns in respect to areas of jurisdiction by the City" (Regina City Council 1993). Since 1993, Taylor Field has hosted two Grey Cups and over 100 football games and special events. Cognizant of its civic responsibility, the Roughrider Club has engaged with Saskatchewan Liquor and Gaming Authority, Saskatchewan Government Insurance, City Council and others to ensure that any potential for adverse effects from the sale of beer are minimized, and hopefully eliminated completely. Initiatives have included provision of increased security at games, termination of beers sales after third–quarter intermissions, operation of designated driver programs and shuttle bus services, and development of an outreach program to elementary and secondary schools stressing the benefits of healthy lifestyles. These initiatives appear to have been successful. In the view of one veteran city councillor the substance of the 1993 Executive Committee report probably still holds true, and adds "I served 10 years on the Board of Police and during that time we had no reports of concern that I recall" (Badham 2005). Instead, neighbourhood concerns have focused on the slow clean up of litter in the neighbourhood following the 2003 Grey Cup game and vandalism of and theft from vehicles of fans attending games at Taylor Field (Dundas 2005).

Sadly, beer sales failed to save horse racing at Queensbury Downs. The last race was run in the fall of 2002. Whilst sales at Agridome and Taylor Field are now routine at most events, few in attendance seem to know, or care, whether the beer is made from fluoridated water. It very likely is. In March 2002, Regina's Molson brewery closed. Most beer now consumed at Agridome and Taylor Field must be shipped from Edmonton or Saskatoon where the breweries use municipally supplied fluoridated water.

Conclusion

The preceding discussion has focused on the context and outcome of three plebiscites conducted as part of Regina's 1985 civic election. Each plebiscite was convincingly if not overwhelmingly rejected. Typically, opposition to the proposals reflected long-standing social status divisions or distance bias effects both of which contrasted inner city with suburban areas, and northern with southern suburbs. In addition, greatest opposition was expressed in special polls most of which were conducted in retirement homes and extended care facilities. Although special polls did not determine the overall outcome of the plebiscites, they might easily have done so had the Election Day polls been more evenly contested. This is no small point. In 1985, special polls accounted for 2.6% of voter turnout. By the 2003 election this share had increased to 3.3%. Over the next few decades societal aging is likely to result in both absolute and relative increases in the size of Regina's elderly population. The population living in care facilities is also likely to increase. Consequently, astute politicians and advocacy groups in future elections may benefit considerably by appealing to or fostering the support of these constituencies.

In 1988, the City again included three plebiscites as part of the civic election. However, since then plebiscites have not been used as an instrument for measuring public opinion. Their absence does not reflect a lack of unique or sensitive issues in civic affairs in recent years. Instead, it more likely reflects increases in the powers of City Council to determine policies without recourse to direct public consultation. Such was the case in the passing of Bylaws 8852, 9361 and 9482 to permit alcohol sales at Agridome and Taylor Field. It also reflects the power of City Council to resist public pressure. For example, in 1995 City Council declined to hold a plebiscite to assess public support for the opening of Casino Regina in Union Station, and this despite the Station being designated a Heritage Railway Station by Parks Canada in 1991. Had City Council conducted a plebiscite it might easily have been lost as was the case when casino plebiscites were held in Saskatoon in 1995 and 2003. Finally, perhaps the absence of plebiscites simply reflects the reluctance of electors to join or form advocacy groups and engage in the political process.

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Notes

[1] The Act stipulated that for acceptance a petition must be signed by more than 5% of the electorate. This set the required number of signatures at 5,555 (i.e., 5% of 111,091 electors). The original petition contained 6,875 signatures. After scrutiny by the City Clerk's office this total was revised to 6,875, an amount well in excess of that required.

[2] Immediately after the election City Council rejected a motion by Alderman W.J McKeown calling for the City to provide assistance to the Regina Pure Water Committee to help meet its financial obligations.

[3] The RCFF's archival record includes its correspondence with City Council, extensive notes on its campaign strategy, a statement of expenditures, plus various clippings from *The Leader Post* and some of the information circulated by the PWAC.

[4] In 1993, the Museum was renamed the Royal Saskatchewan Museum.

[5] Baker entered the campaign late and with a largely unrealistic platform including a proposal to have the provincial government declare Taylor Field a heritage project that would require building a dome over the playing area and greatly increasing its capacity to 50,000 spectators. To date, none of these proposals has been undertaken.

[6] Child dependency is measured as the number of children aged 0-14 divided by the population aged 15-64, times 100. A very similar result is produced if dependency is based on children aged 0-4.

[7] The external boundaries of Regina as defined by the City in 1985 and the census in 1986 differ slightly but both boundaries encompass virtually identical populations.

[8] Educational status is defined as the proportion of the population 15 years and over with at least some university level education.

[9] A precedence exists. Between 1957-1971, Calgarians rejected fluoridation four times, but then approved it in 1989 and voted to retain it in 1998.

[10] The Grey Cup is the oldest and most coveted trophy in Canadian professional sport. Each year the leading CFL teams in eastern and western Canada compete for the Cup at a host venue selected from cities with CFL teams.

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