Prairie Perspectives: Geographical Essays

Prairie Division
Canadian Association of Geographers
Association Canadienne des Géographes

Volume 21, 2019

PRAIRIE PERSPECTIVES: GEOGRAPHICAL ESSAYS

Edited by
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Preface

Prairie Perspectives: Geographic Essays is the journal of the Prairie Division of the Canadian Association of Geographers (PCAG). Each volume is published in coordination with the annual conference and business meeting of the division. The 42nd such gathering was hosted by the Department of Environment and Geography of the University of Manitoba over the weekend of September 28 to 30th, 2018. Seventy seven members attended the meeting, including 29 students. As usual, the weekend consisted of executive and business meetings, paper sessions, poster presentations, field trips, banquet, and keynote address. Two sets of concurrent paper presentations included sessions on food systems, urban geography, community planning, and climate and soils.

The meeting was held at the Lakeview Hecla Resort, within Hecla Provincial Park, Manitoba. This was not the first time PCAG has held its meeting at the resort, and given its success, it will likely return sometime. The field trips were coordinated by Dr. Heather Hinam, through her company Second Nature. Dr. Hinam is an ecologist with over 20 years' experience as a nature and heritage interpreter. Dr. Hinam led participants on the physical geography field trip to the northern point of the island, where they were able to see the expanse of Lake Winnipeg and learn about the surrounding boreal forest. From there the field trip stopped at the East Quarry to search for fossils and to learn about the area's rich archeological heritage. The physical geography trip ended with a walk on the boardwalk through the Grassy Narrows Marsh at the southern end of the island. The cultural geography trip was guided by David Hems from Manitoba Parks and focused on the rich history of Icelandic settlement on Hecla Island, which started in 1887. The Heritage Division of Manitoba Parks keeps this history alive through tours of restored buildings in the village site, and by focusing on the unique Icelandic settlement identity and the important fishery based out of the Hecla Village harbour. Participants in the tour walked through the village and learned about the trials of living in the harsh landscape and the resilience of cultural practices in the area.

The keynote speaker at the Saturday evening banquet was Dr. Genevieve Ali. Dr. Ali is a highly respected hydrologist who was an Associate Professor in the Department of Geological Sciences at the University of Manitoba at the time (she has recently moved to the University of Guelph). Her research has focused on the hydrological dynamics of inputs into Lake Winnipeg. Her talk, *Failure to Reduce Nutrient Loading to Lake Winnipeg? Understanding the role of Water Connectivity and Legacy Contamination*, focused on alternative explanations of current nutrient loading of Lake Winnipeg. Dr. Ali's research details the data collection methods employed to try to establish if nutrient loading in the lake, and the resultant algal blooms, is best reduced through blanket management of the 1,000,000 km^2 watershed, or by better, targeted methods of management. The talk led to a lively discussion and interest in potential management solutions to a significant provincial and prairie-regional problem.

Also at the banquet, Dr. Rachel Herron of Brandon University received the PCAG Early Career Award for her "significant scholarly contributions to the discipline and demonstrated exceptional achievement in teaching." Recognition was also extended to Dr. Roderick A. McGinn, of Brandon University, who received the John H. Warkentin Award for his "outstanding scholarly contributions to the geography of the western interior."

This volume of Prairie Perspectives contains three research papers and three review pieces. In the first research paper Katie Doke Sawatzky and Joseph Piwowar address the decline of the range of prairie grasslands between 1990 and 2015. They employ data from Agriculture and Agri-food Canada to show that, whereas concern for diminishing grasslands has long been voiced, only 14% rather than 20% of Saskatchewan's original grasslands remains. The second research paper, by Yossi Katz and John Lehr, examines the digital revolution within Hutterite communities on the prairies. While many of the religious regulations followed by the colonies restrict access to the Internet, in practice these restrictions are not universally followed. This situation is shaped by individual desires to access the Internet as well as the need to use Internet-based communication for the economic and administrative work of the colonies. The restrictions thus become an ideal mediated by practice and an on-going source of tension within the colonies. The final research paper by Jacqueline Binyamin and Hailey Robichaud tests the sensitivity of forest ecosystems to climate oscillations. They argue that as extreme weather and unusual climatic patterns increase with the onset of climate change, a greater understanding of the influences of these events on ecosystem productivity is required. Using net ecosystem productivity measurements in a pine forest in southern Ontario, the authors estimate the influence of El Niño Southern Oscillation and the North Atlantic Oscillation on the productivity of the forest.

Hồng Thị Hà and Aaron Kingsbury return in this volume with the second part of a project that they first reported on in Volume 20. In the current volume they asked rural American University students take everyday life photographs of themselves for students in North Vietnam to view. They report that, as in the earlier paper, the photographs elicited comments that recognized similar or shared social worlds which transcend the cultural divide and great physical distance separating Vietnam and the United States. In the second review, Christoph Stadel and Don Huisman describe the history and characteristics of the Riding Mountain Biosphere Reserve (RMBR). Building on the protected status of Riding Mountain National Park, the RMBR brings together stakeholders in the region surrounding the park to establish priorities for protecting this important ecological and cultural landscape. In the final review, Bernard Thraves presents a content analysis of Prairie Perspectives. By leading the reader through a detailed examination of journal content, the review highlights the success of the journal as both a forum for academic work and a community hub for prairie geographers.

Acknowledgements

I extend my thanks to the authors for submitting their manuscripts and meeting the challenges of the double-blind review process. Thanks are also extended to the reviewers for their pivotal role in assessing the quality of the manuscripts. For their work behind the scenes, Jonathan Peyton, Janna Wilson and Bonnie Hallman deserve recognition. Bernard Thraves took great care in copyediting all of the work in this volume, which contributes to the quality of the papers. Special thanks are extended to Weldon Hiebert at University of Winnipeg for his tireless work in dealing with the many technical challenges in the design and layout of the journal.

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Changes in prairie grassland extent in Saskatchewan from 1990 to 2015

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Key Messages

- The Saskatchewan government does not have an up to date inventory of the extent of grasslands in the province.
- We estimate that only 14% of Saskatchewan's original grasslands remain intact.
- Grassland ecosystems are a conservation priority and are threatened.

Grasslands are ecologically productive ecosystems: they provide habitat for a wide range of threatened and endangered species, act as carbon sinks, and are efficient nutrient recyclers. Yet grasslands are one of the world's most disturbed biomes, largely as a result of agricultural conversion. In North America it is estimated that only 30% of the original grasslands remain. In in Saskatchewan, the provincial government currently puts this estimate at closer to 20%. However, this estimate is based on a report that was published 18 years ago and we suspect that economic conditions have favoured additional grassland conversion since then. In this study, we examine published data from Agriculture and Agri-Food Canada (AAFC) to provide a more recent estimate of grassland extent in Saskatchewan. We find that the province had 17% of its grasslands intact in 1990, but by 2015 this was reduced to 14%, representing a loss of 3% over 25 years. Surprisingly, the AAFC data show that there is currently at least 6% less grassland coverage than is being reported by the Saskatchewan government. We conclude that the provincial government's agricultural policies do not make grassland conservation a priority.

Keywords: grassland, prairie, extent, Saskatchewan, policy

Introduction

The grassland biome is found on every continent except Antarctica and in total covers about 37% of the world's land surface (Hauser 2000; O'Mara 2012). Grasslands are ecologically productive with rich soils and are the source of most of the grains and legumes consumed by humans and ruminants (Suttie et al. 2005). Grasslands provide many goods and services including food, forage, and livestock; biodiversity; nutrient recycling, soil and water conservation, climate regulation, and carbon storage; as well as tourism and recreation (White et al. 2000; Hammermeister et al. 2001; Kulshreshtha et al. 2008).

Despite their importance, grasslands are one of the world's most disturbed and threatened ecosystems (Gauthier et al. 2003; Watmough and Schmoll 2007). As the global need for food continues to increase, and the landscape footprint of urban and other economic activities grows ever wider, they do so at the expense of grassland ecosystems. Ramankutty et al.

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(2008) report that around 20% of the world's grasslands have been converted to cultivated crops. In North America, the situation is more dire: Gauthier et al. (2003) found that less than 30% of original, mixed-grass and short-grass prairie remains. Further, the North American range of tall-grass prairie has been reduced to just 1% of its original extent (Gauthier et al. 2003). In Saskatchewan, an 18-year old study estimated that between 17% and 21% of the original prairie grasslands remain intact (Hammermeister et al. 2001). We suspect that this decline in grassland extent is continuing, but the Government of Saskatchewan continues to rely on this 18-year old statistic. Neither the Saskatchewan Ministries of Environment nor Agriculture know how much grassland is currently left in the province (Hall 2018; Sawa 2018).

The objective of this study is to provide a more recent estimate of grassland extent in Saskatchewan.

Context

Prior to the arrival of European settlers on the Great Plains in the latter half of the 19th century, Indigenous populations lived in a symbiotic relationship with grasslands (Daschuk 2013). However, the early settlers plowed much of the land for agriculture. From 1906 to 1916, the population of southwestern Saskatchewan quadrupled from 45,000 to 178,000, and cropland expanded from 200,000 ha to 2,000,000 ha (2,000 to 20,000 km^2) (Balkwill 2002). In order to take advantage of the economic potential of this newly settled region, the federal government called for more prairie to be plowed during World War I, and so 5,000,000 ha (50,000 km^2) more of prairie grassland were lost to agriculture (Gray 1967). The Saskatchewan Provincial Pastures (SPP) program began in 1922 with the intent of helping ranchers expand their herds (Government of Saskatchewan n.d.).

However, a combination of drought and poor farming techniques sent eroded soil into the air during the dust storms of the Dirty Thirties, leading to the abandonment of many homesteads (Gray 1967). In response the federal government formed the Prairie Farm Rehabilitation Administration (PFRA). Farmers received PFRA assistance to move off submarginal land, allowing those areas to be reseeded into grasses. This was the beginning of the PFRA Community Pasture Program (Gray 1967). At their peak, the PFRA community pastures spanned 930,000 ha (9,300 km^2) (Kulshreshtha et al. 2008), and the pasture management practices that were developed—provided by federally employed, local cowboys—became a global model for grassland management (Gertler 2018; Taylor 2018).

The creation of the PFRA signalled the beginning of the federal government's realization that grasslands and other prairie agricultural resources required more careful management than the exploitive policies that were espoused a decade earlier. The concept of 'management' was expanded to include 'conservation'. More recently, Grasslands National Park was established by Parks Canada to preserve the rich ecological, cultural, and paleontological heritage of the mixed-grass prairie (Parks Canada 2010; Herriot and Gjetvaj 2017).

In 2012, the federal government announced it was cutting the PFRA and that it was going to divest itself of all pastures by 2018, ending an 80-year program that brought employment and services to rural communities across southern Saskatchewan (Mandryk 2012). With Saskatchewan Agriculture's refusal to continue management of either the former PFRA pastures or the Saskatchewan Provincial Pastures, sustainable management was now being placed on citizens' shoulders (Fraser 2012; Robinson 2017).

Thus, the timeline of grassland conservation in Saskatchewan follows an arc from grasslands in the hands of private farmers who mismanaged it to public grassland managed well by third-party managers of community pastures, to now back in the hands of private patron groups, some with little grassland management expertise (Doke Sawatzky 2018).

Knowing how much grassland is left in Saskatchewan is a matter of public interest because grassland offers a variety of ecological goods and services. The province no longer regularly monitors the landscape and has no current estimates of how much grassland is left, which makes this study an important tool in informing the public. It also matters to Indigenous hunters and people who were forcibly removed from the plains and struggle to reclaim their identity, which is intimately tied to prairie land (Daschuk 2013).

Methods

Our focus in this study was on the grassland-dominated regions of southern Saskatchewan, as defined as the Prairie Ecozone by Agriculture and Agri-Food Canada and Environment Canada (Ecological Stratification Working Group 1995), because this is where most of the grassland loss has occurred (Figure 1).

Data on various land covers in the agricultural regions of Canada are available from Agriculture and Agri-Food Canada (AAFC). For this study, we accessed two AAFC data sets: Land Use 1990, 2000, 2010 (AAFCa n.d.) and Annual Crop Inventory 2009 to present (AAFCb n.d.). The Land Use (LU) data series begins in 1990 and is updated on a decadal period—a time scale that is suitable for our analyses. However, since we were interested in determining grassland extent more recently than 2010, we supplemented the Land Use series with 2015 data from the Annual Crop Inventory (ACI).

Although both the LU and ACI products are derived from satellite imagery, they were independently produced using separate methods and for different purposes. For example, the LU data were produced to support Canada's reporting to international organizations such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Food and Agriculture Organization of the United Nations (FAO) (AAFCa n.d.). The LU data have a simplified classification scheme designed to match the definitions of the Intergovernmental Panel on Climate Change (IPCC): forest, water, cropland, grassland, settlement, and otherland (barren land, ice, rock and unclassified). The accuracy of the LU classification was assessed by comparing the assigned classes of random locations with data from field sur-

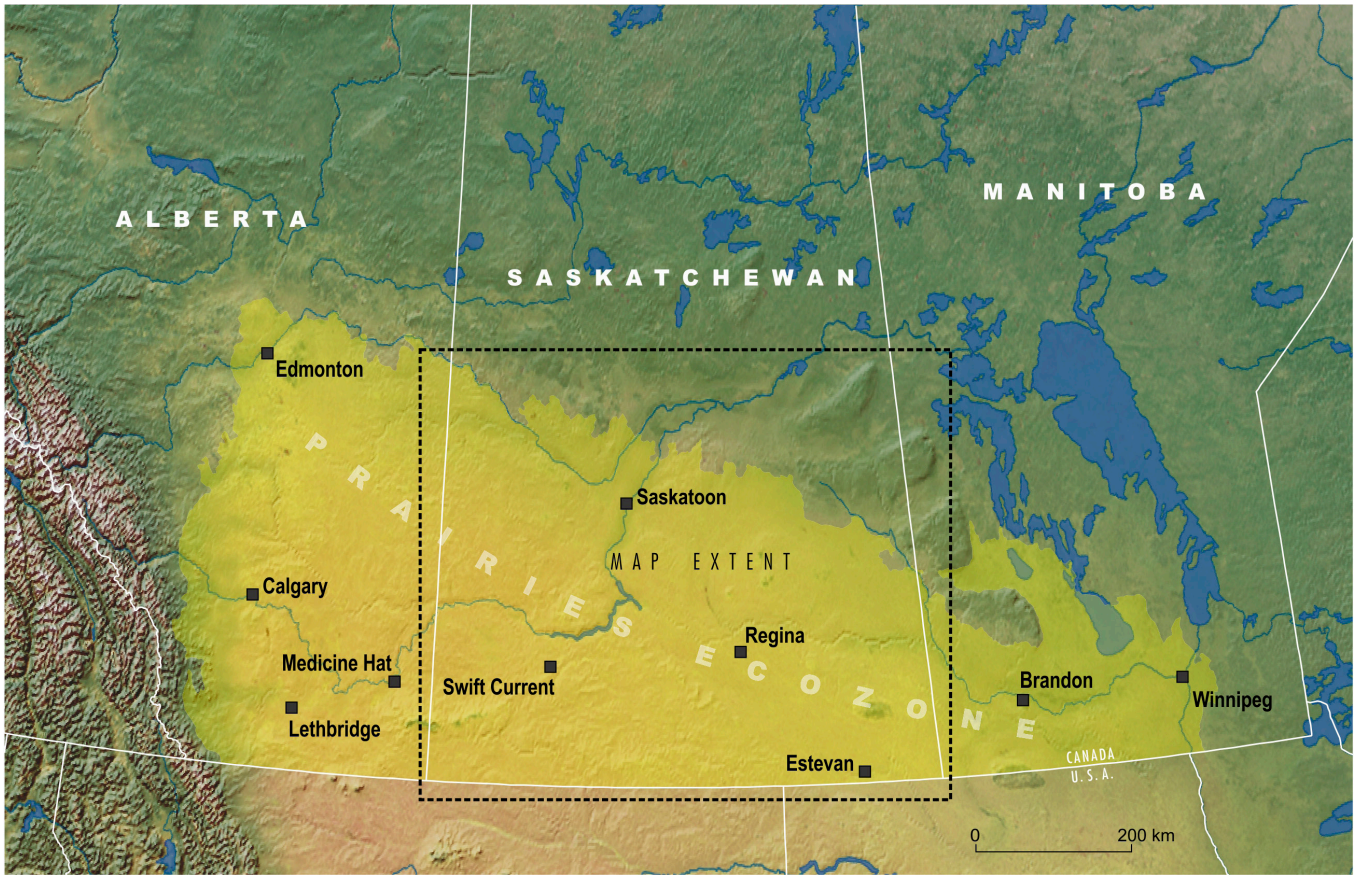

Figure 1
The extent of the Prairie Ecozone in Saskatchewan (Ecological Stratification Working Group 1995)
Cartography: W. Hiebert
Basemap: Natural Earth

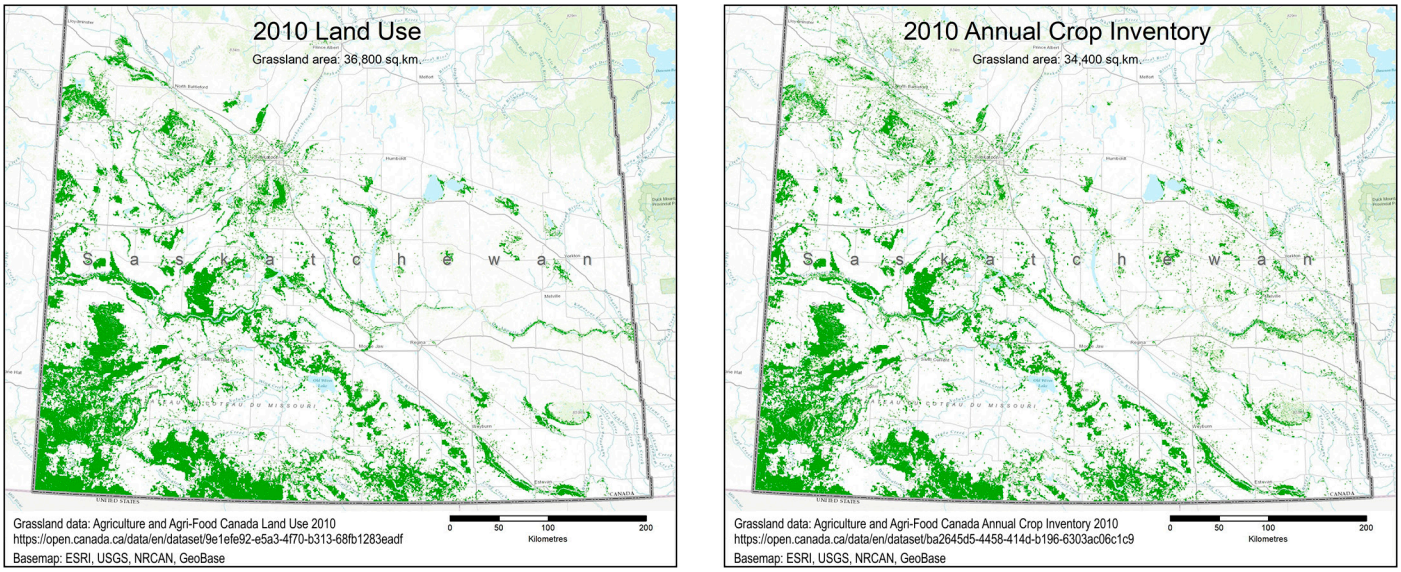

Figure 2
Comparison of grassland extents in the 2010 AAFC land use and 2010 AAFC annual crop inventory data
Cartography: J. M. Piwowar

veys or derived from visual interpretation of aerial photos or high-resolution satellite images. The overall accuracy for the 2010 classification was reported as 93%; somewhat lower in the grassland class (AAFCa n.d.).

On the other hand, the ACI data were produced for domestic agriculture policy and planning purposes. Similar to the LU data, the ACI data have a spatial resolution of 30 m (56 m for 2009–2010) but have a finer discrimination of various land covers than the LU data (AAFCb n.d.). The overall accuracy of the 2010 ACI classification for the Prairie Provinces was reported as 85% (AAFCb n.d.).

We wanted to extend the decadal LU time series (that presently ends in 2010) to 2015, so we augmented it with annual ACI data. In order to establish confidence that we could supplement the decadal LU data with the annual ACI classifications, we compared the grassland data from the period of overlap of the two data series for 2010 (Figure 2). The grassland extent compared favourably, showing an 82% correspondence between individual grassland locations in the two data sets and differing in total area by only 2,400 km^2 (6.7%). Since grassland extent differed by less than 10% between the LU and ACI data, we concluded that data from the two data sets could be used concurrently. We then had to decide which of the 2010 data sets we wanted to use in our analysis: LU or ACI. To help blend the transition between the data sets and to better match the 2015 data, we opted to use the ACI data for 2010. In summary, we measured grassland extents from: 1990 LU, 2000 LU, 2010 ACI, and 2015 ACI. Table 1 lists key characteristics from each data set.

Results

Grassland extents for 1990–2015 are shown in Figure 3. As summarized in Figure 4, the area covered by grasslands fell from 41,300 km^2 in 1990 (17% of the estimated extent of grasslands before European settlement) to 33,300 km^2 in 2015 (14% of original extent). Although the loss of grasslands has been widespread across the province, the changes have not been uniform. Figure 5 shows that while most of the grassland loss has occurred in the southwestern part of the agricultural region, there are some areas in the north and eastern parts that have seen an increase in grassland extent over this period.

Discussion

Determining the extent of grasslands is a difficult task, whether done manually or semi-automatically with the aid of remote sensing data. A manual survey of grassland extent would require a substantial workforce to visit every quarter section of the agricultural region of the province. Even then, there would be some areas that could be inaccessible by foot. Thus, grassland inventories are substantially improved with the use of remote sensing data, either collected from aircraft (i.e., air photos) or spacecraft (i.e., satellite imagery).

Air photos show grassland areas in an easily understandable format and at a large-enough scale to facilitate interpretation. However, their interpretation is time-consuming, and success depends on the visual acuity training and skill of the interpreter. If several interpreters are involved during the inventory process, some inconsistencies may arise. Nonetheless, experience tells us that the manual interpretation accuracy of grasslands on air photos is about 90% (Piwowar et al. 2017).

The identification of grasslands in satellite images is a purely objective and consistent process (Piwowar 2005). Satellite images are typically multispectral (i.e., colour, with additional information acquired in non-visible wavelengths of electromagnetic radiation) and all areas that have the same spectral properties as a known sample of grassland, will be categorized as grassland (Piwowar 2005). Since the interpretation process can be automated, it is many orders of magnitude faster than air-photo interpretation. Further, satellite image interpretation benefits

Table 1
Grassland data set characteristics

Year	Data Set	Attribute Data	Spatial Resolution	——Reported Classification Accuracies——	
1990	LU	managed grassland	30 m	Overall: 84% Grassland: User's – 55%	Producer's – 71%
2000	LU	managed grassland	30 m	Overall: 87% Grassland: User's – 58%	Producer's – 68%
2010	ACI	grassland	56 m	Crop classes: 85%	
2015	ACI	grassland	30 m	Crop classes: 90% Non-agricultural land cover: 69%	

Sources: LU - Land Use (AAFCa n.d.); ACI - Annual Crop Inventory (AAFCb n.d.)

from its repeated temporal coverage and from its ability to discriminate different grassland vegetation species by their spectral properties (Piwowar 2005). The former adds an important verification option to flag areas that were once grassland but are now identified as water or are currently non-vegetated. Such areas may, in fact, still be grassland but are flooded in the present year or may no longer be grassland because they have been plowed.

The varied nature of grassland vegetation and the spectral similarities between grasses and other plant species means that they are occasionally misidentified in satellite imagery as other vegetation communities. For example, AAFC data show that grasslands are sometimes confused with forested or cropland areas (AAFCa n.d.). The overall error rate for non-crop classes (including grasslands) in 2015 was 31% (AAFCb n.d.). Thus, although an inventory of grassland extent from air-photo interpretation may be more accurate, such a process is impractical particularly if the inventory is to be repeated on a regular basis. Although the accuracy of grassland extents is somewhat less when compiled from satellite imagery, such inventories are useful because of the objective and repetitive nature of the satellite image classification process (Piwowar et al. 2017).

Although the loss of grasslands has been widespread across the province, some areas have seen an increase in grassland extent over this period (Figure 5). We conducted an analysis of the areas of grassland loss using past and present satellite imagery and found that most of them are now cultivated croplands.

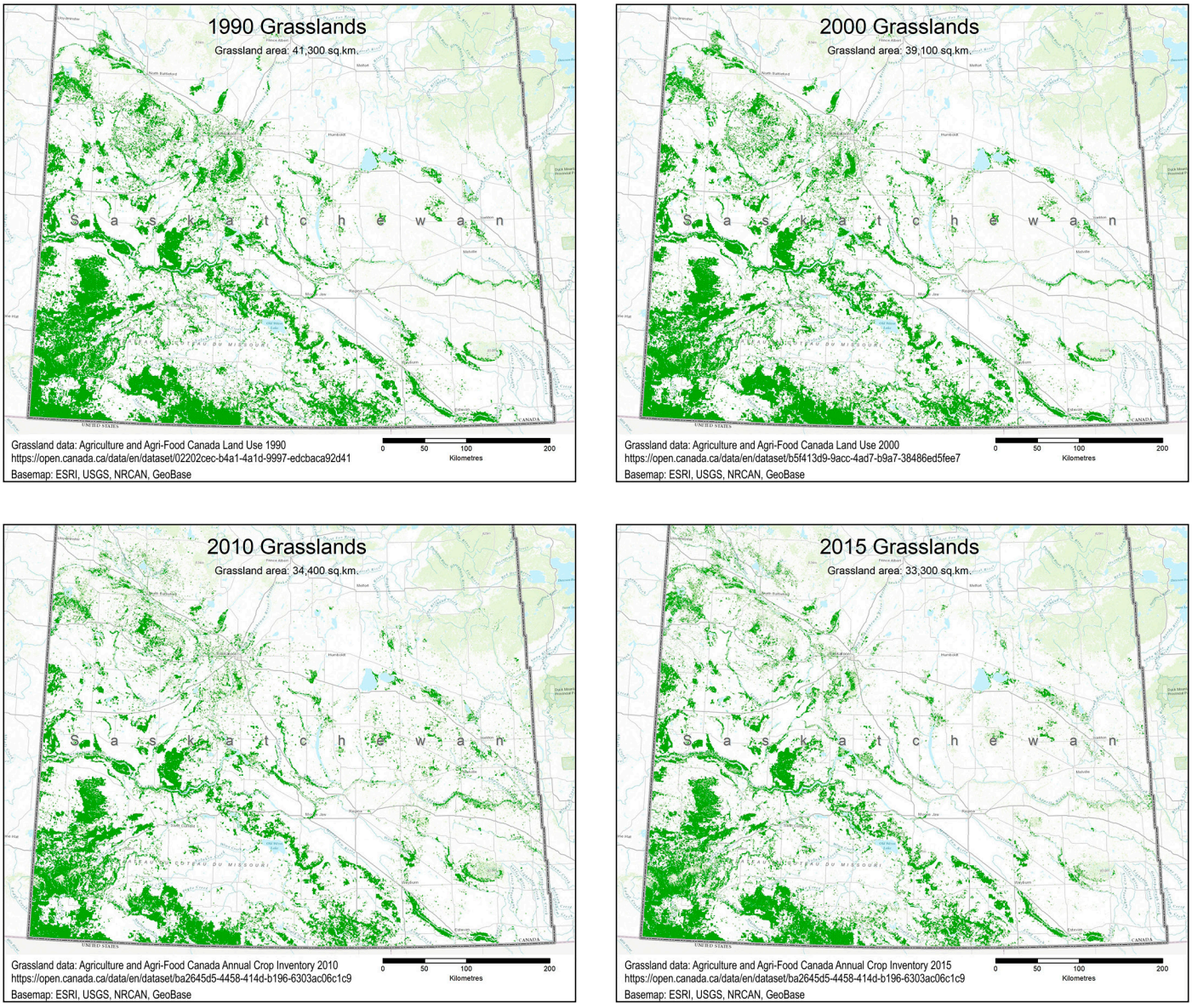

Figure 3
Grassland areas 1990–2015
Sources: (AAFCa n.d.; AAFCb n.d.)
Cartography: J. M. Piwowar

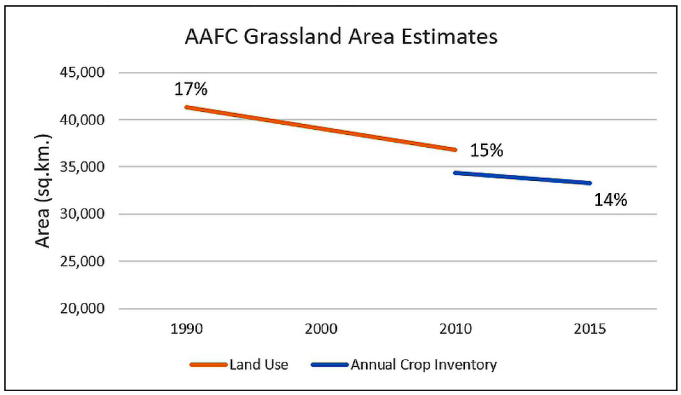

Figure 4
Estimated area of modern era grassland expressed as a percentage of grassland existing prior to European settlement
Sources: (AAFCa n.d.; AAFCb n.d.)

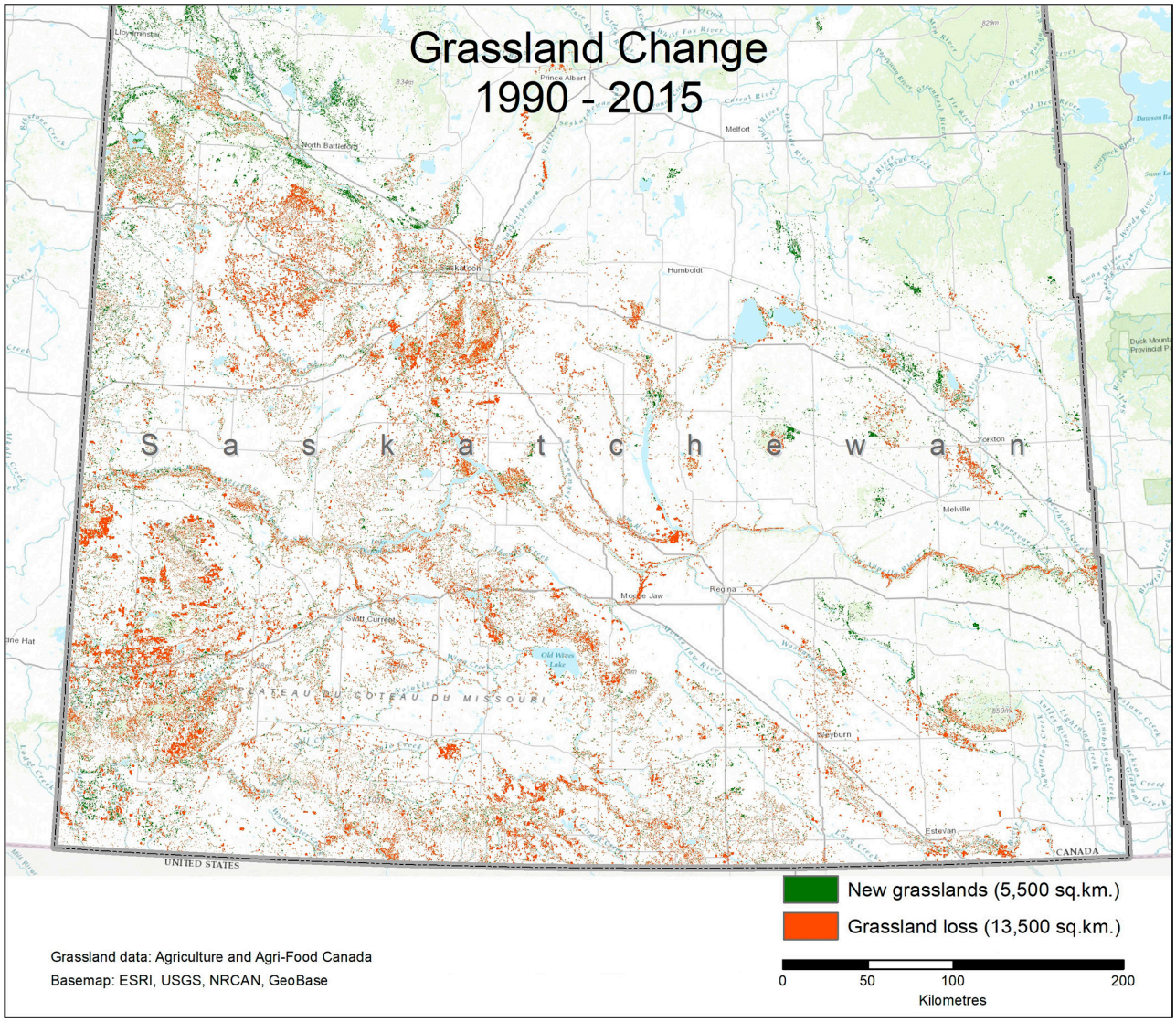

Figure 5
Grassland change: 1990–2015
Cartography: J. M. Piwowar

Those regions of grassland increase in Figure 5, however, have been established in areas that once were shrublands and wetlands. These changes are likely products of changing economic and climatic conditions (Sauchyn et al. 2010). For example, between 2011 and 2016, the area under cultivation in Saskatchewan increased by 11% to almost 164,000 km^2, with some of this growth attributable to the conversion of pastures to cropland (Statistics Canada 2017). This has been aided by the adoption of new technologies and improved agronomic practices so that grasslands that were once marginal are being brought into production as farmers look for new ways to improve the profitability of their operations (Cross 2017). Changes in grassland area are also being forced by changes in climatic conditions. Thorpe (2011) found that a warmer climate is leading to more areas of open grassland in areas that once had tree cover in the southern boreal forest and aspen parkland ecoregions of Saskatchewan.

The management of grasslands on Crown land in Saskatchewan is caught between two different government mandates. The Saskatchewan Ministry of Agriculture is responsible for Crown land in southern Saskatchewan because most of it is grazed by livestock (Ashton 2018). The ministry operates under the assumption that ranchers and other producers are the best stewards of the land. Although this may be true in many cases, there is increasing evidence that some patron groups are farmers that have no range-management expertise or knowledge at all (Hoehn 2018). The PFRA recently reported that at least half of the existing prairie grasslands are not in good condition (Smith and Hoppe 2000). On the other hand, the Saskatchewan Ministry of Environment administers Crown conservation easements for the former PFRA and SPP pastures, as well as other Crown lands that are assessed to have no more than moderate ecological value under the Wildlife Habitat Protection Act (WHPA) (Hoehn 2018). However, landowners can ask to have the easement removed and the ministry can agree if it is in the public interest to do so (Government of Saskatchewan n.d.). In short, making land available to producers competes with conserving the ecological value of grassland, which is why the WHPA was amended in 2014 to allow some WHPA protected lands to be sold (Hoehn 2018).

The split Agriculture-Environment mandate for grassland oversight reflects government disinterest when it comes to prairie monitoring and investing in long-term grassland management. Further, while the Saskatchewan Ministry of Environment does have scientists in the field collecting data on endangered species, there are no community ecologists on staff currently gauging the health of the native prairie region as a whole (Sawa 2018).

Despite a need for an accurate inventory, the best the government can do is to provide out-of-date and inaccurate estimates. For example, in 2016 the Government of Saskatchewan estimated the extent of grassland ecosystems in the province to be 12 million acres (48,500 km^2) (Figure 6). This is 1.7 million acres (7,000 km^2) more than the extent estimated by AAFC in 1990 (Figure 4). Using the trend we observed in our AAFC grassland extent time series, we estimate that the 2016 extent is closer to 8 million acres (33,000 km^2).

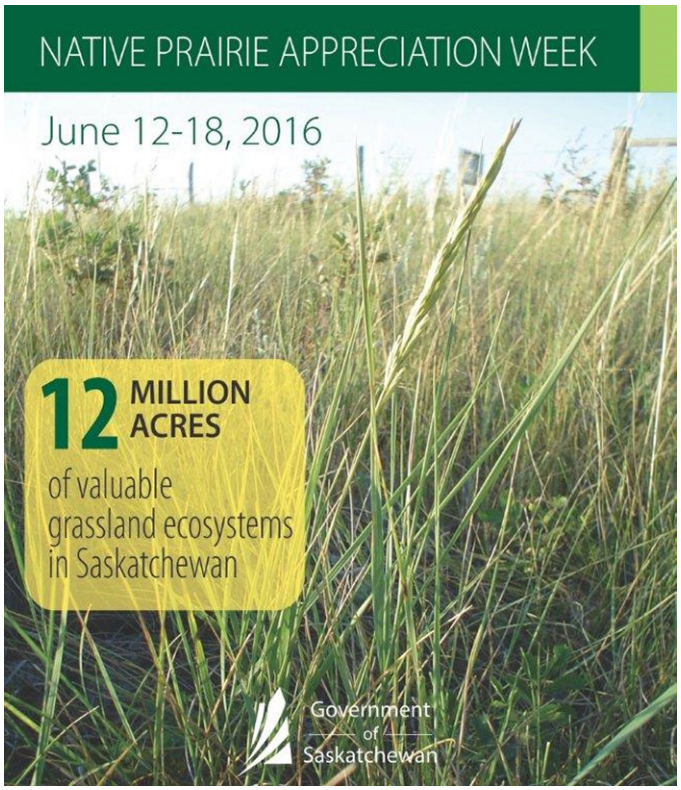

Figure 6
Government of Saskatchewan estimate of grassland extent

Conclusions

Grasslands are an ecologically productive, yet threatened, ecoregion. They provide many goods and services including livestock forage, biodiversity, nutrient recycling, soil and water conservation, climate regulation, carbon storage, and tourism and recreation. Unfortunately, many grasslands have been converted to cropland and are reduced to a fraction of their original extent. Using published data from Agriculture and Agri-Food Canada, we mapped the grassland extent in Saskatchewan. We found that the province had 17% of its grasslands intact in 1990, but by 2015 this was reduced to 14%, a loss of 3% over 25 years. Surprisingly, this is a full 6% lower than the Saskatchewan government's stated estimate of 20% remaining in 2016. It appears that the provincial government's agricultural policies do not make grassland conservation a priority.

More work needs to be done to properly assess the extent of grasslands, not only in Saskatchewan, but across the prairies. Ultimately, this will require the development of improved classification strategies to accurately identify grassland areas in satellite imagery. The Saskatchewan Ministry of Environment is currently testing modelling methods that should make this process easier but will not have a complete inventory for another five to ten years (Hall 2018; Sawa 2018). In the interim, a more accurate estimate may be possible by combining data from multiple sources, both from government (e.g., AAFC, the Commission for Environmental Cooperation), and non-governmental organizations (e.g., Ducks Unlimited).

Ultimately, grassland preservation should matter to governments and citizens, conservationists and recreational users, and Indigenous and non-Indigenous peoples. Having a credible estimate of the amount of grassland that remains is an important contribution to preservation efforts.

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

The digital revolution and the Hutterite community: The rules and reality

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Key Messages

- Hutterites see their colonies as religious arks on a sinful secular sea and crave isolation to protect their society from the penetration of secular values.
- The protection of physical isolation has been eroded by digital communications and enabled the penetration of alien values into Hutterite society.
- Attempts by the Hutterite leadership to prevent the entry of this technology have been largely unsuccessful.

The Hutterites are a German-speaking Anabaptist Christian group in western Canada and the northern states of the Great Plains that practice community living and community of goods. Since their arrival in North America they have sought isolation from the secular world by locating their colonies in rural areas, away from other settlements, and screened off from public view. Hutterite leaders have avoided contact with the outside world as much as possible to prevent the infiltration of ideas antithetical to their faith and way of life. Radios and television were banned, although they embraced other forms of technology that improved their economic status without compromising their ideals. Beginning in the 1990s, the digital revolution gave ever-increasing easy access to the Internet via personal computers and smartphones. Hutterite leaders have attempted to manage this new threat, but their success has been limited, at best.

Keywords: Hutterites, Internet, smartphones

Introduction

Most conservative religious societies in the western world fear the intrusion of secular values into their communities—a fear that has been heightened in the digital age. The Internet, (phones capable of accessing the Internet and sending and receiving data) and even radio and television carry views and opinions antithetical to their beliefs. Hence, the introduction of these recent technologies is viewed with suspicion and alarm (Barker 2005; Barzilai-Nahon and Barzilai 2005; Campbell 2006). Amongst these societies, the leaders of Hutterian Brethren in North America have been at pains to manage this onslaught of alien values and have devoted considerable efforts to shield their members from the values of the cultures that surround them.

The values of an increasingly liberal and secular Western society contradict with the values of many conservative religious individuals, threatening their culture, upbringing, and way of life. They also reduce the individual's probability of retaining

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his or her religious views and conservative attitudes, as well as affecting the prevailing views among the leaders of their religions. Thus, the spiritual leaders of conservative communities instruct their followers to avoid these components of secular western culture, particularly those elements that bear upon sexual mores, interpersonal relationships, and acceptable practice of their faith. Any information that might challenge the principles of their religious belief—such as information regarding competing and contradicting religious practices—is threatening, lest the believer's faith be challenged and weakened. Thus, to prevent any chance of apostasy, religious leaders of conservative societies are anxious to block the flow of any information that contradicts their values.

It might be expected that members and leaders of conservative religious societies, regardless of their faith, would strenuously resist the threat of the Internet and smartphones and enforce prohibitions upon their entry into their communities. However, this is not the case. Even the most conservative religious societies are being exposed today to the Internet and smartphones, with all the implications of unrestricted access to worldly information and secular values. We examine here the penetration of the Internet and advanced cellphones into the Hutterite Christian community in North America. The Hutterites are a conservative, fully communal, Anabaptist community, originating in the 16th century and numbering today about 50,000 people in over 520 colonies in Canada and the United States (Figure1).

Our opinions are based on over 20 years of research into the Hutterite community that has focused on its colonization process, social history, and religious beliefs from the 16th century until today. We eschewed a structured questionnaire-based

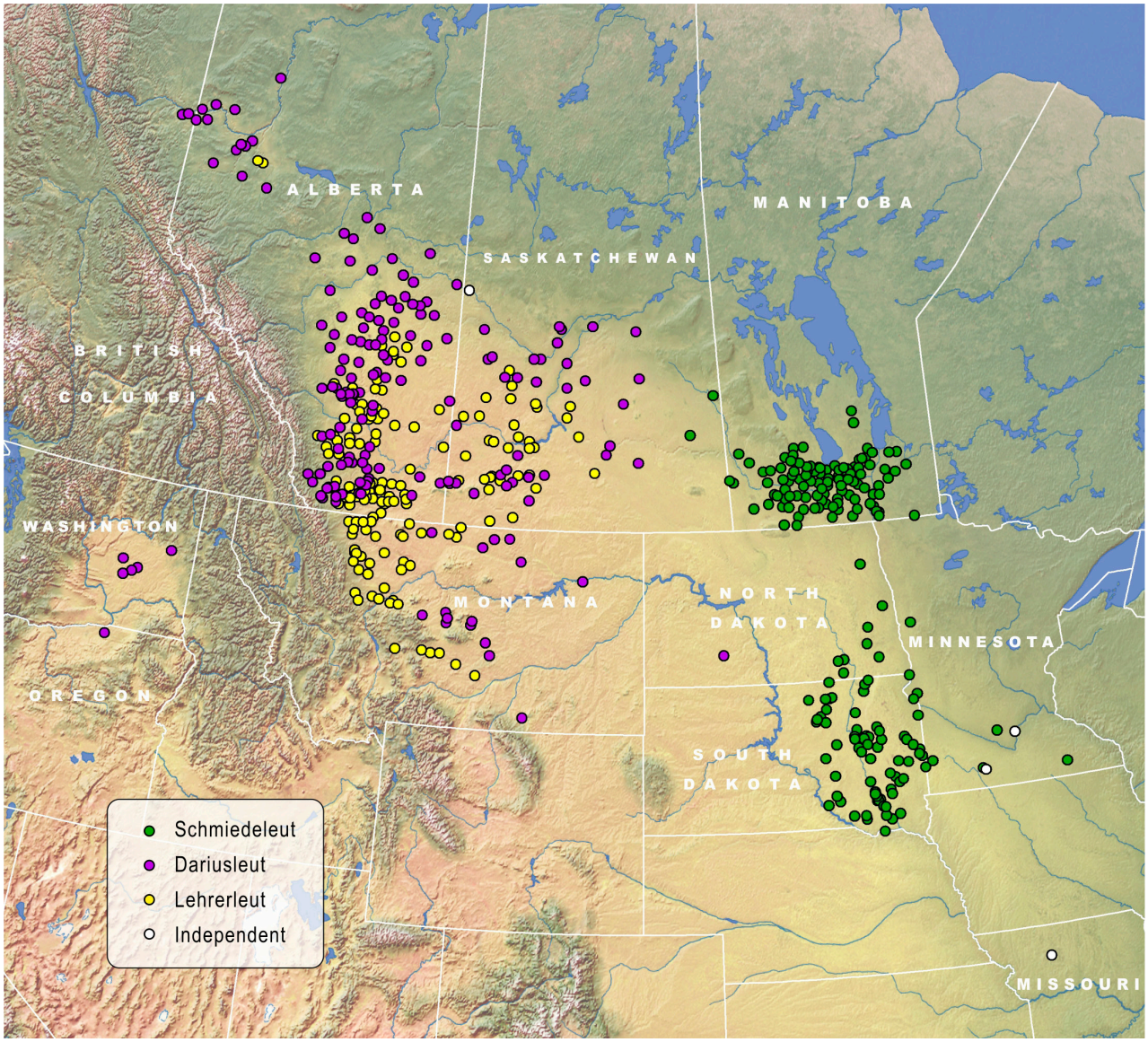

Figure 1
Hutterite colonies in North America by leut, 2018
Cartography: W. Hiebert
Basemap: Natural Earth

enquiry based on our experience working with the Hutterite community, which tends to be wary of formal documents seeking informed consent, questionnaires, and overly structured interviews. Interviews of Hutterite community members by both authors, and numerous informal visits to Manitoba colonies by the second author, were supplemented by archival materials obtained from colony leaders to form the core of our research. This approach follows the path pioneered by anthropologist Clifford Geertz (1995) who argued culture can only be imperfectly studied through the objectifying quantitative methods of scientism. Since the subject is controversial within the Hutterite community many of our sources did not wish to be identified. Accordingly, only the date and group affiliation (leut) of Hutterite informants is given.

Background information about the Hutterites, their religious beliefs and social organization has been extensively covered in the literature (Peters 1965; Hostetler 1974; Horsch 1994; Hofer 2004; Janzen and Stanton 2010; Katz and Lehr 2014). Suffice it to say that the Hutterites are divided into three branches or leut: the Schmiedeleut, the Dariusleut, and the Lehrerleut. Since the mid-1990s the Schmiedeleut, found mostly in Manitoba and the Dakotas, have split into two factions: the more liberal Group 1 and the more conservative Group 2. We will examine the ways in which the leaders of the Hutterite community, especially the Schmiedeleut, are coping with the challenge posed by the Internet and the smartphone. We also argue that the leaders of the Hutterite community are unable to block the penetration of information technology into their community, though it can be argued that they have managed the transition in an effective way.

The Hutterite community and communications

As most work on the subject makes clear, the Hutterite community is characterized by religious piety and conservatism. However, as mentioned above, it is divided into three leut that differ regarding: the level of piety and conservatism; the extent of geographical and social exclusion from the surrounding world; the attitude towards community members who have sinned; the maintenance of dress codes; the use of modern technologies (as opposed to the Amish community, which totally rejects any use of modern technology); and the acceptance of an authority in the form of a spiritual leadership that sets the rules for what is allowed and what is forbidden, even though obedience is not total.

The telephone

When the telephone first began to be used by the Hutterites it was generally confined to the office of the colony manager and/or to the house of the first minister and used strictly for colony business. Later, in the 1980s, individual dwellings were connected to the telephone via a central colony switchboard that was often automated. Access to a private phone line was welcomed by colony members, especially the married women, who according the Hutterite custom had left their home colony to move to their husband's colony upon marriage. Some colonies placed a ten-minute automated cut off on outside calls to relatives on other colonies (which were often long-distance) but even then, the colony lines were often continually busy in the evenings.

In the last decade Schmiedeleut Hutterite families have had increasing access to an outside line, usually through a central automated switchboard. In the 2018 Hutterite Telephone Directory approximately 20% of Schmiedeleut colonies, and 47% of the Dariusleut colonies, now list only one central number without the ability to transfer a call to a specific family. Surprisingly, of the generally more conservative Lehrerleut colonies, almost all list individual family phone numbers. Nevertheless, at least one of these colonies, which previously listed individual family numbers, recently reverted to a single colony phone to reduce outside contact (Evans 2019).

The Internet and, later, smartphones began to appear in the more liberal Hutterite colonies in the late 1990s, about a decade after personal computers became widely available in western secular society (Anon. Dariusleut 2014a; Anon. Schmiedeleut 2018a). It was about this time that colonies began to provide general access to landline telephones by installing colony switchboards. Through the 1990s, the use of computers in the communes became increasingly common, including the replacement of old models by newer more powerful ones that allowed the operation of sophisticated games. In 1994, at the annual conference of the Schmiedeleut, the issue of computers was tackled for the first time: "Radios, TVs, videos, VCRs, TVs in schools, cameras, taking pictures, ball games, playing hockey, and volleyball are not allowed. These are all signs of disorder that should be stopped in earnest…" (Katz and Lehr 2014, 380).

It was difficult to enforce this ordinance, and computer games spread even more widely. As years passed, floppy discs, CDs, and USB drives became less expensive and smaller. Consequently, it became very difficult for the leaders to physically restrict their presence (Katz and Lehr 2014, 235–238; Katz and Katz 2015, 166–172)

Entry of email and the Internet into the colonies

During the 1990s, email use widened around the world, but most colony administrations did not employ it, preferring to use the more easily monitored fax, landline telephone, and regular mail, to conduct their business dealings. To use email, one had to connect to an external network that was not easily monitored by the leadership, a situation that colony leaders wished to prevent. Thus, even today, in the 2018 edition of the Hutterite Telephone Directory, although GPS co-ordinates are given for each colony, few email addresses are published, only postal addresses, landline phone numbers, and fax numbers (Murphy 2018). This is not truly practical in the world of modern communication, so many colony business managers have email accounts that they access when off the colony in nearby town libraries (Katz and Katz 2015, 79–82, 134–138, 154–155.) In fact, until a few years ago, while many colony members had private email addresses

that they used for colony business and for private needs, no colony had a formal email address (Murphy 2018). As far as the leaders were concerned, the mailing address of the colony was the regular postal address and fax number.

The Internet started to enter the colonies at the end of the 20th century and the beginning of the 21st century. Since then, it has gained a steadfast hold, even though most colony leaders still oppose the use of the Internet, except for those colonies that have industries. Even these colonies are required to use the Internet in a restricted way, and until recently, even there it was not officially allowed.

The entry of the Internet to the colonies was spontaneous. The demand for the Internet came from the colony schools as well as from the managers of the various economic branches within in the colonies. The former requested to use the Internet for learning and educational purposes, as was customary in the non-Hutterite schools in the region. The managers of the colonies' economic endeavours also became aware of the Internet's many advantages for communication and even the promotion of economic activities. For example, colony managers could check weather forecasts, compare prices of commodities in the various commodity markets, check economic deals, market and promote themselves, and buy and sell goods. To some extent Internet use was not strictly necessary. For example, in Manitoba, some colonies received a government-run weather-only radio channel that provided round the clock weather information for farmers in the region. However, it became clear to the colony leaders that if they would not use the Internet for access to economic information, as their competitors in the outside world did, they would suffer economically. They could not let this happen, for they managed the colonies as economic units and so desired to maximize their profits to maintain a standard of living comparable to that of the surrounding world, to retain enough capital to maintain colony infrastructures but also to enable the establishment of daughter colonies. Internet access became crucial, especially in those colonies that were diversifying into industry.

However, colony leaders were aware of the destructive potential of the Internet if it served as a conduit for the culture of the secular and sinful world to penetrate the colonies and threaten the communal way of life. The Hutterite community had never faced a challenge of this magnitude before. The traditional defense of seeking spatial isolation and locating colonies away from public view and reducing interaction with the secular world as much as possible was no longer effective. A sweeping resolution made during the 2002 annual conference of the Schmiedeleut ministers, recognized this:

> In a short time, the Internet will no longer be allowed, and those who have it will have to get rid of it — out of the houses, barns, shops, and schools. This alarming abhorrence should open our eyes. We must all help to protect our children from it for it is a great evil for a people of God. We have often experienced it that our children are not protected when they have the opportunity. The impure, heathen things that are on there should not even be mentioned. Therefore, the Internet among us in any way is not to be tolerated at all, and those who refuse to get rid of it should be examined (Katz and Lehr 2014, 396).

Two years later the annual conference reiterated its opposition to the Internet: "In short time the Internet will no longer be tolerated among us under any circumstances. Let us read the conference letter from July 2, 2002" (Katz and Lehr 2014, 402).

However, these resolutions failed to prevent colony members, especially the younger generation, from looking for ways to connect to the Internet to satisfy their enormous curiosity, to establish connections and to correspond with people outside the colony. They could easily learn about the secrets of the Internet during their visits to town libraries, where they could surf freely, open G-mail accounts and, later, even Facebook accounts. An opportunity to surf the Internet was also provided during visits to neighbouring farmers, coffee houses and other shops whenever they visited nearby towns—either for medical appointments or for settling colony business (Anon. Schmiedeleut 2014a). As laptop computer prices declined during the first decade of the 21st century, young colony members started secretly buying laptops and communication software, which they connected directly to the telephone system, or wirelessly to the Internet system that served the school, or to another Internet supplier. The colony managers kept clarifying that the use of the Internet is necessary only for colony administrative and economic needs, but they, too, started using the Internet to email messages and for other purposes that had nothing to do with the economic matters of the colony (Katz and Katz 2015, 55–56, 106, 114, 154, 158; Anon. Lehrerleut 2014; Anon. Schmiedeleut 2014a).

Thus, in the annual conference of the Schmiedeleut held in 2006, a further resolution regarding the Internet was made:

> Internet is generally not allowed. Many have taken the liberty to acquire it, therefore all ministers and colony managers are requested to forbid it and those that have taken this liberty must apologize and repeal this at the great gathering because they were disobedient.
>
> Dear Brothers, it is a dishonor (sic) that we as leaders of the community consider it as if it is not important that something is forbidden, or worse that we go against it and attack the oldest ministers. Didn't we see the example of the children of Israel who wanted meat, meat and yet couldn't get it, not even for a day or a month. As it still was between their teeth, burning snakes came and led to the death of many. We must ensure that this Internet does not bring the burning snakes and the punishment of God. It is surprising, so few see the terrible aversion and the great danger of the Internet when we know the great harm and impurity in it. We also know that the young people cannot avoid this, when they have the opportunity to use it. Why don't we take a more critical stand? Many worldly people do not let this great aversion to come to their homes to protect their children from such pagan things. We should instead work against it, so that we are not also led into temptation. We shall not think that we need it to go about our business since there are communities with large economies and manufactur-

> ing that do not have it—it is a great evil to the people of God. We can try to filter it and lock it out and only allow email. But whomever you talk with will tell you that before you even get to email, the pictures of exposed women already appear. The children of Israel were also captivated by pagan idolatry only because there were fleshly idols there. Therefore, let us remove it from us until further council has been sought.
>
> Many colony managers have been ordered to examine whether it is possible to only have email in communities that manufacture (Katz and Lehr 2014, 407).

Since 2006, this refrain had been repeated by Schmiedeleut leaders during their annual conferences: The Internet is forbidden. It became one of the main issues discussed at those conferences, if not the most central one. This suggests a constant increase in Internet users, despite the official prohibition. This is consistent with the information that we have been receiving from colony members since the beginning of the 2000s (Janzen and Stanton 2010, 5–6, 100, 157, 192, 242, 260–261, 265).

Examination of Hutterite ministers' resolutions since 2006 regarding the use of the Internet shows inconsistency. Although private use continued to be forbidden, when it came to use the Internet for colony work, things were different. At first, after the sweeping prohibition, resolutions allowed the use of the Internet only in colonies that had an industrial component. Later, it was forbidden even in those colonies, except for the use of email. In 2009, it was made possible to use the Internet in the industrial colonies, but only if permission was given by the head of the Schmiedeleut. It is evident that the inconsistency regarding the use of the Internet in the colonies reveals the tremendous tension between the economic needs of the colonies and the deep and justified concern regarding the moral and religious damage resulting from the invasion of the outside world into the colonies via the Internet.

Internet use by Hutterites has increased every year, despite prohibitions published in Conference Ordinances. The rules laid down by the leadership and the reality experienced on the colonies grew apart. The person in charge of the Internet in one colony told how every colony member who wishes to surf the web may come to his office while he is there and do so. Problematic websites, that is those containing pornographic content or movie websites, are blocked. Also, the heads of the industrial branches may use computers in the shops to gain access to websites relevant to their business. However, they are the only people qualified to approve the websites but once these permitted sites are opened, it is not complicated to break into blocked websites (Anon. Schmiedeleut 2014a).

A visit by the first author to Canadian Hutterite colonies in the summer of 2014 included visits to Lehrerleut colonies, the leut that is considered the most conservative of the three. Naively assuming computers and the Internet did not enter these colonies as there are no computers in their schools, he was surprised to find that despite the strict prohibition on use of the Internet and smartphones (and although the heads of the colonies told him decisively that no such use exists), in practice things were very different. The use of email, the Internet, and smartphones was already established there. This was revealed when one of the colony members, a man in his 30s, addressed him with a complaint about the aggressiveness of Israel towards the citizens of Gaza during the Tzuk Eitan operation. When asked about the source of his information, he answered simply that he received it from a friend in Pakistan. He did not hesitate to admit that it is done through Facebook, to which he connects via the Internet in the library of the nearby town. When asked how this was in line with the prohibition on the use of the Internet (especially since his father is the Second Minister), he answered: "Everyone here surfs the Internet." On request, after some hesitation, he even provided his Gmail address (Anon. Lehrerleut 2014).

Today, it seems that the use of the Internet has become a common phenomenon in most or all colonies, despite the prohibitions and warnings issued by the heads of the three leut and ministerial resolutions following their annual conferences. Indeed, a stranger inquiring among colony members if they use the Internet would be given denials: "It is forbidden." Clearly, this is not the case. Many, especially the younger generation use email and have open access to all content. In the more liberal Group 1 Schmiedeleut colonies some colony members even have blogs in which they post their observations and communicate with both members of the Hutterite community and those outside it (for example, see: http://www.hutterites.org/blogs/ which carries links to eleven Hutterite blogs). There are now dozens of WhatsApp group sites among the Schmiedeleut, from both the Group 1 and Group 2 colonies. Specialty groups for colony carpenters, electricians, and others are used to share information and advice concerning their trades. One Hutterite has a WhatsApp group for members of his own family, to enable him to contact them on the colony without using the colony's public address system. Obviously, these members have easy access to the Internet via computers and smartphones and are trusted by their colony ministers to behave responsibly (Anon. Schmiedeleut 2018a). In most colonies, surfing to problematic websites is forbidden and blocked, but it is a simple matter to bypass the blocking applications using software and laptops, or by surfing at public libraries, shops, or even at the houses of neighbouring farmers. In addition, the use of smartphones has become much wider, and thus there is no need any more to use laptops secretly, to try to bypass blocking or to leave the colonies to surf the Internet (Anon. Schmiedeleut 2012). Most of the colony managers, although they are aware of the issues attendant upon bringing the outside world into the colonies, do not enforce the annual conference resolutions. They do not do so because they cannot or do not wish to, for they are fearful that the colony economies might be damaged without the use of email and the Internet, or colony members might leave if they keep the reins too tight (Katz and Lehr 2014, 419; Anon. Schmiedeleut 2014b)

Smartphones in the colonies

At the beginning of the 2000s, when cellphones (mobile phones without Internet capability) were already common in the secular

world, the colonies began to adopt them. Initially, only the heads of colonies were permitted to use them during their trips outside the colonies. Soon all members travelling outside the colonies were permitted to take colony provided cellphones with them for safety reasons. Until a few years ago James Valley Colony, for example, had several cellphones available on a sign-out basis for colony members taking a trip off the colony. This is no longer so, since the assumption is that almost everyone has their own cellphone, or more usually today, a smartphone (Anon. Schmiedeleut 2018a).

Perhaps the biggest problem faced by any colony member intent on having a personal smartphone is the cost of acquisition and operation. Schmiedeleut colony members receive a monthly stipend of only three dollars for "personal expenses." However, if a trip to town is necessary, the colony will provide cash or a credit card to cover the cost of lunch, coffee, and other necessary expenses. However, it is not too difficult for a colony member to acquire a smartphone even without some additional income. According to one informant, one can acquire an older model phone cheaply, use it in coffee shops with free Wi-fi or set up a Wi-fi hot spot on the colony and have unlimited access to texting and access to cheap data downloads (Anon. Schmiedeleut 2018a).

Realizing the impossibility of controlling access to cellphones and smartphones the Schmiedeleut leadership relented in its total opposition to cellphones and permitted members to own a cellphone "provided it did not have a camera function," but as one Hutterite remarked, "What cellphone doesn't have a camera? It's impossible to get one!" (Anon. Schmiedeleut 2017).

Cellphones and other small gadgets, such as USB drives, cameras, and video cameras, bought clandestinely with money made on the side, have also become increasingly common, despite the prohibition against them. During the first decade of this century, second and third generation cellphones and smartphones entered the colonies, mostly without permission, enabling people to take pictures, send messages, connect to the Internet, and correspond through email (Katz and Katz 2015, 40, 80). It became much easier to surf the Internet and watch everything that the outside world had to offer. The continuous decrease in the prices of cellphones and smartphones, increasing miniaturization, and dropping rates for Internet use have accelerated the entrance of cellphones and smartphones into the colonies, bringing in the outside world.

It is now quite common for younger colony members to maintain Facebook and similar accounts. At the end of 2014, the heads of the three leut issued, separately, clear resolutions prohibiting the use of smartphones, which they consider a catastrophe for the future of the colonies. A similar resolution was issued by the high echelons of the Hutterite church (Anon. Schmiedeleut 2012, 2014c; Anon. Dariusleut 2014a, 2014b, 2014c). However, these resolutions seem to fail to impress the members of the colonies; many say they will not betray a trust by inappropriate use of a smartphone or computer; while many simply have no interest in visiting inappropriate sites (Anon. Lehrerleut 2014; Anon. Schmiedeleut 2014d). Even those who leave the colonies still abide by their convictions and use their phones mostly for communication and retrieving non-salacious content. Thus, while in some colonies there is no formal use of the Internet or email and there are no computers, many members possess smartphones that enable them to connect freely with the outside world (Anon. Schmiedeleut 2017). It is now common for families to hold a cellphone with permission of the colony hierarchy (Katz and Katz 2015, 36, 109, 168–169). A few years ago, the leadership was concerned about members' enthusiastic patronage of garage sales. This has now abated somewhat as "most of the best stuff is now sold on Kijiji, so we go on-line to find it there" (Anon. Schmiedeleut 2018a). The greatest problem faced by Hutterites in using such sites is their inability to leave their colony at will to retrieve purchased items.

Hutterites have a limited gene pool and are concerned about the dangers of inbreeding. Every colony minister has access to a Hutterite Family History for his leut, which is consulted when two young people show an interest in one another, as the Hutterites frown upon marriages between second cousins and prefer the couple to be genetically distant. Today there is an App that may be downloaded to a smartphone that according to members of a Group 2 colony can determine within a few seconds the exact genealogical relationship between any two Hutterites (Anon. Schmiedeleut 2019a). Ordinances passed recently at the annual meetings of the Schmiedeleut ministers have urged responsible use of the Internet, a contrast to those of a few years ago that recommended banning it completely (Anon. Schmiedeleut 2019b).

Conclusion

In religious-conservative societies, the rules established by the leadership are seldom followed to the letter. The rules issued by the leaders represent the ideal, but the actual conduct of the membership represents reality.

This paper has argued that the Internet and the smartphone entered the religious-conservative Hutterite community despite the efforts of the community's leaders to prevent them, for they regarded them as a threat to the future of the community. Thus, the Hutterite colonies are open today more than ever to the outside world, from which the Hutterite community has always wished to keep afar. The spatial isolation from the outside world has no significance today, for this world has already entered the colonies. The processes of exposure to the outside world began before the entry of the Internet and the smartphone, as, newspapers and news magazines were widely read on the colonies or by colony members in local libraries. The difference lies in the ease of access and the intensity of exposure to a wider range of content available on the Internet. Moreover, while in the past the leaders could control the extent of opening to the outside world, today they have very little power to do so. This situation holds far-reaching consequences for the social and religious future of the Hutterite community, and even for its existence. Thus, for example, some leaders fear the vast array of information about the outside world and the many options it presents will encourage young colony members to move to the cities and older members to embrace other religious beliefs.

The leaders of the Hutterite community, which has strong ties to the market economy and targets itself towards maximizing colony profits, are unable to prevent the use of the Internet in the colonies, for to do so would have severe economic consequences. The genius of Hutterite governance over the decades has been the way in which change has been managed, whether it be in clothing styles, introduction of secular world traditions around celebrations and funerals, or latterly the intrusion of modern electronic media. The resolutions against the Internet that were made during the ministers' annual conferences—severe as they may be—were no more than declarations that not only could not be enforced but also were not meant to be enforced. Thus, the Internet's percolation into the colonies was gradual; colony members adjusted to its presence gradually and for the most part responsibly. The only alternative option was to filter the websites available to users. However, this solution was far from being perfect, not to mention the fact that colony members were soon able to gain access the Internet privately and easily through use of smartphones. Access to the Internet was no longer dependent on access to a desktop or laptop computer.

It is easy to overstate the threat posed by the Internet to the integrity of the Hutterite community. In the past leaders were equally concerned about the penetration of radios into the colonies, fearing their members would be seduced by the broadcasts of charismatic evangelists, promising salvation without communal life (Katz and Lehr 2014, 211). The Internet is little different; the message is the concern, not the medium.

Strange as it may sound, the Internet might come to the assistance of the colonies since the Internet is value neutral. How it is employed determines its effect on the individual and community. Just as it can enable the penetration of unwanted values into the colonies, it can be employed to strengthen belief, to proselytize, and build community solidarity as well as to build connections with like-minded societies of different faiths. Some Hutterite leaders have expressed interest in the 'kosher smartphone,' which filters content, as is issued for the ultra-orthodox Jewish community in Israel. Some might see it as a salvation, providing that they will be able to convince their colonies that such a device is a viable alternative to the smartphone. Whether the membership of the Hutterite community would share this view is open to question. It is worth noting, however, that not all Hutterites see the threat to their colonies as being driven by external threats; of greater significance, some think, is poor leadership and bad management of certain colonies (Anon. Schmiedeleut 2018b).

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

Net ecosystem productivity response to ENSO and NAO events in a young temperate pine plantation forest

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Key Messages

- Seasonal trends of GEP, NEP, RE, and PAR are recorded in a pine plantation in southern Ontario.
- ENSO and NAO teleconnections impact the NEP of a young white pine plantation forest.
- Climate variability affects the growth of white pine plantation (*Pinus strobus*) in southern Ontario.

It is important to understand the effects of extreme weather events and climate oscillations on forested ecosystems to enable quantification of their sensitivity to these events. This study highlights the response of a young planation forest to low frequency climate oscillations. Half hourly fluxes of net ecosystem productivity (NEP) in a twelve-year-old white pine plantation were used to evaluate the impacts of El Niño Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO) events from 2008 to 2013. In general, spring NEP values were higher than those of summer. The highest NEP values were recorded in spring 2012 at 1.8 g C m^{-2} day^{-1} when the winter of 2012 experienced a moderate La Niña episode and a strong positive NAO phase at the same time. The effect of ENSO on NEP was most pronounced during springs following winters with warm ENSO phases. However, in winter 2010 the effects of a moderate El Niño event were offset by a concurrent strong negative phase of NAO. Warm winter temperatures brought by positive NAO, and wet conditions by both La Niña and positive NAO contributed to high NEP spring values.

Keywords: Net ecosystem productivity, gross ecosystem productivity, ecosystem respiration, photosynthetically active radiation, El Niño Southern Oscillation, North Atlantic Oscillation, *Pinus strobus*

Introduction

Forest ecosystems act as carbon sinks and have the potential to offset anthropogenic emissions (Houghton et al. 2015). The correlations between weather changes at one location and some remote locations are called teleconnections. Defining the effects of low frequency climate oscillations, or teleconnections, on the productivity of forests is fundamental in understanding how the terrestrial ecosystem may respond to climate change (Morgenstern et al. 2004; Hember and Lafleur 2008; Wharton and Falk 2016). A consequence of increasing seasonal temperatures is generally a longer growing season and greater carbon uptake. However, Krishnan et al. (2009) showed that climate change factors can alter productivity (carbon uptake) and can control carbon release (respiration) from forests. Climate oscillations are known to influence seasonal and annual conditions (temperature and precipitation), which can ultimately impact productivity, either negatively or positively, and determine if a forest serves as a carbon sink or source.

The carbon balance of a forest is explained by net ecosystem productivity (NEP), which is the difference between gross

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ecosystem productivity (GEP) and ecosystem respiration (RE). Each of these variables is sensitive to changes in solar irradiance, temperature, and water availability (Krishnan et al. 2009). Photosynthetically active radiation (PAR) defines the spectral range of solar radiation from 0.4 to 0.7 μm that photosynthetic organisms are able to use in the process of photosynthesis. When photosynthesis is greater than RE in an ecosystem, NEP will be positive. During the winter months in southeastern Canada, NEP is negative due to an absence of photosynthetic activity, since the trees are dormant under extreme cold temperatures and the presence of snow reflects a large portion of the incoming solar radiation back to space. Zarter et al. (2006a) showed that in some species of subalpine conifers in forest 15 km north of Nederland, Colorado, complete down-regulation of photosynthesis occurred during winter, and reactivation occurred during spring. Photosynthesis recovery is strongly correlated with air temperature as late spring conditions, sustained warm air temperature (above 0˚C), and a readily available water supply are favourable for photosynthesis in coniferous forest ecosystems (Ensminger et al. 2004; Zarter et al. 2016a, 2016b).

This study examined the effect of two major teleconnections—El Niño Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO)—on the NEP of a pine plantation forest in southern Ontario. ENSO and NAO are important atmospheric phenomena that introduce anomalies in atmospheric circulation and thereby influence temperature and precipitation of the midlatitude North American region in particular during winter and spring seasons (Hember and Lafleur 2008). An ENSO event shows a relatively stronger effect during winter. ENSO has three phases: El Niño (warm phase), La Niña (cool phase), and La Nada (neutral). El Niño induces warmer winter temperatures and drier conditions, while La Niña brings colder winter temperatures and wetter conditions in southeastern Canada (Shabbar and Bonsal 2004). During the La Nada (neutral) ENSO phase, the sign of the NAO exerts more influence.

A forest ecosystem can change from a net carbon sink to a net source in response to ENSO. Morgenstern et al. (2004) found that high air temperatures in the 1998 El Niño year led to lowest NEP annual values, and high NEP values were achieved in La Niña years for (1998 to 2001) at their Douglas-fir forest site in British Columbia, Canada. Wharton and Falk (2016) also reported that the forest acts as a moderate net carbon sink during La Niña years and a small carbon source during El Niño years at an old-growth evergreen needleleaf forest located in southern Washington State, USA.

Variability in NEP has been attributed to El Niño/La Niña events, which can cause regions of drought or abundant precipitation (Keeling et al. 1995; Morgenstern et al. 2004; Krishnan et al. 2009; Wharton and Falk 2016), and changes in the timing and length of the growing season (Randerson et al. 1997). Warmer temperatures promote high rates of RE and therefore decrease NEP when soil moisture is ample. But if climate warming is associated with drying, one can expect reduced assimilation and lower rates of soil/root respiration in temperate ecosystems (Baldocchi et al. 2000).

The NAO is an oscillation of atmospheric pressure at sea level between the Icelandic Low and the Bermuda (Azores) High, and the surface westerly winds between them, mainly in winter (Hurrell and van Loon 1997). In the positive phase of NAO, the intense Icelandic low-pressure system keeps the cold air north, whilst in the negative phase of NAO the weak Icelandic low-pressure system forces the cold air south to more southerly latitudes. Over southeastern Canada a positive (warm) phase of NAO produces a wet and mild winter, whereas a negative (cold) phase creates a dry and cold winter (Hurrell and van Loon 1997; Bonsal et al. 2001; Visbeck et al. 2001). Previous studies have shown links between ENSO and NAO (Rogers 1984; Huang et al. 1998). Both teleconnections can affect temperature and precipitation depending on the region. Bonsal et al. (2001) found that over eastern regions of Canada, the simultaneous occurrence of El Niño (La Niña) events with positive (negative) NAO phases affect temperature by generally making it warmer (colder).

The main goal of this paper is to report the six-year (2008 to 2013) seasonal trend of NEP in a 12-year-old pine plantation in southern Ontario. The primary objective is to investigate and describe the relationship between NEP, GEP, RE, and PAR. The secondary objective is to describe the relationship between seasonal NEP and atmospheric teleconnections, ENSO and NAO.

Methods

Site description

The study site, Turkey Point Flux Station youngest pine forest (known as TP02 or CA-TP1 in global Fluxnet), was planted in 2002. It is located at an elevation of 265 m above sea level close to the town of Turkey Point on the northwestern side of Lake Erie in southern Ontario, Canada (42°40′N, 80°34′W). The site was formerly sandy agricultural land (98% sandy soils), which was abandoned a few years prior to the planting of eastern white pine (*Pinus strobus* L.) seedlings. White pine is an important species in North America due to its sensitivity to seasonal and annual climatic variability which enables the species to adapt to dry environments, and allows it to grow on nutrient poor, dry sandy soils. Due to its long life span of 350 to 400 years, and its potential height of 45 to 60 m, it is a preferred afforestation species in eastern North America. The location of the TP02 site is unique in that it is in the transition zone between the cooler northern boreal zone and the broadleaf deciduous temperate zone. This characteristic makes it an ideal area to observe and quantify sensitivity to climate variability. The climate of the region is temperate having a 30-year mean annual temperature of 8.0°C and mean annual precipitation of 1,036 mm. This region has one of the longest growing seasons in Canada with at least 150 to 160 frost free days (Arain and Restrepo-Coupe 2005).

Flux and meteorological measurements

Half-hourly fluxes of carbon, water, and energy were measured using a closed-path eddy covariance (EC) system comprising a CSAT3 sonic anemometer produced by Campbell Scientific Inc.

of Edmonton, Alberta, and an IRGA model LI-7500 infrared gas analyzer produced by LI-COR Inc. of Lincoln, Nebraska (Peichl et al. 2010). Downwelling PAR represents photosynthetic photon flux density (PPFD) hitting a surface per unit area per unit time. It was measured with LI-COR LI190 quantum sensors. NEP, that is net ecosystem CO_2 exchange (NEE), was calculated as the sum of the CO_2 flux and the CO_2 storage from the air column below the EC sensors. Ecosystem respiration (RE) was calculated for each half-hour from exponential regressions between nocturnal NEE at high friction velocity and soil temperature at 2 cm depth. GEP was obtained by adding NEP to RE during the growing season. Both GEP and RE were given positive signs and NEP was positive for carbon sinks. Flux measurement height was increased from 3 to 4 m on top of a triangular tower as the trees grew taller. All flux and meteorological data were quality controlled and averaged at half-hourly intervals. Further details of the closed-path EC system, data quality control protocols, gap-filling, and meteorological and soil measurements are described in Arain and Restrepo-Coupe (2005).

Half-hourly values of GEP, NEP, and RE in μmol CO_2 m^{-2} s^{-1}, and downwelling PAR in μmol photons m^{-2} s^{-1} were used from 2008 to 2013. GEP, NEP, and RE values were then converted to g C (carbon) m^{-2} day^{-1} whilst PAR was estimated in MJ m^{-2} day^{-1}. The half-hourly GEP, NEP, RE, and PAR values were then averaged to get daily means.

Monthly recordings were categorized into four seasons: winter (W) comprising January, February, and December of the previous year (DJF); spring (Sp) comprising March, April, and May (MAM); summer (S) comprising June, July, and August (JJA); and fall (F) comprising September, October, and November (SON). Seasonal averages for GEP, NEP, RE, and PAR were calculated from daily means. Annual totals of GEP, NE, and RE were calculated by adding the daily NEP averages for each year. The average annual temperature for the study period was 8.9°C. Seasonal average temperatures ranged from a low of −2.8°C for winter through 8.1°C for spring and 10.3°C for fall, to a high of 20.2°C for summer.

ENSO and NAO data

ENSO is characterized by the ocean-atmospheric interaction in the equatorial Pacific and overlying atmosphere. The Southern Oscillation Index (SOI) defines the atmospheric anomaly and is generated by the pressure differences between Tahiti and Darwin, Australia. El Niño events are represented by large negative values of SOI, while La Niña events are represented by large positive SOI values (Diaz et al. 2001). SOI data were taken from the Climate Research Unit (2019).

NAO is one of the major modes of variability of the Northern Hemisphere atmosphere. It is particularly important due to its influence on winter weather conditions in the Northern Hemisphere. Positive (negative) phases are represented by positive (negative) values. NAO indices were obtained from NOAA's Climate Prediction Center (2019).

Average seasonal indices of SOI and NAO were calculated for winter (DJF), spring (MAM), summer (JJA), and fall (SON). These values were then compared with the NEP seasonal averages for 2008 to 2013 by applying Pearson's product-moment correlation. Values of p less than 0.05 were considered significant.

Results and discussion

Seasonal variation in GEP, NEP, RE, and PAR

Mean seasonal values of GEP, NEP, RE, and PAR from 2008 to 2013 are shown in Figure 1. PAR, GEP, and RE followed a similar pattern in all seasons throughout the years. Maximum values of GEP, RE, and PAR were observed during summers and minimum values during winters. The highest GEP and RE occurred in summer 2013 at 9.08 and 7.79 g C m^{-2} day^{-1} respectively, when PAR was 7.05 MJ m^{-2} day^{-1}.

Pearson's coefficient of determination, R^2, between daily values of GEP (g C m^{-2} day^{-1}) and PAR (MJ m^{-2} day^{-1}) for all years was 0.673 ($p<0.001$), indicating a positive relationship at the 0.001 significance level. When the daily annual data were analyzed separately for individual years, R^2 ranged from 0.633 in 2009 to 0.707 in 2008 with statistically significant correlations with p-values < 0.001 in all years. Overall, little change was observed in PAR values between years over the 2008 to 2012 period, followed by a large decrease of roughly 2.1 MJ m^{-2} day^{-1} in 2013 due to cool and cloudy conditions in a spring and summer La Niña event (Thorne and Arain 2015). NEP showed a different pattern than GEP, RE, and PAR with maximum values during springs and minimum values during winters. This shows that RE increased during summers due to warmer temperatures causing a decrease in NEP values (i.e., NEP = GEP − RE).

NEP reached its highest peak during the spring of 2012 (Figure 1) at 1.8 g C m^{-2} day^{-1} when the PAR value was 8.7 MJ m^{-2} day^{-1}. The opposite trend was seen for PAR when summer values were considerably greater than spring PAR. The difference in PAR between the lowest value in spring and the highest value in summer was almost 6 MJ m^{-2} day^{-1}. Xing et al. (2007) observed that productivity increased with PAR up to 11 MJ m^{-2} day^{-1}, then gradually decreased with further increases in PAR. This shows that intense PAR during the summer may create an environment that reduces the effectiveness of the forest as a carbon sink, therefore extreme warm temperatures above average can increase the rate of respiration compared to photosynthesis (Grant et al. 2006; Xie et al. 2014).

Figure 1 also shows that NEP for winter seasons was not notably different among the years and remained relatively constant ranging from −0.6 to −0.8 g C m^{-2} day^{-1} whereas winter PAR fluctuated between 1.8 to 3 MJ m^{-2} day^{-1}. NEP was most negative during the winter of 2013 (−0.8 g C m^{-2} day^{-1}). This suggests that cooler than average temperatures and the large decrease in PAR contributed to the decrease in photosynthesis and hence NEP. Fall NEP was higher (0.1 to 0.7 g C m^{-2} day^{-1}) than winter NEP in each year. This finding can be attributed to low evapotranspiration, higher soil moisture, and cool air temperature leading to reduced evaporation.

Öquist and Huner (2003) noted that overwintering evergreens vary from high photosynthetic capacity and efficiency

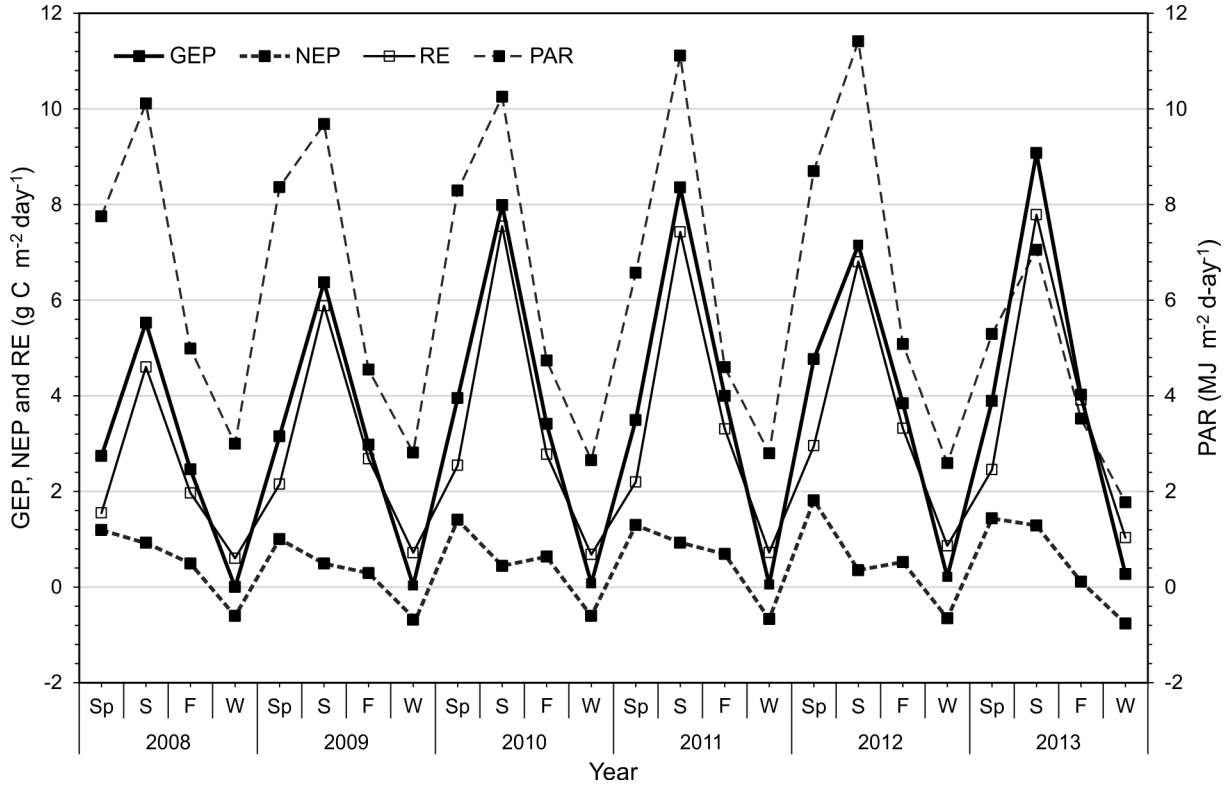

Figure 1
Annual totals of GEP, NEP, RE, and PAR at the Turkey Point white pine plantation, 2008 to 2013

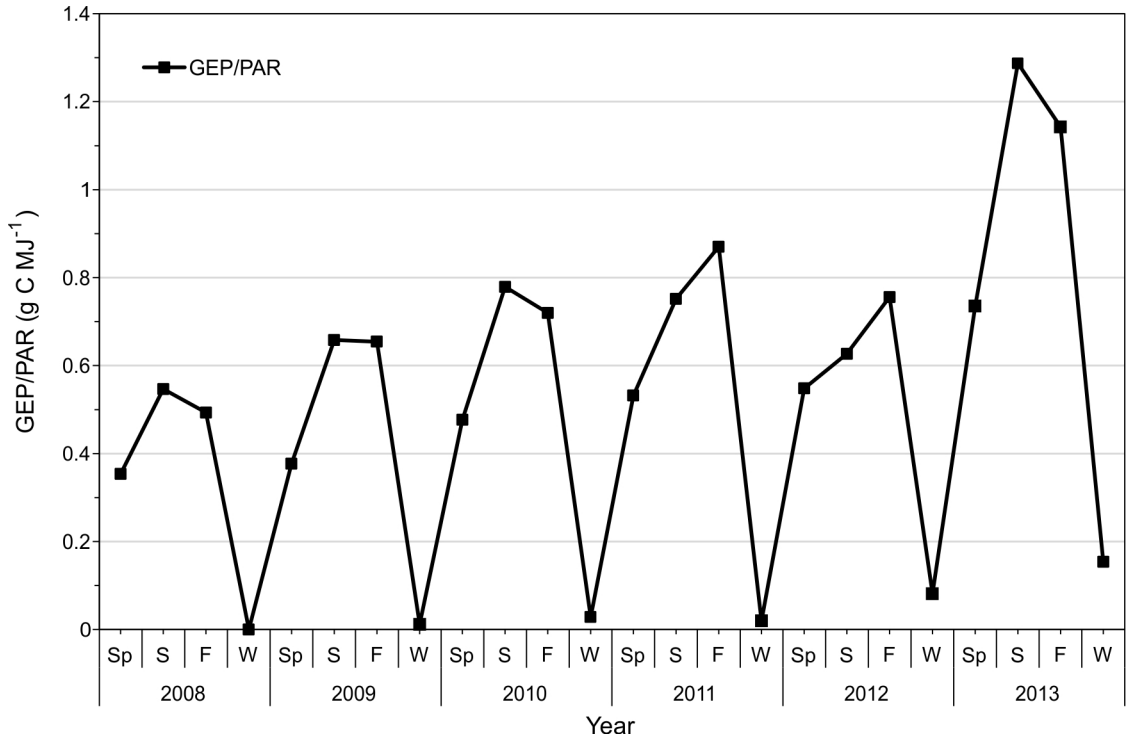

Figure 2
Seasonal variation in GEP/PAR ratio at the Turkey Point white pine plantation, 2008 to 2013

during the summer to low capacity and efficiency in the winter due to freezing temperatures which inhibit photosynthesis. Coniferous forests have negative values of NEP during the winter; however, the trees continue to absorb light energy which is not being used for photosynthesis processes (Zarter et al. 2006a). It is assumed that coniferous pine plantation forests in southern Ontario during winter require warmer temperatures for photosynthesis and have down-regulated photosynthetic capacity due to the decrease in air and soil temperatures. Moisture availability during the winter is sparse as precipitation falls as snow and soil remains frozen, therefore creating a drought-like environment for vegetation.

The GEP/PAR ratio provides a useful indicator in studies of interannual variability and drought (Valentini et al. 2000; Moreno et al. 2012). The ratio of GEP/PAR = ε faPAR indicates the fraction of assimilated carbon consumed by vegetation (ε) and the fraction of photosynthetic active radiation absorbed by vegetation (faPAR) (Goerner et al. 2009, 2011; Moreno et al. 2012). Figure 2 shows that the trend of the GEP/PAR ratio is upwards, and that GEP increases by approximately 0.8 g C MJ^{-1} during the six-year study period. Drought is also shown as a slight decline in the summers of 2011 and 2012 (Figure 2). This is because GEP decreases in response to drought situations (Barr et al. 2002; Asner et al. 2004; Wen et al. 2010). Similar results were found in a Mediterranean forest by Moreno et al. (2012) where during dry summers the high water stress factor reduced the GEP/PAR ratio. In the current study, the GEP/PAR ratio averaged 0.68 for the six years during the growing season and dropped below 0.1 during winter periods (Figure 2). The ratio also showed a large increase during 2010 due to El Niño, and a sharp increase in the summer of 2013. This can be attributed to the growth of the plantation, and the increase in canopy coverage facilitating more productivity.

The ratio of NEP/GEP follows the same pattern as NEP/PAR (Figure 3). These ratios are important in showing the effect of RE and PAR on NEP. For all years both ratios were highest in spring followed by fall, except in 2013, which showed them higher in summer than in fall. This could be attributed to the cooler summer of 2013 by an average of 1°C due to a weak La Niña, and therefore lower respiration (Thorne and Arain 2015). The ratios of NEP/GEP and NEP/PAR were also positive for all seasons except the winter. Since there is no photosynthesis occurring during the winter, the pine plantation forest is a carbon source rather than a carbon sink (Amiro et al. 2006). The average spring and summer NEP/GEP ratios over the course of the six years were 0.37 and 0.1 respectively, which indicates the negative effect of RE on summer NEP values. Similarly, higher PAR values in the summer had a negative effect on summer NEP values.

Linear regression analysis was performed to examine the effect of spring and summer mean air temperatures on seasonal values of GEP and NEP (Figure 4). It shows that mean spring temperature explained 54% of the variation in GEP and 35% of the variation in NEP across the site during the six years. An increase in spring temperature had a positive effect on GEP and NEP. However, the correlation was stronger for GEP ($r = 0.74$, p-value = 0.04) than NEP ($r = 0.59$, p-value = 0.22). The influence of summer temperature on GEP and NEP was not significant and the correlation coefficient was slightly positive for GEP ($r = 0.27$, p-value = 0.62) and slightly negative for NEP ($r = -0.2$, p-value = 0.72). Similar results were reported by Krishnan et al. (2009), which showed a strong positive correlation between spring temperature and annual values of GEP and RE but their correlation with NEP was not significant. NEP also showed a negative relationship with summer and fall temperatures at a young forest sites similar in age to the Turkey Point site; RE increased with increasing temperature leading to a sharp plunge in NEP (Krishnan et al. 2009).

Table 1 shows the annual values of GEP, NEP, RE, and the GEP/RE ratio for the study period. The ratio of GEP/RE, which describes ecosystem carbon balances, was 1.15 on average. This ratio is similar to values reported by Falge et al. (2001) for temperate coniferous forest and to Law et al. (2002) for temperate and boreal coniferous forests. When GEP exceeds RE (ratio > 1), it means the system is storing carbon, and is usually found in young growing plantation. When the ratio equals one, the system is in carbon balance (i.e., GEP = RE and NEP = 0). Usually, the ratio is between 1 and 2 during the growing season and below 1 during the winter period (Falge et al. 2001).

Effect of ENSO and NAO on NEP

ENSO and NAO episodes occur regularly, and can affect the climate in southeastern Canada. During the period of 2008 to 2013, ENSO occurred in most years. There were four La Niña periods (2007–2008, 2008–2009, 2010–2011, and 2011–2012), one El Niño (2009–2010), and one La Nada (2012–2013). NAO mean winter values were strongly positive in 2007–2008 and 2011–2012, and strongly negative in the winters of 2009–2010 and 2010–2011 (Climate Prediction Center 2019).

The effect of ENSO and NAO events on seasonal NEP values is shown in Figure 5. NEP values were positive in all seasons except winter. The highest value was recorded in spring 2012 (La Niña), followed by spring 2013 (La Nada), and then spring 2010 (El Niño). Winter 2010 was a moderate El Niño event with a strong negative phase of NAO (Figure 5). Any potential increase in NEP values from warm El Niño temperatures may have been offset by the strong negative phase of NAO. Osborn (2011) noted that the winter of 2009–2010 had the most nega-

Table 1
Annual totals of GEP, NEP, RE and GEP/RE ratio at the Turkey Point white pine plantation, 2008 to 2013

Year	GEP	NEP	RE	GEP/RE
	g C m^{-2} $year^{-1}$	g C m^{-2} $year^{-1}$	g C m^{-2} $year^{-1}$	
2008	987.81	188.18	799.63	1.24
2009	1,154.04	99.78	1,054.26	1.09
2010	1,413.94	172.91	1,241.03	1.14
2011	1,473.46	211.94	1,261.52	1.17
2012	1,471.25	184.61	1,286.64	1.14
2013	1,566.29	183.65	1,382.64	1.13

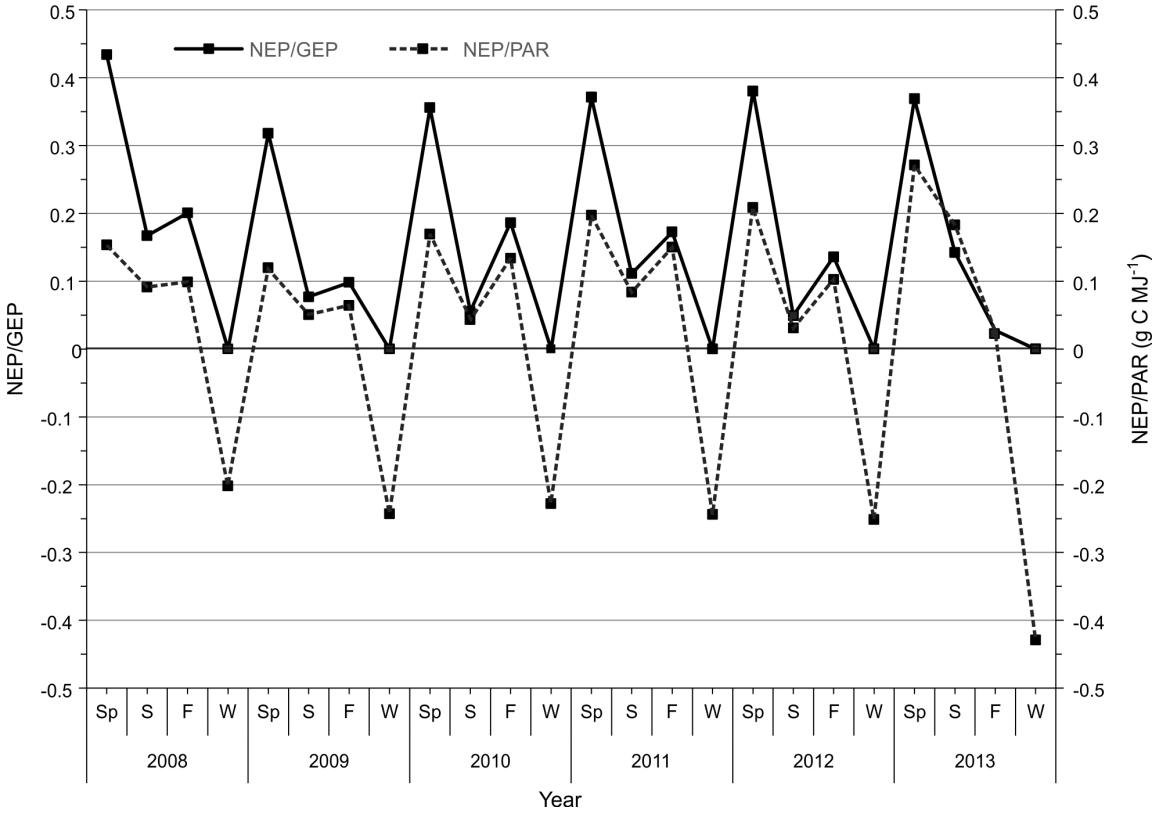

Figure 3
Seasonal variation in NEP/GEP and NEP/PAR ratios at the Turkey Point white pine plantation, 2008 to 2013

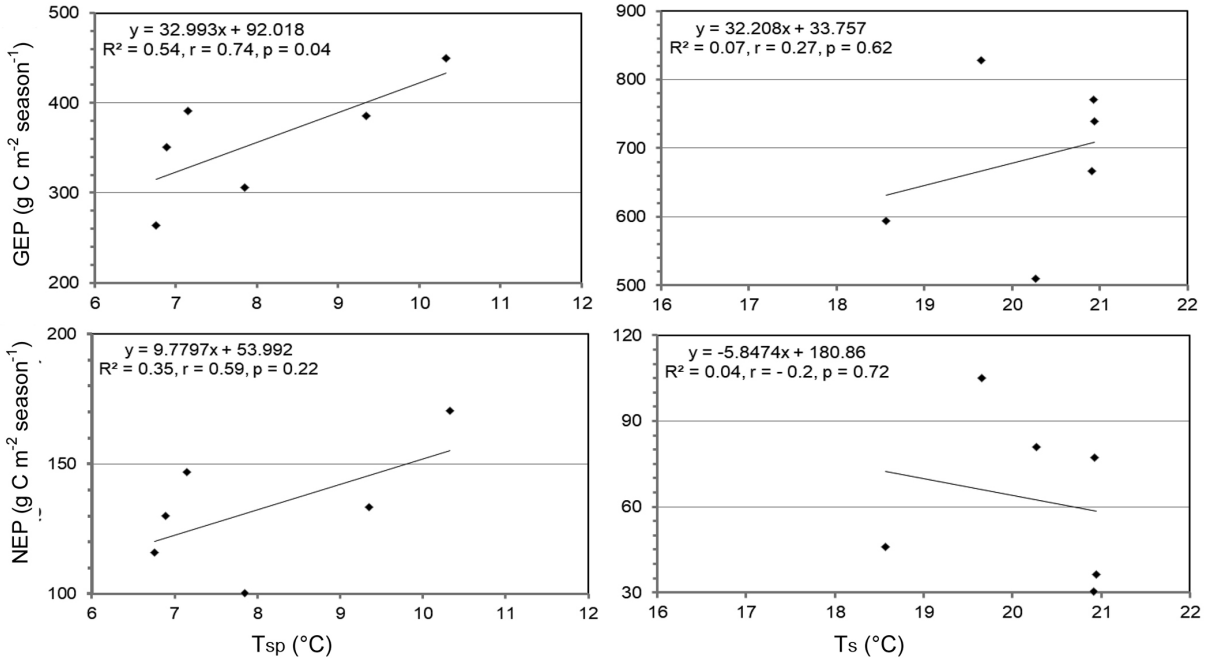

Figure 4
Seasonal GEP and NEP as a function of spring (TSp) and summer (TS) mean air temperature at the Turkey Point white pine plantation, 2008 to 2013

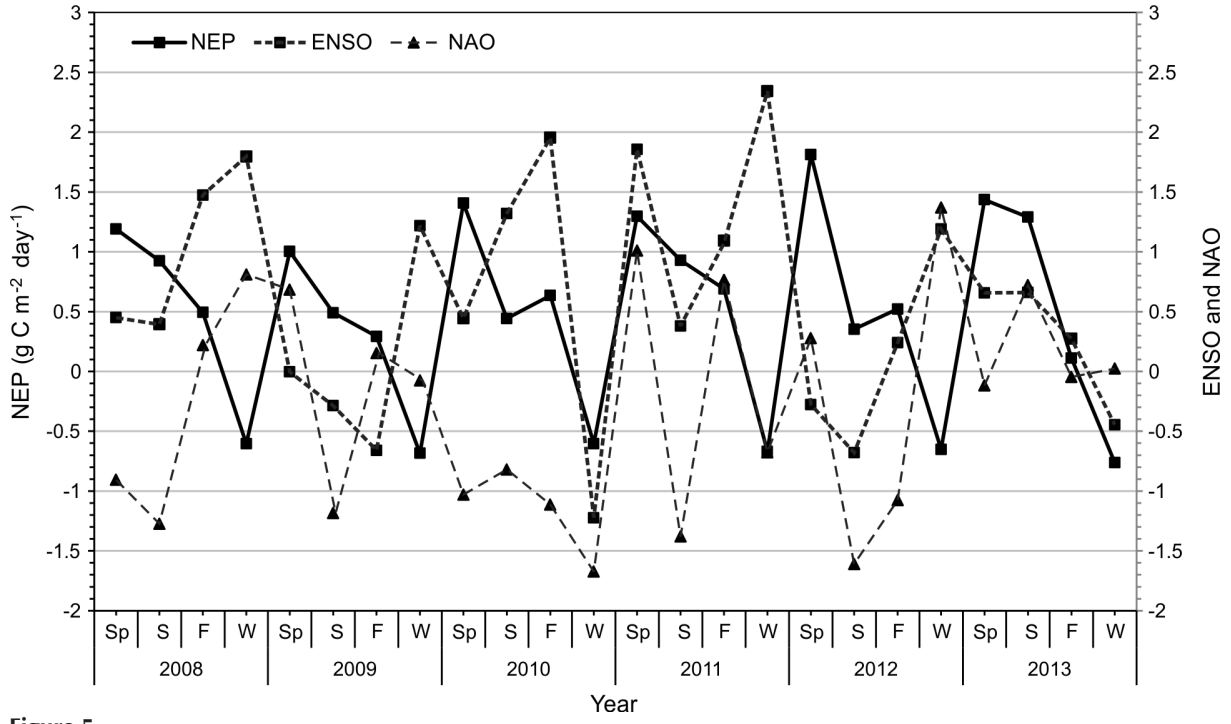

Figure 5
Effect of El Niño Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO) on seasonal NEP at the Turkey Point white pine plantation, 2008 to 2013

tive NAO index measured during almost the entire 190-year data record. In contrast, winter 2012 experienced a moderate La Niña episode and a strong positive NAO phase at the same time, which contributed to the highest NEP values occurring in the subsequent spring of 2012. Thorne and Arain (2015) also observed that the warm winter of 2012 enhanced carbon uptake, extended the growing season, and produced more rainfall than snowfall.

The annual NEP values for the study site varied between 99.78 and 211.94 g C m^{-2} $year^{-1}$ (Table 1). The highest NEP occurred in 2011, even though GEP was lower than in 2013 by 6% (Table 1). The year 2011 was a strong La Niña year and NAO values were strongly positive in the spring and fall (Figure 5). The lowest NEP annual values were observed in 2009 (Table 1), which was a weak La Niña year and NAO values were weakly positive in the spring and fall. Following the 2009–2010 El Niño event, above average temperatures led to high annual RE (1,241.03) in 2010 and subsequently to the second lowest annual NEP (172.91 g C m^{-2} $year^{-1}$) during the six years (Table 1). In the 2008 and 2012 cool and cloudy La Niña years, NEP was comparable to that of the 2013 La Nada year (Table 1).

Morgenstern et al. (2004) and Wharton and Falk (2016) also reported that an increase in winter and spring temperatures followed by a dry summer during El Niño may increase NEP during spring and reduce it in summer due to high RE values, therefore reducing NEP values for the whole year. Wetter conditions in winter followed by cool and cloudy conditions in spring and summer during La Niña can enhance NEP, and decrease RE (Morgenstern et al. 2004). Similarly, a positive NAO can lead to increase NEP and a negative NAO would favour RE (Hember and Lafleur 2008). During drought-like conditions, such as during a La Niña and a negative NAO winter, moisture availability at the study site is low as it is bound by freezing. Non-drought events can be represented by El Niño and positive NAO, where warmer temperatures assume that precipitation will fall as rain, supplying moisture to surviving plants.

Black et al. (2000) reported that the productivity of a boreal deciduous forest in Saskatchewan during 1994, a moderate El Niño year, was more than double that during 1996, a moderate La Niña year. During the winter and early spring, NEP values were negative. The highest NEP values of the four years studied by Black et al. (2000) were in 1998, which was recorded as a strong El Niño year. While Black et al. (2000) showed that productivity levels were higher during warm and dry El Niño years compared to cold and wet La Niña years, the current study shows that temperatures that are too high (i.e., hot summer temperatures) can negatively impact ecosystem productivity, presumably because of increased drought-like conditions.

Due to increase in winter precipitation, spring usually experiences an abundance of water for productivity and tree growth. Krishnan et al. (2009) showed that in Douglas-fir stands on the east coast of Vancouver Island, British Columbia, NEP peaked during April to June, however, during the latter part of the growing season (July to August) RE increased greatly with increasing temperatures offsetting NEP. Figure 5 reports peak NEP values occur during spring, and decrease during summer and fall. It can be assumed that because the peak in NEP follows the peak in temperature, and since peak NEP has shifted from summer months to early spring (Figure 5), the emergence of seasons,

particularly the growing season, is occurring earlier than in several earlier decades, and may be attributed to climate changes.

In other cases, such as Grant et al. (2012), rainy and dry seasons were modeled to predict how they will affect NEP with climate change. NEP was affected by the intensity and duration of carbon uptake during both rainy and dry periods. In rainy periods, temperature increased, and in effect NEP increased. These temperature increases can be attributed to El Niño events. As temperatures increase during El Niño, more rain is seen during winter and spring months. During the 2010 El Niño year, NEP values were less negative during the winter months and increased to maximum values during the following spring (Figure 5).

As photosynthesis relies heavily on moderate temperatures and the presence of needles for the exchange of carbon, it can be assumed that the increase in atmospheric temperature by teleconnections influences the increase of productivity in the forest site. Most vegetation cannot survive during cold Canadian winters; hence no productivity is observed. During La Niña, where dormant seasons begin earlier and active seasons arrive later, it can be expected that NEP will be at its lowest due to the substantial decrease in the length of active seasons.

In relation to natural forests where carbon is stored mostly in the soil, it can be assumed that the positive values of NEP during spring, summer, and fall offset the negative values of NEP during winter, and on an annual basis make the Turkey Point TP02 site more of a carbon sink than a source.

Summary and conclusion

This study evaluated the seasonal trends of GEP, NEP, RE, and PAR and their relationship with two teleconnections, ENSO and NAO, in a 12-year-old white pine plantation site in southern Ontario from 2008 to 2013.

Findings indicate that maximum values of GEP, RE, and PAR were observed in the summer. The highest GEP and RE occurred in the summer of 2013 at 9.08 and 7.79 g C m^{-2} day^{-1}, respectively, when PAR was 7.05 MJ m^{-2} day^{-1}. Summer NEP values were considerably less than spring NEP values, which is attributed to the higher intensity of PAR and lower soil moisture availability. The highest NEP values were recorded in spring 2012 at 1.8 g C m^{-2} day^{-1} when PAR was 8.7 MJ m^{-2} day^{-1}.

The GEP/PAR ratio was highest in summer except in 2011 and 2012, when GEP decreased in response to drought. Ratios of NEP/GEP and NEP/PAR followed each other and showed highest values in spring in all years. Intense PAR and a low NEP/PAR ratio during the summer indicated an environment where the effectiveness of a forest to sequester carbon was reduced. The ratio of annual GEP/RE, which describes ecosystem carbon balances, was 1.15 on average. When GEP exceeded RE (ratio > 1), it meant the system was storing carbon, as is usually found in a young growing plantation.

An increase in spring temperature had a positive effect on seasonal values of GEP and NEP, where the correlation was stronger for GEP ($r = 0.74$, p-value = 0.04) than for NEP ($r = 0.59$, p-value = 0.22). However, the influence of high summer temperature on GEP and NEP was not significant and the correlation coefficient was slightly positive for GEP ($r = 0.27$, p-value = 0.62) and slightly negative for NEP ($r = -0.2$, p-value = 0.72).

The simultaneous occurrence of La Niña events with positive NAO phases had a positive impact on NEP. Winter 2012 experienced both a moderate La Niña and a strong positive NAO, which contributed to highest spring NEP values. However, annual NEP values were highest in 2011 (211.94 g C m^{-2} $year^{-1}$) and lowest in 2009 (99.78 g C m^{-2} $year^{-1}$). The year 2011 was a strong La Niña year and NAO values were strongly positive in the spring and fall. In contrast, 2009 experienced a weak La Niña year with weak positive NAO values in the spring and fall. The high temperatures in the 2009–2010 moderate El Niño year led to high RE of 1,241.03 and low NEP of 172.9 g C m^{-2} $year^{-1}$ in 2010. The El Niño effects were offset by a concurrent strong negative phase of NAO. For La Niña and La Nada years, RE was reduced and NEP was increased due to lower temperatures.

The warm phases of ENSO and NAO have a positive impact on forest productivity. The emergence of warmer temperatures during spring and the development of needles occur earlier with increasing strength of teleconnections. The peak of NEP from winter to spring is correlated with the growth of vegetation, increased photosynthesis, and melting of the snowpack.

Future research should include further examination of Eddy Covariance flux measurements of energy, water vapour, and carbon dioxide using MODIS (Moderate Resolution Imaging Spectroradiometer) products of different spectral indices that are useful under water stress conditions. Long-term flux measurements, in combination with ecosystem productivity models and high resolution remote sensing data from MODIS, will provide accurate estimates of net carbon sequestration by plantation forests that will help Canadian policy makers in planning realistic strategies to offset fossil fuel CO_2 emissions.

Acknowledgements

This research was supported by a University of Winnipeg Discretionary Grant. Fluxnet data were provided by Dr. Altaf Arain from McMaster University. The authors thank the numerous scientists, students, and technicians responsible for the day-to-day collecting of the flux data at Turkey Point station. The authors are also indebted to Dr. Bruce Erickson of University of Manitoba, Dr. Bernard Thraves, formerly of University of Regina, and the two anonymous reviewers for their insightful comments and suggestions.

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

The 'Self and Society Project' reversed: Students share their rural American university culture with peers in the north of Vietnam

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This paper is the second of two stemming from a project that used cell phones images of students in North Dakota and Vietnam to bridge cultural divides, expand cultural competence, and promote the sharing of social worlds. In reverse of the first paper, it reports on the exhibition of photographs taken by rural American students and the perceptions of those images by the Vietnamese audience.

The 2018 edition of Prairie Perspectives reported on a collaboration between Dr. Aaron Kingsbury of Mayville State University in rural North Dakota (Figure 1) and Hồng Thị Hà of Thái Nguyên University of Agriculture and Forestry (TUAF) in Thái Nguyên City in the north of Vietnam (Figure 2). Dr. Kingsbury had worked as a visiting scholar and taught an introductory geography course with Ms. Hà supporting as teaching assistant. In that first paper, they concluded with a promise to provide further updates as they expanded on their project. This report briefly summarizes that earlier paper and shares how these next phases were successfully concluded.

In 2017, the authors organized a multi-phase project which employed the tools of social media to encourage university students to identify, expand, and then cross-culturally share their environmental and cultural place-ness. That is, we approached notions of reflexive photography from the perspective of international cross-cultural exchange, and sought to expand cultural competence by allowing for reflection on images of social worlds selected specifically for sharing by the 'other.'

Figure 1
Location of Mayville State University, Mayville, North Dakota
Cartography: Muto-Kingsbury Emiko, redrawn by W. Hiebert, made with Natural Earth

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Figure 2
Location of TUAF, Thái Nguyên City, Vietnam
Cartography: Muto-Kingsbury Emiko, redrawn by W. Hiebert, made with Natural Earth

As part of a class project, Vietnamese university students captured over 1,000 images with GPS-enabled cell phones that best exemplified the social worlds they valued highest. They then incorporated their images into ESRI StoryMaps (i.e., a format that combines cartography, narrative texts, and multimedia content) to share the images and then present the myriad of stories they hold to fellow Vietnamese classmates. After this was finished, the students then collectively selected a subset of images for an exhibition at a university gallery in rural North Dakota to help challenge lingering, often incorrect, and occasionally racist stigmas/stereotypes from the 1960s and 1970s about Vietnamese people still held by many Americans. Finally, external funding was awarded to host a public event in Mayville where the American community was able to communicate with live-streaming Vietnamese students. A survey was available at the gallery and public event to gather the thoughts and opinions of participants.

Overall, 65 members of the student body, community, faculty, and staff of Mayville completed the survey. This was an incredible number when considering the small size of the local community and campus. Indeed, Mayville has less than 2,000 residents and only one traffic light. Interestingly, mirroring the vocalized opinions of those in attendance at the public event, over 95% of all surveys completed mentioned similarities between student culture in the USA and Vietnam. Most also expressed some element of surprise at this. American students in particular shared opinions of "Everything seemed so similar," "I do the same things!" "They are exactly like us!" and "A lot of things look surprisingly similar to what we do in the USA." Other American students were impressed with how modern and wealthy Vietnam looked in contrast to what they had imagined.

The most popular images related to pets, with American students selecting images of cats and dogs as their favourites as they claimed to relate to them directly or appreciated how much the Vietnamese students also loved their pets. One American student expressed a thought shared in the comments of many others, which the authors feel matched the goal of the project: "It is awesome to see how much I actually relate to them [i.e., the Vietnamese students] and the activities they do." Overall, the project drew from a number of disciplines to show that despite considerable geographic distance, university students share more proximate and universal loves, concerns, and aspirations. The authors were very pleased with how the gallery and public event were perceived in the US, and decided on reversing the project to bring images taken by rural American university students to the north of Vietnam to spark reactions, conversations, and understanding.

Since that initial publication, the seven Vietnamese participants in the live-streaming event were asked by Dr. Kingsbury over coffee in Thái Nguyên City to reflect on their experiences speaking to a large and unknown audience. All expressed how fearful they were before participating, with the challenges of language and being culturally appropriate first on their minds. They also mentioned that an unintended consequence of the audience being in a slightly darkened room was that they felt less restricted to behave and speak to those of different ages and positions in society. Overall, the seven each mentioned an increased level of personal confidence from the experience in communicating publically in a foreign language and with international audiences. Despite their initial apprehensions, they were happy to be able to communicate with those from a culture very different and geographically distant from their own.

During the spring semester of 2018, Dr. Kingsbury organized his students in North Dakota to capture images of their social worlds. The rules and procedures were the same, with the roles simply reversed. American students voted on which 25 images they felt best reflected their identity. Over the summer of 2018, Dr. Kingsbury brought these images to the TUAF campus where they were exhibited. Local students, faculty, and staff were invited to view the images and complete a Vietnamese language survey of which 53 were completed. Like their counterparts in the United States, the images that were scored highest by the Vietnamese related to cute pets, sports, and family. With

Figure 3
Enjoying the falling snow
Photography: MSU students

Figure 4
The snow shovellers
Photography: MSU students

that said, the images that garnered the most responses related to winter. With snow notably absent in tropical Thái Nguyên City, Vietnamese students most appreciated images of snowfall, snow shoveling, and broomball (Figures 3 to 5). Many expressed surprise that the ice would not break when walking on it. Indeed, most wrote something approximating how much they have always wanted to be able to see snow and ice in person.

Interestingly, unlike their American counterparts, most Vietnamese were not terribly surprised by the cultural trends they saw in the images. Many even expressed how familiar they felt they were with the culture of the United States as they had seen so many movies and television shows from the country. Despite this, the Vietnamese students indicated they were excited to see the more personal aspects in the lives of actual American students. They also mentioned surprise at both the lack of skyscrapers and the feeling that the general atmosphere in rural North Dakota is "Not noisy, but very quiet." This apparent lack of understanding about the state is not surprising, considering how little North Dakota contributes to and is represented by contemporary American popular culture. Perhaps most interesting of all, nearly every Vietnamese person who completed the survey mentioned the desire to visit, study, or stay for a short while in the Upper Great Plains. Most mentioned something approximating "I really want to see this culture first-hand" as well as an

Figure 5
Broomball
Photography: MSU students

attributed rise in the motivation and confidence to travel to parts of the world foreign to them.

Overall, the authors feel this approach to bi-directional cultural sharing was successful in a number of ways. While languages and beliefs may differ across cultures, some universals seem to remain. Globalization and the reach of global youth culture notwithstanding (and they are treated in more detail in the 2018 publication), this project distilled some of these universals, and in doing so began the process of re-humanizing Vietnamese living in the north of their country by sharing an immensely personal glimpse of its next generation of social, economic, cultural, environmental, and political leaders. The sharing of social worlds however worked equally well in both directions. In particular, students and community members of both Vietnam and the US seemed to benefit most from views of another country and culture often ignored or misrepresented in the media and entertainment industry. The authors hope that by sharing these personal glimpses of our social worlds, the common universals across cultures will help to bridge remaining historical divides.

Acknowledgements

The authors would like to thank participating students from classes K45, K46, and K47 in the Advanced Education Program at TUAF and those students at Mayville State University for their contributions and enthusiasm. The gallery and public program on Mayville State Campus were funded by a grant from the North Dakota Humanities Council and the Mayville State University Office of Diversity and Inclusion.

Prairie Perspectives: Geographical Essays
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The Riding Mountain Biosphere Reserve (RMBR): Challenges, opportunities, and management issues at the southern fringe of Riding Mountain National Park, Manitoba

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Key Messages

- Riding Mountain Biosphere Reserve (RMBR) is one of three biosphere reserves in the Canadian prairies.
- Multiple interactions take place between Riding Mountain National Park, the adjacent municipalities, and First Nation reserves.
- Projects and activities pose challenges that for successful resolution require cooperation among RMBR stakeholders.

Riding Mountain Biosphere Reserve (RMBR) was founded in 1986, 53 years after the establishment of Riding Mountain National Park (RMNP). Currently the RMBR is one of 18 biosphere reserves in Canada, three of which are located in the Prairie region. The reserve has a total area of approximately 13,310 km² comprising the RMNP core area measuring 2,700 km², a buffer zone of 268 km², and a transition zone or cooperation area of 10,342 km². Fourteen municipalities and four First Nation reserves are located within the transition zone. Three of the reserves (Rolling River, Keeseekoowenin, and Waywayseecappo) are located in the southern part of the RMBR. This paper focuses on the complex ecological, demographic, cultural, socio-economic, and political-administrative framework and relationships between RMNP, the municipalities, and the First Nation reserves. 'Baskets' of complementarities, mutual opportunities and benefits contrast with multiple challenges, diverging interests, and potential sources of conflict. Recently, enhanced communication, closer interactions, and joint projects have characterized relationships, at least in some areas between the National Park, and some of the municipalities and First Nation reserves. However, genuine environmental commitment and protection, as well as a strong, diversified economic base, and a harmonious coordination of these principal objectives may require an even stronger effort and cooperation between all of the regional stakeholders.

Keywords: Riding Mountain Biosphere Reserve, Riding Mountain National Park, rural municipalities, First Nation reserves, interaction and cooperation, challenges and regional management issues

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Introduction: Biosphere reserves in Canada

In 2016, the United Nations Educational, Scientific and Cultural Organization (UNESCO) recognized 669 designated biosphere reserves in 120 countries. Of these, 18 are located in Canada and three—Riding Mountain, Manitoba, Redberry Lake, Saskatchewan, and Beaver Hills, Alberta—within the Prairie region (Figure 1). The biosphere reserves are composed of three interrelated zones with supposedly complementary and mutually reinforcing functions. Core areas comprise legislated protected regions whose principal aims are the conservation of landscapes, ecosystems, species, and genetic resources. Buffer zones adjoin the core areas. Their function is the pursuit of activities compatible with a sound ecological base. Transition zones, or areas of cooperation, are regions where the greatest human-nature interaction takes place. The mandate of such zones is community and regional development that is both ecologically and socioculturally sustainable.

Biosphere reserves in Canada are highly diverse in size, physiography, ecology, and human activity, as well as in their function and management mandates. In general, the reserves have three principal functions. First, they contribute to the conservation of ecosystems, and to the preservation of cultural heritage. Second, they foster the economic and social viability of the countryside and the livelihoods of local people. Third, they contribute to local and regional capacities for education, training, research, monitoring, networking, and partnerships with respect to conservation and regional sustainable development.

Today, local perceptions of and attitudes towards biosphere reserves are ambivalent and sometimes controversial. Some communities are proud of being part of a biosphere reserve, may identify with it, and are aware of the benefits, in terms of maintaining ecological integrity, or enhancing their economic potential, for example in ecotourism promotion. Others may perceive biosphere reserves as externally imposed administrative units that hinder the exploitation of natural resources and regional development opportunities. Borrini-Feyerabend et al. (2002, 5) have pointed out that, in the context of local heritage, indigenous people have made, and continue to make, a significant contribution to the establishment, maintenance, and conservation of sacred sites that long precedes the establishment of legally established protected areas.

Figure 1
The UNESCO world biosphere reserves of Canada
Source: www.biosphereresservecanada.ca
Cartography: W. Hiebert
Basemap: Natural Earth

Biosphere reserves in Canada are represented and supported by the Canadian Biosphere Reserves Association (CBRA). It coordinates projects by providing funding, research, monitoring, education, and training. The vision of the CBRA is

> to be a leader in creating vibrant, healthy, sustainable communities across Canada, while conserving Canada's natural and cultural heritage. As model regions and dynamic learning sites for collaborative projects…BRs strengthen and celebrate Canadian values and action national priorities including biodiversity conservation, sustainable development, and reconciliation between indigenous and non-indigenous peoples (CBRA 2018, 1)

In 2013, the CBRA cooperated in the compilation of the guidebook *Learning From Each Other: Proven Good Practices in Canadian Biosphere Reserves* (Godmaire et al. 2013). This report lists projects relating to the broad themes of land management and ecosystem services, sustainable tourism, and education. It uses most of the Canadian biosphere reserves as case studies.

The objective of this paper is to examine the multiple ecological, cultural, economic, social, and political-administrative interactions between the core area of Riding Mountain Biosphere Reserve (RMBR), the Riding Mountain National Park (RMNP), and its adjacent zone of transition. The latter includes 14 municipalities and four First Nation reserves. The focus of the study is on the southern fringe of RMNP as this is the most dynamic arena of interchanges and cooperation, but also of frictions. A host of issues and challenges characterize this zone, for example in wildlife management, infrastructure services, the viability of municipalities and First Nation communities, sustainable agricultural development, and the proliferation of cottage subdivisions.

The Riding Mountain Biosphere Reserve (RMBR): General characteristics

RMBR (Figure 2) was established in 1986, 53 years after the founding of Riding Mountain National Park. The RMBR is located in western Manitoba, some 300 km northwest of Winnipeg, and about 100 km north of Brandon. Its core coordinates are 50°45′N and 100°19′W. The RMBR is situated in the so-called "Parkland region," a transition zone of grassland, and aspen-oak and mixed forest biomes. Within Manitoba's Prairie region, the RMBR represents a unique topographic, ecological and cultural landscape. Its altitudinal range extends from 304 m at the shore of Lake Dauphin to 755 m at the highest point of Riding Mountain. The total area of the RMBR is 13,310 km^2, with the core area of RMNP measuring 2,700 km^2, a small adja-

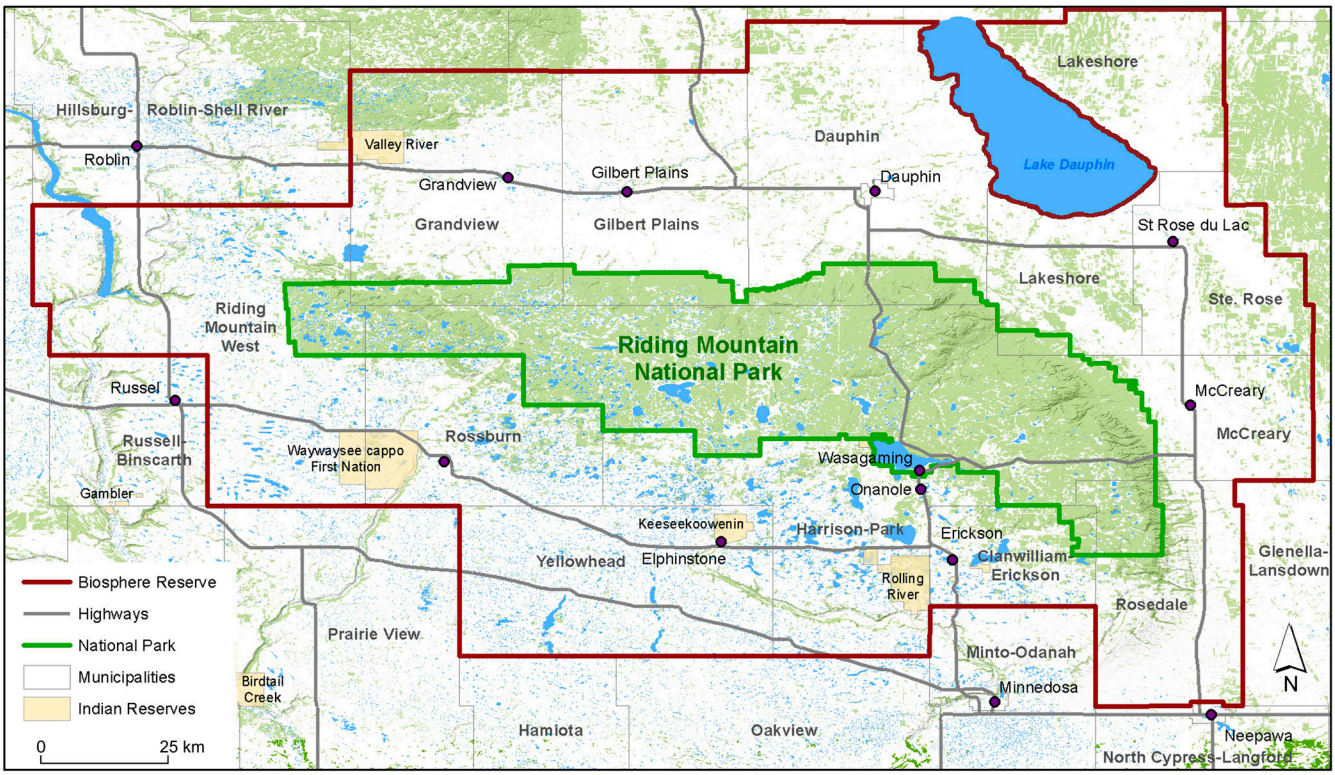

Figure 2
Riding Mountain Biosphere Reserve
Source: Stadel 2015, updated 2019
Cartography: W. Gruber

cent buffer zone of 268 km^2, and a neighbouring transition zone of 10,342 km^2 (UNESO 2015).

As part of the Manitoba Escarpment, Riding Mountain rises conspicuously from the flat Manitoba Lowlands at its eastern and northern faces. To the south and west, in contrast, there is a gradual landform transition to adjacent hummocky knob and kettle topography, gently rolling moraines, outwash plains and some deeply entrenched glaciofluvial channels. Because of its higher elevation and associated cooler and moister climate, the RMBR represents an ecological niche of different forest and grassland biomes (CPAWS 2004). Historically, the ecological island character of the biosphere was further enhanced by the fact that the terrain, soil and climate, except for its forest resources, proved to be largely unattractive to agricultural colonization and early European pioneer settlement. Although it has been described as an "island of natural vegetation in a sea of human-altered environments" (Stadel 2015, 84), forestry and milling operations, as well as haying and grazing began as early as the 1870s. These enterprises were later supplemented by agricultural activities in the vicinity of Riding Mountain, mostly by Ukrainian and Scandinavian settlers. In 1895, the Riding Mountain Timber Reserve was established. Despite this, logging continued, even with the establishment of Riding Mountain National Park in 1933; the last timber mill in Riding Mountain closed only in 1949.

The early European impact on the region should not conceal the spiritual, cultural and economic significance of *Wowwaswajicus* (Hill of the Buffalo Chase) for the indigenous Cree and Assiniboine societies. To these communities, Riding Mountain has always been a sanctuary and a source for a variety of resources. Indigenous people used the rich resources of the Riding Mountain region for hunting, fishing, trapping, and berry and mushroom picking. They also relied on its rich supply of water, wood, and pastures. With the advent of the European fur trade and the establishment of trading posts and trading routes by the Hudson's Bay Company, many indigenous people participated in this economic venture (Stadel 2015, 84–85).

The human landscape and its economic orientation in the Riding Mountain region has been fundamentally transformed since the second half of the 19th century. This development was spurred by four principal factors: first, the subdivision of the land under the Dominion Lands Act into a grid of sections and townships initiated in 1869; second, the political integration of the prairies into the Dominion of Canada; third, the building of the Canadian Pacific Railway across the southern prairies in the early 1880s and the Canadian Northern Railway (formerly the Lake Manitoba Railway and Canal Company) in the 1890s in the Parkland region, as well as the dense network of colonization railways and branch lines in the following years; and fourth, the allocation of homestead lands to settlers facilitated by the above factors. The railway transportation 'revolution' triggered a massive influx of European settlers to the prairies. These were mostly British, French, Ukrainian, Scandinavian, and people of German origin. They settled in dispersed farmsteads or in strings of low to high order service centres, predominantly along the railway lines. Very quickly, southern Manitoba was shaped by an agricultural economy dominated by large-scale grain farming and livestock operations. In the Parkland region, agricultural activity was supplemented by lumbering and timber operations in the upland areas (Stadel 1995, 144–147).

Quite early in the 20th century, the recreational potential of the lakes and forests of Riding Mountain was discovered. Initially, primarily local people visited the beaches of Clear Lake; they camped and built their first cabins in Riding Mountain. With the rise of automobile traffic and the improvement and expansion of roads, recreation and tourism in the Riding Mountain region increased. Its recreational hinterland expanded into the entire region of southern Manitoba, especially attracting visitors from the towns and cities, the foremost of which were Brandon and Winnipeg (Everitt 1981, 20–25). Soon, there emerged a touristic infrastructure of hotels and shops to service the cottagers and visitors. The recreational and touristic appeal of Riding Mountain was further enhanced with the establishment of Riding Mountain National Park in 1933 (Stadel 2015, 85–86). In the 1930s, a large infusion of capital funding and relief camps of approximately 2,500 men provided cheap labour. Infrastructure was further expanded in the 1940s when conscientious objectors continued to provide cheap labour. In the post war years the automobile provided more and more access from further away.

Today, the Riding Mountain region still has a primarily dual agricultural and recreational function (Figures 3 and 4), supplemented by a range of other commercial activities that are mostly concentrated in the service centres of the region. Since the late 20th century, the rural areas and small towns and villages of the region have exhibited a tendency for population decline. However, population forecasts of the late 20th century envisaging a general dramatic decline of rural and small town populations, and the disappearance of most villages and hamlets, has not taken place. Overall, population change has been rather complex and a result of a range of different factors.

Between 2011 and 2016, the resident population of the RMBR decreased by 1.6% from 30,809 to 30,324 (Statistics Canada 2017; Table 1). During the same period, the population of Dauphin, the largest settlement in the RMBR, declined from

Figure 3
Combining in the Municipality of Harrison Park
Photography: C. Stadel

Figure 4
Visitor Centre in Wasagaming, Riding Mountain National Park
Photography: C. Stadel

8,457 to 8,251 (−2.4%); and in keeping with this general trend, the combined population of the 13 rural municipalities in the RMBR also declined from 19,987 to 19,566 (−2.1%). In contrast, three municipalities experienced a population increase between 2011 and 2016. Of these, the RM Dauphin experienced by far the greatest increase (+8.5%). Among the ten municipalities that experienced decline, the sharpest was in the RM of Harrison Park (−9.8%). Interestingly, Harrison Park has the highest number of cottages (877) and likely the highest concentration of summer seasonal residents, but these persons are not included in census figures. The RMBR also includes four First Nation reserves with a 2016 total population of 2,507, representing an increase of 6.0% since 2011. Here too, population change has varied from reserve to reserve: Rolling River and Waywayseecappo experienced significant increases of 14.3% and 12.0% respectively, whilst Keeseekoowenin has undergone major population decline of −14.2%.

It is evident that the RMBR is characterized by an intriguing diversity of features of both the natural and human environment. With the National Park at its core, the establishment of the RMBR included a wider settled area and thereby amplified the mandate and planning requirements of the region. This is true for not only ecological concerns, but also for the viability and sustainability of the resident population.

Mandates, tasks, and challenges of the Riding Mountain Biosphere Reserve

When the RMBR was established in 1986, its core area, Riding Mountain National Park, was already in existence for over half a century. The areal designation of the biosphere reserve was entrusted to the Riding Mountain Liaison Committee, whose mandate it was to seek regional cooperation of RMNP and the neighbouring towns, municipalities, and First Nation reserves.

Table 1
Population change in the Riding Mountain Biosphere Reserve, 2011 to 2016
Source: Statistics Canada (2017)

Municipalities	Population		Population change (%) 2011–2016
	2011	2016	
Municipalities			
Clanwilliam-Erickson	901	870	−3.4
Dauphin (City)	8,457	8,251	−2.4
Dauphin (Rural Municipality)	2,200	2,388	8.5
Gilbert Plains	1,623	1,470	−9.4
Grandview	1,505	1,482	−1.5
Harrison Park	1,799	1,622	−9.8
Lakeshore	1,401	1,363	−2.7
McCreary	946	892	−5.7
Riding Mountain West	1,390	1,420	2.2
Rosedale	1,627	1,672	2.8
Rossburn	1,046	976	−6.7
Russel Binscarth	2,553	2,442	−4.3
St. Rose du Lac	1,023	1,021	−0.2
Yellowhead	1,973	1,948	−1.3
Total	28,444	27,817	−2.2
First Nation Reserves			
Keeseekoowenin	450	386	−14.2
Rolling River	343	392	14.3
Valley River	353	364	3.1
Waywayseecappo	1,219	1,365	12.0
Total	2,365	2,507	6.0
Grand Total	30,809	30,324	−1.6

With the amalgamation in 2015 of most rural municipalities into larger administrative regions, the RMBR today nominally consists of the federally administered National Park, the locally and provincially governed incorporated towns, villages and municipalities, as well as the four First Nation reserves. The latter are largely self-governed but to a great extent depend financially on the federal Ministry of Indian and Northern Affairs. Therefore, the delimitation of the RMBR based on political-administrative principles is rather arbitrary.

The mandates and objectives of the National Park, the municipalities and First Nations reserves are quite diverse, and this is even the case between individual municipalities and First Nation reserves. RMNP fulfills a dual function of ecological protection and recreation/tourism. Because the resident population of cottage owners, business people, and park employees is largely restricted to the summer season, the mandate of nature protection and ecological integrity is more easily implemented than in the transition zone of the biosphere reserve. Nevertheless, even within the National Park, the interests of stakeholders may be diverse and can be a source of frictions, especially in the resort town of Wasagaming during the summer peak season (Stadel and Selwood 1996). With the creation of RMNP, Anishinaabe people (Cree and Assiniboine) were expelled from their land within the National Park and were stripped of their traditional activities of hunting, fishing, and berry picking. In partial

restitution of these injustices, the Keeseekoowenin First Nation was given back a piece of land on the northwestern shores of Clear Lake.

In the transition zone of the biosphere reserve, the situation is more complicated. Here, within the triple political-jurisdictional framework of provincial, municipal, and First Nations, competence and power may have a complex impact on goals and activities. While the Manitoba government exercises a high degree of authority over many larger environmental, political, economic, and social agendas, individual municipalities control local taxes, land use, and infrastructure. In turn, First Nations have a considerable degree of administrative authority over land regulation, infrastructure services, and social services. The transition zone of the RMBR is characterized by an agricultural economy of grain growing and cattle operations, supplemented by the service functions of the towns and villages. During recent decades, numerous lakes and forested areas have become attractive locations for recreationists. This has resulted in a proliferation of new subdivisions, especially in the wooded areas adjacent to RMNP, and along the shores of the larger lakes. A large proportion of the incoming population comprises summer seasonal dwellers, but the number of new permanent residents has also increased. This development has transformed considerably the functional orientation, land-use pattern, and social fabric of the region at the southern fringe of RMNP (Borgfjord 2010). In some municipalities, the councils are no longer exclusively dominated by local farmers and their interests. Instead, they may be challenged by a new political class of urban newcomers with interests and agendas often different from those with a traditional rural-agricultural outlook (Stadel 2005). The new functional orientation, re-zoning of the land into residential lots, land speculation, and dynamic real estate market in choice locations have driven up land prices. This has either made it costly for farmers to acquire more agricultural land, or has enticed them to give up farming and sell their land. In turn, municipalities with recreational potential have benefitted from substantial hikes in residential taxes, allowing for the provision of better infrastructure and services.

The vision of First Nations is to preserve the natural environment, its resources, and the cultural heritage of their homeland. This vision is similar to the general objectives of the biosphere reserves. The resource base of the reserves is modest and economic opportunities are scant. Consequently, unemployment and underemployment are serious problems, with many people having to work outside the reserves. Economically, the reserves are highly dependent on subsidies paid by the federal government. The reserves are equipped with basic infrastructure and services, but are deficient in the number and variety of commercial activities. Therefore, a combined and coordinated effort to maintain environmental integrity, preserve and revive the cultural heritage, stabilize the population, enhance economic and employment opportunities, and attenuate social problems, are major challenges for a viable and sustainable future for the reserves (personal discussions between the authors and band elders and a band manager in 2018).

It follows that the visions, mandates, challenges, and priorities of the National Park, the municipalities, the First Nations, and those of visitors and recreationists, may be quite diverse. But the overriding goal and challenge of the biosphere reserve is to harmonize the different interests in a cooperative approach, in order to both maintain the ecological integrity of the region, as well as to ensure the welfare of its residents.

Interactions, exchanges, and regional cooperation within the southern part of the RMBR

Interactions within the RMBR take place in an array of different spatial and sectoral levels both within and between each of the primary stakeholders, namely RMNP, the individual municipalities, and the four First Nation reserves (Figure 5). Interactions take place in ecological, demographic and social, economic and financial, as well as in political-administrative terms. Some of these interactions are positive and mutually beneficial, whereas others are frictional and problematic. In terms of ecological overlaps and interactions, it is obvious that vegetation and fauna are not affected by political boundaries. For example, at times beavers have migrated out of Riding Mountain causing changing water levels, and flooding of fields and roads. Other wildlife are moving freely between the National Park and adjacent areas, offering hunting opportunities, but feeding on crops (bears, deer, geese) or transmitting animal diseases (bovine tuberculosis). The National Park in turn can be affected by harmful invasive plants and animals (e.g., zebra mussels—*Dreissena polymorpha*).

In terms of population interactions, there is a great seasonal flow of vacationers both into and out of the National Park, with marked peaks in July and August and during long holiday weekends. This involves not only people from the neighbouring municipalities but also from southern Manitoba and southern Saskatchewan, as well as tourists from other places in Canada, the United States and overseas. Of particular interest for the purpose of this paper are the mobility patterns between the National Park and the adjacent municipalities and First Nation reserves. Here, the most active movements are those of cottage residents, both inside and outside of the National Park. In the townsite of Wasagaming, the Wasagaming Community Plan (Parks Canada 2011) lists for 1998 a total of 246 cottage lots, 520 cabin lots, 510 camping sites, and 35 commercial businesses. Since 1998, there has been little change in these numbers. However, the recreational subdivisions in the municipalities adjacent to RMNP have experienced a phenomenal increase in recent decades. These subdivisions are no longer zoned as seasonal recreational land, but simply as rural residential lots, reflecting the fact that many of the new dwellings have become year-long secondary residences or new homes for people, especially retirees. The large number of new residents, especially in the municipalities of Harrison Park and Clanwilliam-Erickson, means that substantial population movement takes place in the summer and fall months between these municipalities and the National Park, and in particular in Wasagaming with its recreational, commercial, and entertainment amenities. Many of the employees of the

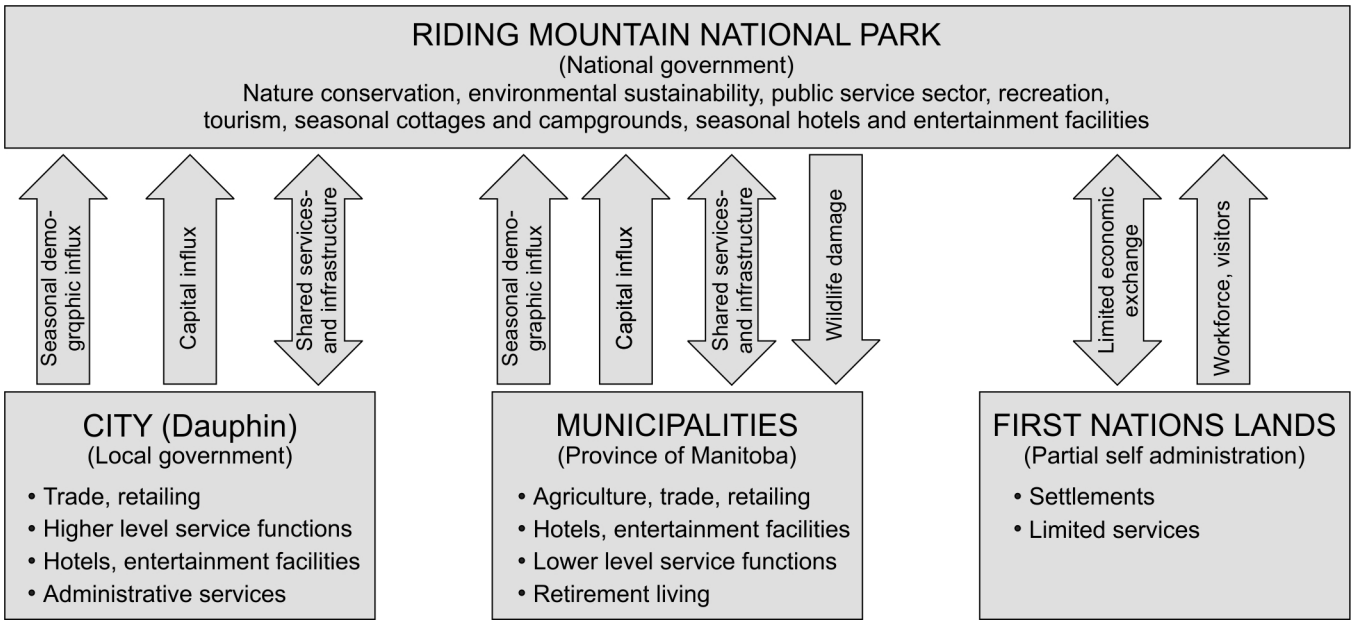

Figure 5
Interactions of administrative levels within the Riding Mountain Biosphere Reserve
Source: Stadel 2015, modified 2019
Design: W. Gruber

National Park live beyond its boundaries and commute to their workplaces in the Park, an activity that is largely restricted to the summer season.

Significant mobility patterns can be further observed between the three First Nation reserves located in the southern part of the RMBR and their neighbouring municipalities. This movement involves to a large extent only First Nation people. They frequent the commercial facilities of nearby towns and villages (e.g., Erickson, Onanole, Sandy Lake, Elphinstone, and Rossburn) and also depend on a variety of social, medical, and other professional services and infrastructure in the vicinity. Children from the reserves have to commute to the schools of the nearby centres and, given the limited employment opportunities on the reserves, adults have to seek work outside the reserves. First Nation people also have links with the National Park mostly for work or recreational purposes. Not least, Keeseekoowenin First Nation is a partner of RMNP in the townsite of Wasagaming where it operates a centre for introducing visitors to their cultural heritage.

It is obvious that the population exchanges within the RMBR have an economic and financial impact on the National Park, the municipalities, and the First Nation reserves. The National Park (i.e., the federal government), benefits financially from cottage and cabin leases, campground, golf course, tennis, and park entry fees, plus to a lesser extent from some services provided for visitors. Furthermore, businesses in Wasagaming (hotels, restaurants, shops) draw substantial external investment money into the townsite. At the same time, the summer season also generates significant outflowing incomes. For example, businesses located outside the National Park (e.g., restaurants, grocery stores, hardware stores, financial institutions, real estate agencies, developers, builders, and craft and trade people) draw customers not only from the municipalities, and to a lesser extent from the First Nation reserves, but also from within the Park. Within the RMBR, there are undoubtedly some good prospects for fostering ecotourism activities, but in the opinion of the authors, this potential so far has not been adequately explored and acted upon. Other common economic activities are farmers markets and flea markets, but in general the RMBR could likely find other activities for stimulating the regional economy.

It is obvious that the administrative boundaries of RMNP, the municipalities, the First Nation reserves, and the RMBR are arbitrary, at least in part. But the multiple interactions within the entire region call for an attenuation of barriers and boundaries, and for a facilitation of exchange flows. Stakeholders in the biosphere reserve may be well aware of the long-term benefits of a strengthening of regional ties, but the implementation of regional cooperative ventures proves to be a challenging task. These difficulties notwithstanding, in a concluding section of this paper, examples of cooperation and joint projects are outlined.

Cooperation and joint projects within the RMBR: Achievements and setbacks

An important component of interactions among RMNP, the municipalities, and First Nation reserves is their shared infrastructure plus services. Although Highway 10 linking southern Manitoba with its northern regions, as well as Highway 19 linking Riding Mountain with the Manitoba lowlands to the east, are

provincial highways, the National Park (i.e., the federal government) is responsible for the maintenance of these highways. In turn, the federal Royal Canadian Mounted Police post in Wasagaming services not only the National Park but also the adjacent municipalities. In terms of shared infrastructure and services in the southern part of the RMBR, the Rural Municipality of Harrison Park provides a volunteer Fire Protection Unit, as well as an open land fill and recycling facility both for the municipality and the National Park. Elsewhere, a newly implemented central water system pumps fresh water from Clear Lake into the residential and commercial establishments at the southern fringe of RMNP and to Onanole Elementary School. This staged project is not yet completed but in time will be complemented by a centralized sewage disposal system; already, sewage from the Elkhorn Resort, located in the Municipality of Harrison Park, is disposed of in the RMNP sewage lagoon.

To date, infrastructure cooperation among municipalities and between municipalities and the First Nation reserves has been limited and negatively affected recently by political squabbles. The planned joint landfill site for RMNP, the Keeseekoowenin First Nation, and the municipalities of Clanwilliam-Erickson and Harrison Park on reserve land has stalled. Meanwhile, the Rolling River Reserve and the Municipality of Clanwilliam-Erickson plan to haul their garbage to the regional Evergreen landfill site near Neepawa. RMNP is also looking for alternatives, possibly shipping the garbage to Dauphin.

Over recent years, the RMBR has conducted a number of projects and activities. In 2003, the Bovine Tuberculosis Stakeholders Advisory Committee was formed. It is chaired by the RMBR and financed by RMNP. The objective of the Committee is to fight TB at the deer/elk and livestock interface in the Riding Mountain ecosystem (Godmaire et al. 2013, 23). The RMBR is also coordinating the control and management of invasive plant and animal species whose spread threatens the environment, economy, and society. Most recently, the RMBR has been concerned about the potential impact of aquatic invasive species (AIS), especially zebra mussels, into watersheds and lakes. A public AIS awareness program has been introduced and all watercraft in RMNP are required to be inspected. In 2012, the RMBR, in partnership with the Centre for Sustainable Watersheds, developed a water stewardship education program to protect and preserve the region's rich water resources and their habitats (RMBR 2012). In addition, the Parkland Habitat Partnership, a coalition of agencies in the RMBR, promotes habitat conservation and has been instrumental in securing over 1,000 acres (405 ha) in conservation agreements. Furthermore, the RMBR has started to create a number of Native Species Gardens to display and highlight diverse plant species that are attractive to butterflies and birds, and one that is resistant to grazing by deer. The RMBR continues to be involved in a number of educational programs with school divisions and other interested groups, for example with the Park West School Division and the Turtle River School Division. Of growing interest to visitors is the Caching Riding Mountain program, an adventure game for GPS users, developed in partnership with Friends of Riding Mountain National Park and supported by RMNP.

A popular showcase for a lively regional agricultural economy within the RMBR is the yearly fall event, At the Farm Gate, where small-scale producers and crafts people display their products in the Onanole and District REC Centre. Unfortunately to date, little initiative is evident to stimulate and promote the rich and diverse ethnic heritage and the material culture of the region. Similarly, the significant potential of regional economic and cultural tourism has not been adequately explored. In general, and in comparison with many other biosphere reserves, the RMBR is not well known within its immediate hinterland and beyond, and little has been done to make it more visible and familiar to the general public. Undoubtedly, insufficient outside funding may be a hindrance, but in the opinion of the authors, a dynamic and innovative group of committed stakeholders could find avenues for self-supporting activities and for the promotion of the RMBR as a rich and attractive region in the Canadian prairies.

A number of joint projects have been implemented within the RMBR. However, other important issues have been ignored, and a number of planned regional ventures have failed. In some cases, the reasons for this may have been insufficient reliable funding, but in other instances divergent particular interests on the part of stakeholders and a lukewarm dedication to mutual regional projects, have been a hindrance to effective cooperation. Innovative and dynamic activities within the biosphere reserve require strong leadership within each of the political constituencies, a climate of trust, and an enhanced awareness and support of the goals of the biosphere reserve by the general public.

Conclusion

The southern part of the RMBR represents a highly complex natural and human environment. This part of the Parkland region has witnessed many and great transformations; first by the European colonization and settlement process; second by the profound transformation of the agricultural economy and both business and industrial sectors; third by the challenges facing rural communities and First Nation reserves; and most recently by a recreational boom.

The establishment of biosphere reserves has been guided to channel ecologically sensitive areas into a path that ideally protects the environment and also fosters sustainable human development. In short, "Biosphere Reserves and related institutions have to work towards true integration of their ecological, social and economic potentials, and set up a framework of genuine sustainability governance" (Stoll-Kleemann and O'Riordan 2017, 89).

The RMBR has set a number of positive initiatives for joint ecological programs, infrastructure cooperation, and fostering of regional compatible and sustainable economic activities. But, in the opinion of the authors, the potential for effective, innovative, resilient and sustained ecological protection and economic development has not been fully acted upon. This requires an enhanced awareness of and commitment to the goals of biosphere

reserves by all stakeholders in a climate of mutual trust and co-operation.

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

A content analysis of Prairie Perspectives: Geographical Essays, 1998–2018

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Key Messages

- Papers range across 30 geography sub-disciplines with those in biogeography, cultural geography, weather and climate, urban geography, and tourism and recreation featuring most often.
- Papers utilise an array of research tools including fieldwork, questionnaires, remote sensing, GIS, statistical analysis, laboratory analysis, and archival research.
- Student scholarship is featured in over half the papers.

Prairie Perspectives: Geographical Essays was first published in 1998. Since then a further 19 annual volumes have been produced. Papers appearing in the journal are not restricted to prairie topics or themes. Rather they reflect the research interests of prairie-based geographers. These range from the local to the international. Of the 215 papers published between 1998 and 2018, 151 (70.2%) focus wholly or in part on prairie topics, and 34 (15.8%) on international subjects. Scholarship by students as lone, first, or second authors is presented in 130 (60.5%) papers. Papers are identified in 30 geography sub-disciplines. Among these, papers in biogeography, cultural geography, weather and climate, urban geography, and tourism and recreation appear with greatest frequency. Identifiable research themes or topics include papers on flooding, water resource conservation, climate change, grasslands ecology, and urban planning. Questionnaires and fieldwork are reported on in 67 (31.2%) and 46 (21.4%) papers respectively, with results commonly supported by the use of descriptive and inferential statistics. Papers are liberally illustrated with one or more maps appearing in 158 (73.5%) papers. Photographs, bar charts, line graphs, and scatterplots are also employed widely in support of research findings.

Keywords: authors, locational focus, geography sub-disciplines, research tools, illustrative materials

Introduction

Prairie Division of the Canadian Association of Geographers (PCAG) was founded in 1977 with the departments of geography at universities in Manitoba and Saskatchewan identified as founding institutions. In 1980, University of North Dakota was granted affiliated status in the Division, as was Lakehead University (Thunder Bay) in 2011. The first annual conference and business meeting of PCAG was hosted by Brandon University in September 1977 at Wasagaming, Riding Mountain National Park, Manitoba. Since then meetings have been held annually with member institutions serving as hosts in rotation. Between 1977 and 1997 selected papers from the annual meetings were published by the hosting institutions in several different geographic series and in various formats. For example, in 1979 University of Regina hosted the annual meeting in Fort San, Saskatchewan with papers from the meeting published as volume 3 of *Regina Geographical Studies* (Seaborne 1980). Similarly, Brandon University hosted the 1995 meeting in Dauphin, Manitoba. Papers from that meeting were published as

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volume 1 of *Brandon Geographical Studies* (Welsted and Everitt 1991). While this arrangement worked satisfactorily, a desire to improve access to the scholarship of prairie geographers and to standardize the format of proceedings created pressure to publish them under a single title. This situation resulted in the creation of a new journal, *Prairie Perspectives: Geographical Essays*. Since 1997, printing and publication of the journal have been entrusted to the Department of Geography, University of Winnipeg, while copyright of each volume has remained with the hosting institutions. The content analysis that follows traces the evolution of the journal, the status and affiliation of contributing authors, the locational and sub-disciplinary focus of their papers, and the tools used in conducting and illustrating their research.

Evolution of Prairie Perspectives

The first volume of *Prairie Perspectives* was published in 1998 following PCAG's 1997 meeting hosted by University of Winnipeg in Portage la Prairie. Since 1998, the journal has been published on an annual basis except in 2015 when insufficient submissions were received. During this time several innovations have led to changes in the appearance and accessibility of the journal. Foremost among these has been the decision taken at the 2009 annual general meeting in Russell, Manitoba to cease publishing the journal in paper format. Starting with volume 13 in 2010 all issues of *Prairie Perspectives* have been published online and made available through open access. Publishing online and adoption of enhanced publishing software has made the journal available to a potentially unlimited readership, reduced annual publication costs, enabled use of a larger page format with greater standardization of print layout, and made it easier to incorporate colour images. The latter has been especially beneficial for papers displaying remote sensing images, cross sectional diagrams, and other complex illustrations. Other innovations have followed the lead of the 'parent journal'—*The Canadian Geographer*. For example, keywords were first included with papers in 2002 (volume 5), and contact details for authors in 2007 (volume 10) (Table 1). Unfortunately, until recently uptake of these innovations was not universal. This situation reflected the change in editorship that accompanies each volume, the lack

Table 1
Chronology of PCAG meeting locations, hosting institutions, and associated publication record of *Prairie Perspectives*, 1997 to 2018

Year of Meeting	Meeting Location	Hosting Institution	Prairie Perspectives Volume	Year of Publication	Abstracts (No. Missing)	Keywords (No. Missing)	Email (No. Missing)	Key Messages
1997	Portage la Prairie, MB	U of W	1	1998	12 (1)	-	-	-
1998	Manitou Springs, SK	U of S	2	1999	13 (1)	-	-	-
1999	Winnipeg, MB	U of M	3	2000	10 (1)	-	-	-
2000	Devils Lake, ND	UND	4	2001	13 (9)	-	-	-
2001	Moose Jaw, SK	U of R	5	2002	21	21	-	-
2002	Neepawa, MB	Brandon	6	2003	13	2 (11)	-	-
2003	Gimli, MB	U of W	7	2004	17 (1)	5 (13)	-	-
2004	Muenster, SK	U of S	8	2005	8 (1)	0 (9)	-	-
2005	Winnipeg, MB	U of M	9	2006	8	2 (6)	-	-
2006	Rugby, ND	UND	10	2007	11 (2)	3 (10)	1 (12)	-
2007	Weyburn, SK	U of R	11	2008	8	8	8	-
2008	Boissevain, MB	Brandon	12	2009	11	3 (8)	11	-
2009	Russell, MB	U of W	13	2010	8	6 (2)	8	-
2010	North Battleford, SK	U of S	14	2011	7	6 (1)	5 (2)	-
2011	Devils Lake, ND	UND	15	2012	5 (1)	3 (3)	4 (2)	-
2012	Winkler, MB	U of M	16	2013	6	6	4 (2)	-
2013	Esterhazy, SK	U of R	17	2014	4	4	4	-
2014	Wasagaming, MB	Brandon	-	-	-	-	-	-
2015	Kenora, ON	U of W/Lakehead	18	2016	10	10	10	-
2016	Melfort, SK	U of S	19	2017	7	7	7	-
2017	Morris, MB	UND	20	2018	6	6	6	6

U of M - University of Manitoba; UND - University of North Dakota; U of R - University of Regina; U of S - University of Saskatchewan; U of W - University of Winnipeg

Values in parentheses indicate the number of papers for which the specified feature was not provided

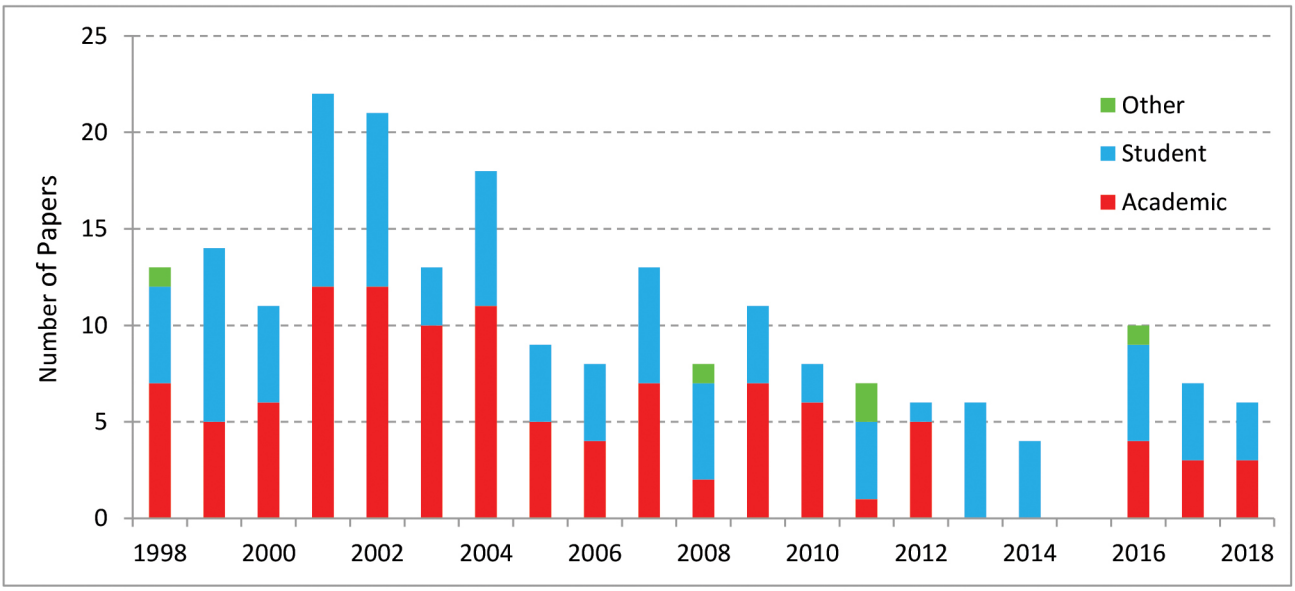

Figure 1
Number of papers by author status

of communication between editors, and the absence of any editorial oversight. The appointment of an editor-in-chief following the Melfort meeting in 2016 has helped eliminate these problems and has provided greater overall consistency in editorial standards.

In 2018 (Volume 20), two additional features were included in *Prairie Perspectives*. First, news from the member departments in the Division was presented under the banner 'Across the Division.' The intent of this section is to record significant news from each department such as appointments, retirements, major program initiatives, awards, faculty and student achievements, and other important events and milestones. The expectation is that the reporting period should reflect activity in the year preceding the annual meeting of PCAG. The second new feature provides brief biographical notes on contributing authors under the banner 'About the Authors.' The intent of the feature is to raise the profile of authors, especially those who are new faculty members or students, and to provide readers with a means by which they might more easily recognize or collaborate with them.

The number of papers published in *Prairie Perspectives* has fluctuated over the years and has declined noticeably since the heady days of the early 2000s (Table 1). During the latter period consideration was given to publishing two volumes of papers each year, an option which was soon rejected when the additional cost and editorial commitment was determined. In contrast, the decrease in submissions over the last decade has caused some concern over the long-term viability of the journal. The retirement of many long-serving faculty members with significant publication records in *Prairie Perspectives* appears linked to this decrease. Not surprisingly, the demise in recent years of other regional geography journals such as the *Great Lakes Geographer* in 2006 and the *Bulletin of the Association of North Dakota Geographers* in 2013 has heightened awareness of this concern.

Status and affiliation of authors

Prairie Perspectives is not a front line journal. As such it is relatively more accessible to individuals seeking their first publication. Of the 215 papers published between 1998 and 2018, 130 (60.5%) present the scholarship of students either as lone (14.0%), first (32.6%), or second (14.0%) authors. Student authorship is found in all volumes. For purposes of analysis, lone and first authors of papers are identified as either academics, students, or other professionals (e.g., planning consultants). On this basis, 110 of the 215 (51.2%) papers were authored by academics, 100 (46.5%) by students, and five (2.3%) by other professionals (Figure 1). Among universities in Manitoba and Saskatchewan, the number of student authorships was greatest at Brandon University with 21 papers, and least at University of Regina with 15 papers. Student authorships from institutions beyond Prairie Division also accounted for 15 papers.

Most papers in *Prairie Perspectives* reflect the research of academics and students at the five universities in Manitoba and Saskatchewan plus the University of North Dakota and Lakehead University. Figure 2 shows the academic affiliation of primary (lone or first) authors. Clearly authors from the University of Winnipeg and Brandon University have helped sustain the journal and together account for 104 (48.4%) of the 215 papers published. Figure 2 also shows that there is a tendency for the distribution of papers to favour hosting institutions. For example, in 2003 University of Winnipeg hosted the annual PCAG meeting and in 2004 accounted for eight (44.4%) of the 18 papers published in volume 7. However, this relationship is far

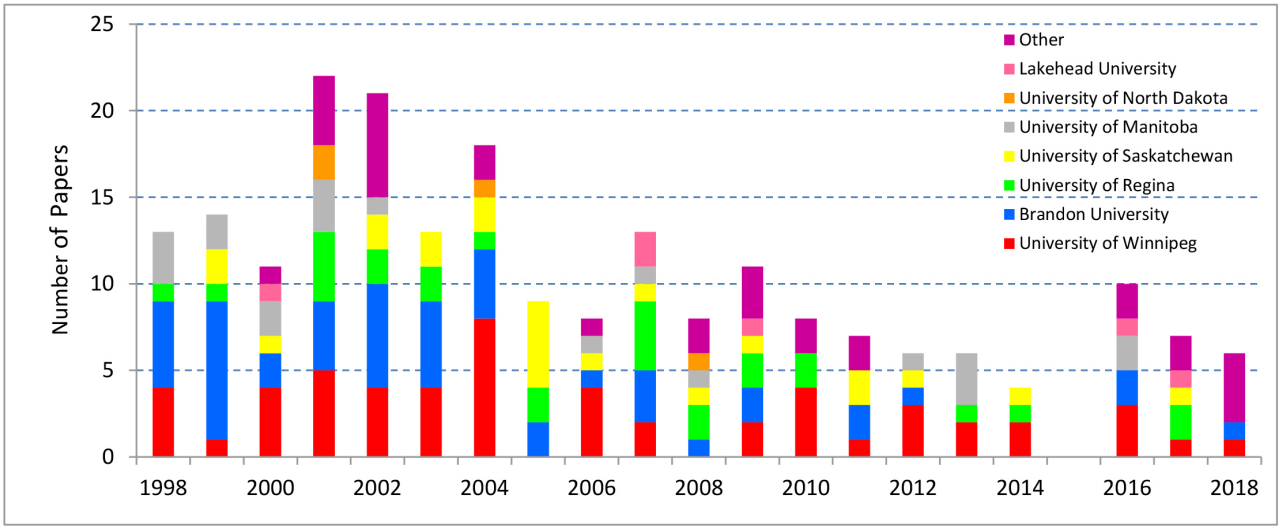

Figure 2
Academic affiliation of primary authors

from universal or consistent. In 1998, University of Saskatchewan hosted the annual meeting but in 1999 accounted for only two (14.3%) of the 14 papers published in volume 2. In contrast, Brandon University accounted for 8 (57.1%) papers in that year. The relatively high and consistent number of papers produced by faculty and students from Brandon may be attributed, at least in part, to the central location of the institution within the Division, and to the comparative ease with which its faculty and students can attend conferences hosted by other institutions. However, this factor would not account for the still higher number of papers published by faculty and students at University of Winnipeg, which occupies a relatively eccentric location within the Division. More likely the high number of papers associated with both institutions reflects the strength of their undergraduate honours programs and the cooperation and encouragement provided by faculty to students in support of publication.

Locational focus of papers

Papers published in *Prairie Perspectives* are not restricted to prairie topics or themes. Rather they reflect the research interests of prairie-based geographers, which may range from the local to the international. Consequently, only 138 of 215 (64.2%) papers focus exclusively on prairie topics with a further 13 (6.0%) papers addressing topics which combine or contrast prairie and non-prairie environments (Table 2). For example, the latter includes McGregor et al.'s (2004) study of the role of government in cross boundary diffusion of Hutterite colonies from the United States to Canada between 1917 and 2003. Papers with an international focus comprise 34 of 215 (15.8%) papers, feature 24 countries or territories, and all continents barring Antarctica (Figure 3). They include Ke and Dale's (2004) richly illustrated presentation postulating that an extensive ice sheet covered much of the Mongolian Plateau during the late Quarternary. Presumably, papers with an international focus reflect the product of sabbatical leaves and the predilection of geographers for vacations spent in exotic places. Finally, six of 215 (2.8%) papers have no specific locational focus. These papers include Sylvestre's (1999) study of aging, and Bell's (2002) study of GIS.

Sub-disciplinary focus of papers

Geography is at once a diverse and integrating discipline in which a large number of sub-disciplines can be identified. A reading of the 215 papers was conducted to assess the relative contribution of various sub-disciplines to the body of work in *Prairie Perspectives*. In total, 30 sub-disciplines were identified. However, assessing the relative contribution of each sub-discipline poses an immediate problem. Some papers, for example McGinn's (2000) study of glaciotectonic features in the Glacial Lake Proven Basin of the Riding Mountain Uplands, are easily placed within a single sub-discipline, in this case glacial geomorphology. In contrast, other papers range across two or more sub-disciplines. For example, Wiseman and Berta's (1998) paper on indicator species analysis draws on themes in both biogeography and natural resource management.

How then should the relative contributions of sub-disciplines to the body of work in *Prairie Perspectives* be measured? Two approaches are taken. In the first, a count of one is given each time a sub-discipline is identified. In the examples given above the McGinn paper scores a count of one for glacial geomorphology, but the Wiseman and Berta paper scores two, one each for biogeography and natural resource management. Repeating this procedure across all papers and summing the counts for each sub-discipline produces the unweighted counts presented column b of Table 3. From this it is possible to conclude that biogeography and cultural geography, each with a count of 33, make the greatest single contributions to the overall disciplinary con-

Table 2
Locational focus of papers

Locational Focus — Prairies, other Canadian and US Jurisdictions, and International	Number of Papers	Percent of Papers	Cumulative Percentage
Prairies (Manitoba, Saskatchewan, Alberta and N. Dakota)	138	64.2	64.2
Prairies with Canadian cities, provinces and regions	6	2.8	67.0
Prairies with US cities, states and regions	6	2.8	69.8
Prairies with Canadian and US cities, states and regions	1	0.5	70.2
Canadian cities, provinces and regions	15	7.0	77.2
Canada	2	0.9	78.1
Canada and US	1	0.5	78.6
US cities, states and regions	6	2.8	81.4
International (countries other than Canada and US)	34	15.8	97.2
No specific locational focus	6	2.8	100.0
Total number and percent of papers	215	100.0	

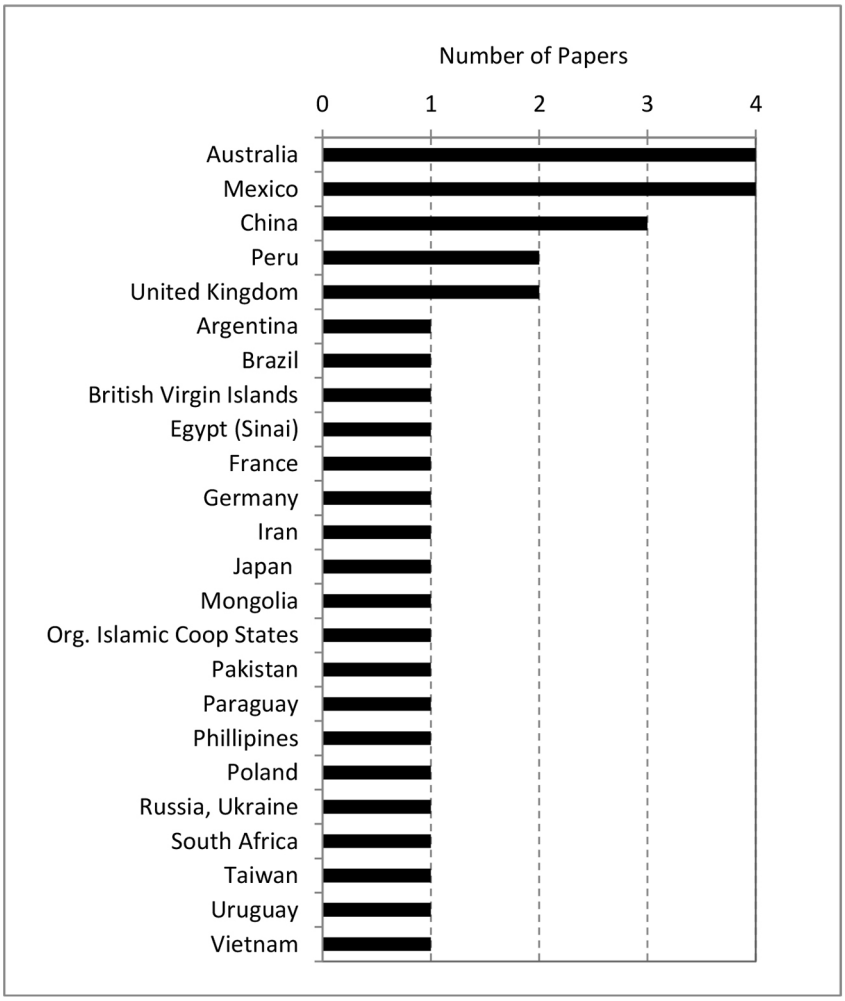

Figure 3
International focus of papers

tent of *Prairie Perspectives*. Conversely, regional planning with a count of just one makes the least contribution. This approach generates a total count of 398 for all sub-disciplines.

The second approach simply allots a count of one to each paper and in cases where more than one sub-discipline is identified the count for each is divided by their total number. Thus in the examples given above the McGinn paper retains a count of one as only glacial geomorphology is identified, but in the Wiseman and Berta paper both biogeography and natural resource management are each assigned a count of 0.5. Similarly, for papers where three sub-disciplines are identified each is assigned a count of 0.33, and in papers with four sub-disciplines each is given a count of 0.25, and so on. When this weighting procedure is applied in all papers where multiple sub-disciplines are identified, the total count for all sub-disciplines adds to 215, the same count as the number of papers (Table 3, column d). As a result of the procedure the counts are reduced for all but three sub-disciplines. Also, some change is observed in the rank order of the sub-disciplines. Most noticeably the ranks of frontier settlement (−9), historical geography (−7), and social geography (−7) are reduced whilst the ranks of glacial geomorphology (+12.5) and transportation and communication (+6.5) are increased (Table 3, column f). Overall, however, the relative contribution of the 30 sub-disciplines to the body of work in *Prairie Perspectives* shows only modest change. Irrespective of which counting procedure is adopted, the same sub-disciplines are ranked within the top six. Confirmation of a strong relationship between the two counting procedures is provided by a Spearman's rank correlation of $r_s = 0.880$.

Table 3
Relative contribution of geography sub-disciplines to the body of work in *Prairie Perspectives*

Geography Sub-discipline (a)	Unweighted Count (b)	Unweighted Rank (c)	Weighted Count (d)	Weighted Rank (e)	Difference in Ranks (f)
Biogeography	33	1.5	18.4	1	0.5
Cultural geography	33	1.5	14.6	5	-3.5
Weather and climate	31	3	17.1	2	1
Urban geography, urban planning	28	4	15.9	3.5	0.5
Tourism and recreation	27	5	15.9	3.5	1.5
Natural resource management	23	6	14.4	6	0
Economic geography, commerce	18	7	6.7	13	-6
Agriculture	16	8	7.6	10	-2
Hydrology	14	9.5	9.2	7	2.5
Social geography	14	9.5	4.8	16.5	-7
Frontier settlement	13	11	4.6	20	-9
Fluvial geomorphology and	12	12.5	8.7	9	3.5
Rural geography	12	12.5	5.6	15	-2.5
Population and migration	11	15	4.8	16.5	-1.5
Geographic education	11	15	6.8	12	3
Geography in literature and the	11	15	7.4	11	4
Historical geography	10	17	3.6	24	-7
Glaciation, glacial geomorphology	9	20.5	9	8	12.5
Soils	9	20.5	4.7	18.5	2
Environmental protection	9	20.5	4.7	18.5	2
Transport and communication	9	20.5	6.3	14	6.5
Political geography	9	20.5	4.3	21	-0.5
Geography of religion	9	20.5	3.6	24	-3.5
Regional/rural economic	6	24.5	3.6	24	0.5
Food and food security	6	24.5	2.3	27	-2.5
Cartography	5	26	4	22	4
Health geography	4	27	1.5	29	-2
Geography of aging	3	28	2.5	26	2
Geomorphology	2	29	2	28	1
Regional planning	1	30	0.5	30	0
Total	398		215		**0**

Research themes

In addition to their sub-disciplinary focus many papers can be grouped by specific research themes or topics such as flooding, water conservation, climate change, grassland ecology, and urban planning. In the context of flooding, the dynamics of Red River floods, both historic and recent, are the subject of several papers by Rannie (1998, 2002, and 2003). Elsewhere, Haque and Rahman (1998) and Haque et al. (2001) have focused on public experiences of recent flooding events in the Red River Valley, and on institutional responses to the flooding which show evidence of poor communication between experts and members of the pubic. As part of the response to repeated flood events, Fraser and Storie (2013) examine a range of geospatial indicators to determine where former wetlands in southern Manitoba might be re-established and new ones created as part of a program of flood mitigation.

Water resource conservation is a vital concern in prairie environments where water deficits and drought conditions constitute a perennial risk and may intensify under certain climate change scenarios. Studies focusing on water resource conservation in Saskatchewan include Wang and Patrick's (2014) critical assessment of five source water protection plans. Still in Saskatchewan, Kitamura et al. (2018) stress the need for greater community-researcher collaboration in maintaining water security. In related work, Paton et al. (2007) focus on wastewater reclamation and re-use in the Clear Lake watershed of Riding Mountain National Park, Manitoba. Elsewhere, Patrick (2009)

identifies capacity-related factors that constrain source water protection at the local water purveyor level in British Columbia's Okanagan Valley.

Investigating the implications of climate change forms a recurrent theme throughout *Prairie Perspectives*. He et al. (2005) assess the effects of enhanced UV-B radiation on crop productivity in China. In northern Saskatchewan, Luo and Piwowar (2007) map change in wildfire risk attributable to expected temperature and precipitation regimes under future climate change scenarios. In broadly similar research, Baidoc and Cornwell (2016) turn their attention to Canada's eastern boreal forest where they measure fire ignition potential under two climate scenarios. Away from the strictly physical realm, Chowdhury and Haque (2008) review the communication gap between experts and the public on the risks associated with climate change-induced heat waves in Winnipeg.

Not surprisingly perhaps, papers focusing on grasslands ecology form a recurrent theme in *Prairie Perspectives*. Some historical context to the expansion of prairie agriculture at the expense of natural grasslands is provided by Rannie (2001) in his discussion of the "Grass Fire Era" of late 18th to the late 19th century. With reference to the current era, Black et al. (2005) examine photosynthesis rates of native and introduced grass species on sloped and upland sites in the West Block of Grasslands National Park (GNP). In related research in GNP, Guo et al. (2005) assess the suitability of the NDVI (normalized difference vegetation index) and the LAI (leaf area index) for estimating plant biomass and moisture content of mixed-grass prairie. The susceptibility of the mixed-grass prairie to climate change is stressed by Piwowar (2009) and prompts his search for environments, indicator species, and remote sensing data of suitable resolution that will best signify such change.

Urban planning and environmental issues are discussed in several papers on Winnipeg. These explore the rise and fall of the city's modernist urban renewal project (Warkentin and Vachon 2010), parking issues in the downtown (Vachon 2012), the effect of neoliberalization in planning policy (Wideman and Masuda 2013), and urban revitalization (Snyder et al. 2006). In Brandon, Morton (1999) examines public perceptions and attitudes towards the operation of a chemical plant located to the east of the city.

Research tools

Inspection of the 215 papers indicates that authors have employed a wide variety of research tools in conducting their research (Table 4). Of these, the prominent adoption of statistical analysis would seem to reflect the legacy of the 'Quantitative Revolution' and an accepted need to add precision and clarity to analysis irrespective of subject matter. In many papers individual research tools such as fieldwork or GIS are not found in isolation but are applied alongside others. Table 5 provides a pairwise summation of the research tools described below. It shows, for example, that of the 46 papers in which fieldwork is reported, 22 also include the use of inferential statistical methods but only one presents archival research. The table confirms a strong association between the use of descriptive statistics and all other research tools.

Adoption of descriptive statistics including simple counts, indices, and measures of central tendency is identified in 127 (59.1%) papers (Table 4). Pairwise analysis of all possible combinations of research tools shows that descriptive statistics are found in association with secondary data in 50 papers, and with inferential statistics methods and fieldwork in over 40 papers each (Table 5). Inferential statistics are recorded in 55 (25.6%) papers (Table 4). Pairwise analysis reveals that inferential statistical methods are found most commonly with descriptive statistics (45 papers), and to a lesser degree in papers reporting fieldwork (22), remote sensing (18), and use of secondary data (18) (Table 5). Inferential statistical methods comprise both parametric and non-parametric analyses.

A wide range of parametric statistical analyses is identified. A single example of each should suffice to illustrate the range of topics and environments investigated by prairie geographers. Starting in the agricultural sector, Quiring and Blair (2000) use multiple regression analysis to assess the utility of teleconnection indices in forecasting crop yields in Saskatchewan. In the Don River watershed of Ontario, Sadowski (2002) applies bivariate linear regression analysis to investigate relationships between chloride concentrations from road salting and the abundance and species diversity of amphibians. Lewis et al. (2002) employ Pearson's product-moment correlation analysis in investigating the pattern of crime in Brandon, Manitoba. Elsewhere, several studies combine correlation and linear regression analyses, and test for significance using the Student's T-test. These studies include Scott and Orlandini's (2002) analysis of point source pollution of soils with copper and zinc from the Hudson Bay Mining and Smelting Company's (HBM&S) base-metal smelter in Flin Flon, Manitoba. Among other parametric statistical methods, principal components analysis is applied by Hansen and

Table 4
Research tools adopted by authors

Research Tool	Occurrence by Paper	
	Count	Percent
Descriptive statistics	127	59.1
Questionnaires and	67	31.2
Secondary data	59	27.4
Essays and reviews	58	27.0
Inferential statistics	55	25.6
Fieldwork	46	21.4
Remote sensing	41	19.1
GIS	30	14.0
Archival research	29	13.5
Laboratory analysis	22	10.2

Table 5
Pairwise frequency of research tools adopted by authors

Research Tool	Descriptive Statistics	Questionnaires and Related	Secondary Data	Essays and Reviews	Inferential Statistical Methods	Fieldwork	Remote Sensing	GIS	Archival Research	Laboratory Analysis
Descriptive statistics	127	37	50	16	45	43	30	19	11	21
Questionnaires and related	37	67	13	11	10	2	6	7	7	2
Secondary data	50	13	59	7	18	8	15	10	8	5
Essays and reviews	16	11	7	58	1	0	3	0	6	0
Inferential statistical methods	45	10	18	1	55	22	18	10	5	10
Fieldwork	43	2	8	0	22	46	18	9	1	21
Remote sensing	30	6	15	3	18	18	41	15	2	6
GIS	19	7	10	0	10	9	15	30	5	4
Archival research	11	7	8	6	5	1	2	5	29	0
Laboratory analysis	21	2	5	0	10	21	6	4	0	22

Hemmasi (2001) to explore levels of development among states of the Organization of Islamic Conference (OIC); and analysis of variance is used by Caron et al. (2016) in evaluating multiple sources of sediment in the lower Little Bow River, Alberta.

The range of non-parametric tests identified is equally impressive. The following provides just a few examples that, once again, illustrate the diversity of research conducted by prairie-based geographers. Starting with chi square analysis, Hansen (2004) applies the technique in contrasting the workplace and socioeconomic adjustment challenges of male and female Bosnian refugees resettled in Fargo, North Dakota. Away from the human realm, Werner et al. (2013) apply a two-sample Kolmogorov-Smirnov test in establishing the homogeneous-heterogeneous vegetation transition as an indicator for shoreline mapping at Bird Cove on the Hudson Bay coastline. In an analysis of large prairie cities, Wouters and Peters (2007) use Spearman's rank correlation to examine the relationship between Aboriginal settlement patterns and various housing characteristics. At Brandon University, Spinney and Kerr (2018) turn their attention to the classroom where they apply both Spearman's and Kendall's rank correlation analyses in assessing student perceptions on the effectiveness of clickers in enhancing their engagement and achievement in an introductory physical geography class. Moving to the Pacific coast of British Columbia, Malcolm and Duffus (2003) employ a Mann-Whitney U-test in contrasting the background knowledge and motivation of whale watchers partaking in excursions from Victoria and Tofino. On the Assiniboine River in Brandon, Terry and McGinn (1998) use a Wilcoxon matched-pairs signed-ranks test to compare daily suspended sediment loads recorded at three sites to assess the effectiveness of a floating turbidity barrier. Last but not least, Henderson and Piwowar (2007) turn their attention to northern Saskatchewan where they employ a Kruskal-Wallis (analysis of variance) H-test to determine if there are any differences in AVHRR NDVI (advanced very high radiation radiometer normalized difference vegetation index) values for selected months over a period of several years; and in related analysis they apply a Kolmogorov-Smirnov D-test to conduct pairwise testing of the same data set.

Questionnaires and related research instruments such as surveys, interviews with key informants, focus group discussions, and participant observation are reported on in 67 (31.2%) papers (Table 4). Of these, 37 employ descriptive statistics (Table 5). Lesser associations are identified for the use of secondary data (13), essays and reviews (11), and inferential statistics (10). Among the papers, Dilley and Lindberg (2009) employ a combination of participant observation and questionnaire with snowball sampling to investigate the motivation and experience of surfers on Lake Superior. Everitt et al. (2005) report on interviews with key informants regarding the status of service provision for senior residents of selected towns in Manitoba and Saskatchewan. In Saskatoon, Fedec and Archibald (1999) survey users of the Meewasin Trail to determine their needs and desires. Not least, in Paraguay, Cipko and Lehr's (2006) study of Ukrainian settlement as part that group's global diaspora is informed by interviews. Other examples of questionnaires and related research implements can be found in Morton (1999), Lewis et al. (2002), Chowdhury and Haque (2008), and Spinney and Kerr (2018).

Presentation of secondary data is identified in 59 (27.4%) papers (Table 4) of which 50 (84.7%) employ descriptive statistics and 18 (30.5%) inferential data analysis (Table 5). The use of secondary data is wide ranging. Frequently employed sources include national statistical agencies, government reports, and published academic works. Among the papers, Bohi and Kozma (2008) refer to records of the Dominion Bureau of Statistics, and submissions by the CNR and CPR to the Royal Commission to Inquire into Railways and Transportation in Canada in their evaluation of interwar rail construction in Saskatchewan and Alberta. South of the border, Kingsbury (2016) employs data from the Minnesota Department of Education, the North Dakota GIS Hub Data Portal, and the 2010 US Census to determine suitable school placements for teacher education candidates. In Germany, Siemer and Matthews-Hunter (2017) access Berlin Open Data to construct a series of maps showing the evolution of gentrification in the city. Still overseas, Hathout (2004) draws on records of Statistics South Africa, reports in the South

African *Daily News*, and payroll records to quantify and explain the movement of doctors from the public to the private sector in South Africa's health care system, and to their emigration from South Africa.

Essays, reviews, viewpoints, and related items are presented in 58 (27.0%) papers (Table 4). Of these, descriptive statistics are found in 16 (27.6%) papers, and questionnaires or related tools in 11 (19.0%) papers. Other research tools are much less evident, and fieldwork, GIS and laboratory analysis are not recorded at all (Table 5). Examples of essays and related items include Paul's (2008) description of the challenging operating conditions and grain/rail landscape of the Northern Plains Railroad as he travels its route from Thief River Falls, Minnesota to Kenmare, North Dakota. In Manitoba, Beattie (2016) recalls the post-World War II initiative of the Manitoba Travel and Publicity Bureau to promote an antimodernist tourism experience as a boost to economic growth and stability. Elsewhere in Manitoba, Bautista and Udarbe (2001) guide the reader through the life history of two Filipino immigrant families in Winnipeg. Again in Winnipeg, Golby (2000) provides a critical review of the emergence of gated communities. Other essays include critical assessments of adult entertainment establishments (Selwood and Kohm 1998), utopias (Zubrycki 2007), the World Trade Center (Patrick and MacDonald 2012), and prairie whiteness (Herman 2017).

Fieldwork, typically involving sampling, measurement, and instrumentation, is reported in 46 (21.4%) papers (Table 4). Of these, descriptive statistics are identified in 43 (93.5%) papers with inferential statistical methods (22), laboratory analysis (21), and remote sensing (18) also commonly reported (Table 5). Most papers reporting fieldwork pursue topics in glacial geomorphology, biogeography, hydrology, or soils. For example, McGinn (2018) transports the reader to the late Wisconsinan (20,000 to 11,000 BP) to explain the creation of forced meanders and glaciofluvial deposits in the McFadden Valley-Polonia Trench of the Riding Mountain Uplands, Manitoba. Again in the Riding Mountain Uplands, Burton and McGinn (2008) investigate the limnological and macronutrient regimes of pothole lakes to determine their suitability for creating a sport fishery. Richea (2002) set out to determine natural stream flow and the frequency of historical floods in the Duck Mountain region of Manitoba. Scott (2000) measures soil acidity downwind of the HBM&S smelter in Flin Flon. Fieldwork is also evident in the aforementioned works by Terry and McGinn (1998), Sadowski (2001), Scott and Orlandini (2002), Werner et al. (2013), and Caron et al. (2016).

Remote sensing is identified in 41 (19.1%) papers (Table 4). Pairwise analysis of research tools shows that descriptive statistics are employed in 30 (73.2%) of these papers (Table 5). Other frequent associated uses are identified for inferential statistics (18) and fieldwork (18). Applications of satellite derived data are found in Henderson and Piwowar's (2007) aforementioned study of boreal forest response to moisture stress. In Grasslands National Park, Yang et al. (2011) select nine experimental plots to test the assumption that they have similar vegetation (LAI) conditions prior to conducting a grazing experiment. In Moose Jaw, Saskatchewan, Travland et al. (2017) employ high resolution aerial photographs to identify land cover/land-use information prior to recommending suitable trail sites in the Wakamow Valley. Again in Moose Jaw, Peng et al. (2018) compare flood zones defined by historical data and point cloud LIDAR data. Other papers employing remote sensing include Simpson and Hathout (1998), Guo et al. (2005), Piwowar (2009), and Doff and Randall (2017).

GIS are applied in 30 (14.0%) papers (Table 4) of which 19 (63.3%) include use of descriptive statistics and 15 (50.0%) apply remote sensing (Table 5). Papers applying GIS include Doff and Randall's (2017) development of an urban forest benefits model to optimize tree planting in Thunder Bay, Ontario. Also in Ontario, Buck (2009) applies GIS analysis to assess the bathymetry of the St. Marys River channel as depicted in a cartographic record spanning four centuries. In southeastern Manitoba, Smith et al. (1999) employ GIS to produce a series of maps tracing the progress of Ukrainian pioneer settlement between 1896 and 1940. Simpson and Hathout (1998) build a GIS model which is sensitive to engineering, environment, and social considerations in determining an optimum route for an all-weather road connecting First Nation communities in the remote areas east of Lake Winnipeg. Other applications of GIS technology can be found in the aforementioned studies by Lewis et al. (2002), Yang et al. (2011), Werner et al. (2013), Travland et al. (2017), and Peng et al. (2018).

Archival-based research is evident in 29 (13.5%) papers (Table 4), of which 11 also employ descriptive statistics (Table 5). Among these, Rannie (2006) turns to eye-witness accounts and historical materials in Hudson's Bay Company Archives and diaries, and letters in Archives of Manitoba to identify wet years in the eastern prairies and northwestern Ontario during the 19th century. McGregor and Lehr (2016) search Archives of Manitoba school formation files to provide a detailed cartographic record of the agricultural settlement of the Canadian prairies between 1870 and 1930. Hamilton (2002) conducts a search of National Archives of Canada, Saskatchewan Archives, and Société Historique Saint-Boniface records to explain the pattern of late nineteenth and early twentieth century francophone settlement in southwestern Saskatchewan. Selwood and Brayshay (2007) review Hudson's Bay Company Archives to interpret the significance of Governor Cooper's visit to the eastern Arctic in 1934. Other archival research is evident in Smith et al. (1999), Rannie (2001, 2002, 2003), Hanuta (2002), and Buck (2009).

Laboratory analysis is identified in 22 (10.2%) papers (Table 4). Of these, descriptive statistics and fieldwork are each employed in 21 (95.5%) papers, and inferential statistical methods in 10 (45.5%) papers (Table 5). The close association between laboratory analysis and fieldwork is not surprising. It is evident in the aforementioned papers by Scott (2000), Scott and Orlandini (2002), Sadowski (2002), Burton and McGinn (2008), and Caron et al. (2016). Other examples are provided by Hanuta (2002) who investigates the relationship between tree ring widths and monthly mean precipitation in bur oak (*Quercus macrocarpa*) stands in Birds Hill Provincial Park, Manitoba; and by Kotowich and Hardenbicker (2014) who analyze the in-

fluence of agricultural land-use changes on sediment deposition in two alluvial fans in the Qu'Appelle Valley, Saskatchewan.

Illustrations

Perhaps more than academics in other scholarly disciplines, geographers tend to employ a wide range of illustrations in support of their research findings. Use of 20 different types of illustration is identified in the 215 papers (Table 6). They include maps, photographs, various types of graph, and remote sensing images. Of the papers under review, 184 (85.6%) include one or more illustrations. Beyond this, assessing the relative contribution of the various types of illustration to the body of work in *Prairie Perspectives* poses a problem. Essentially there are two approaches by which illustrations can be counted. First, they can be counted strictly in accordance with their captions. In this 'limited' approach 'Figure 1' would count as one illustration, and 'Figure 2' count as a second illustration, and so on (Table 6, column b). This seems logical enough except that in many cases multiple illustrations—whether maps, photographs or any other type of illustration—are presented as a single figure whereas they could equally be counted as multiple figures. An example of where this occurs is in Ke and Dale's (2004, 201) presentation of two maps as a single figure, despite each having a distinct cartographic style and showing the distribution of glacial landforms in two quite separate locations—China and the United States. A similar situation occurs when Scott (2010, 74–76) includes photographs showing before and after views to depict the devastating impact of lahars caused by Super Typhoon Reming in the Philippines. Examination of the 215 papers indicates that there is little consistency among authors in assigning multiple illustrations to either a single figure or to several figures. Because of this, a second approach is proposed in which all multiple illustrations are counted as separate figures. This 'expanded' approach results in an increase in the count of many types of illustration (Table 6, column d). However, the relative rank of each illustration type remains largely unchanged (Table 6, column f) with a very strong Spearman's rank correlation of $r_s = 0.944$ recorded for the two counts. One can conclude from this that the above approaches have much the same merit in assessing the relative contribution of the various types of illustration to the body of work in *Prairie Perspectives*.

Unsurprisingly perhaps, irrespective of which counting approach is applied, maps are identified as the single most important tool by which prairie geographers have illustrated their research. Maps identifying study areas are presented in 157 (73.0%) papers. Photographs have also been widely used. They appear in 42 (19.5%) papers, and often in large numbers. When taken together, the frequent inclusion of maps and photographs would seem to express the clear intent of authors to firmly place the reader in the research environment. Bar charts and line graphs, and illustrations combining both, also appear with regularity. Collectively, maps, photographs, bar charts, and line graphs account for nearly 80% of all illustrations irrespective of which counting approach is used. Many other illustrations including histograms, population pyramids, and pie diagrams appear much less frequently. Finally, illustrations are entirely absent from 17 (7.9%) papers. The latter include a suite of papers which focus on geographical elements in the literary works of Margaret Laurence (Payne 2001), the diary of Elizabeth Posthuma Simcoe (Murnaghan 2012), the spiritual writings of the T'ang dynasty poet Li Po (Holub and Simpson-Housley 2001), and the sense of place experienced by Grey Owl (Archie Belaney) in Canada's provincial norths (Simpson-Housley and Williams 2002).

Table 6
Comparatives frequency of illustrations appearing in *Prairie Perspectives*

Illustration Type (a)	Limited		Expanded		Difference
	Count (b)	Rank (c)	Count (d)	Rank (e)	in Ranks (f)
Maps	419	1	469	1	0
Photographs	185	2	264	2	0
Bar charts	73	3	84	3	0
Line graphs	52	4	80	5	-1
Remote sensing images	34	5	81	4	1
Scatter plots	30	6	48	6	0
Other linkage and relationship diagrams	20	7	20	8	-1
Others	17	8.5	8	14.5	-6
Other composite graphs	17	8.5	10	12	-3.5
Bar charts with line graphs	15	10	24	7	3
Flowcharts	14	11	14	9	2
Cross section profiles	10	12	12	10.5	1.5
Stratigraphic sections	9	13.5	12	10.5	3
Schematic diagrams	9	13.5	9	13	0.5
Plans	7	15.5	7	16	-0.5
Pie diagrams	7	15.5	8	14.5	1
Posters	5	17	5	18	-1
3D terrain surfaces	3	18.5	3	20	-1.5
Illustrative drawing	3	18.5	5	18	0.5
Population pyramids	2	20.5	2	21	-0.5
Histograms	2	20.5	5	18	2.5
Total	933	231	1170	231	

The field trips

Field trips have formed an integral part of PCAG annual meetings from the start. Typically, they have been organized by the hosting institutions and presented on Saturday afternoons following the morning paper sessions. The first field trip guides to be published in

Prairie Perspectives appeared in 2003 (volume 6), but for some years thereafter they were published only occasionally (Table 7). Since 2014 (volume 17), field trip guides have been published more regularly. In addition to their intrinsic value as guides to aspects of local and regional geography, the guides help serve as a record of PCAG's activities. Sadly, however, although a group photograph has often been taken during field trips, on only one occasion (2007) has a photograph showing assembled participants been included in the journal (volume 11). Consequently, a record of this feature of PCAG's activities has been lost. More optimistically, it is hoped that future field trips will be recognized for their merit and historical significance, and continue to be published in association with all PCAG meetings. Also, perhaps thought should be given to dusting off and updating field trip guides from earlier meetings, which until now have remained unpublished.

Table 7
Field trip locations and publication record, 2002 to 2018

Year of Field Trip	Hosting Institution	Field Trip Location	Prairie Perspectives Year and Volume
2002	Brandon	Beautiful Plains Region, Southwest Manitoba	2003, 6
2002	Brandon	Huns' Valley, Southwest Manitoba	2003, 6
2006	UND	Prairie Pothole Region, North Central North Dakota	2007, 10
2007	U of R	Weyburn to Big Muddy, South Central Saskatchewan	2008, 11
2013	U of R	Kaposvar National Historic Site and Qu'Appelle Valley	2014, 17
2014	Brandon	Glacial Lake Proven Basin, Riding Mountain National Park	2016, 18
2014	Brandon	Historic Minnedosa, Southwest Manitoba	2016, 18
2015	U of W and Lakehead	Experimental Lakes Area, Northwest Ontario	2016, 18
2017	UND	Red River Valley, Manitoba Morris to Emerson	2018, 20

Conclusion

Since first publication in 1998, *Prairie Perspectives: Geographical Essays* has provided a medium for research conducted by prairie-based geographers. As indicated above, papers have been published across a wide spectrum of geography sub-disciplines and research themes reflecting topics in both physical and human geography. Selected papers provide evidence of a wide variety of research tools and illustrative devices employed in determining and presenting the results of research. The journal has provided an important platform for students and young academics seeking their first publications. Periodic innovations in content and layout, plus the adoption of online publication, have added rigour to the journal and improved its accessibility. *Prairie Perspectives* has survived in an era in which other regional journals have ceased publication. Attention now needs to focus on encouraging manuscript submissions and maintaining the journal's high standard of content and presentation as exhibited in recent volumes under the guidance of its editor-in-chief.

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Across the Division

Brandon University

In fall 2018, Brandon University Department of Geography and Environment welcomed two new faculty members, Dr. Alexandra Giancarlo, on a one-year appointment, and Dr. Kristen Lowitt, on a five-year appointment. Dr. Giancarlo brought a specialization in historical geography and critical race theory. As Dr. Lowitt brings research expertise in food geographies, the department was able to offer a new 'Food, Communities, and Justice: Geographies of Food' course in winter 2019. Also, for the first time in several years, Dr. Derrek Eberts and Dr. Christopher Malcolm offered a field studies course in spring 2019 in which five students participated and travelled to Mexico. They hope to offer the course on a more regular basis in future. Also of note, the department underwent a recent name change from 'Geography' to 'Geography and Environment' to better reflect the interdisciplinary nature of our work spanning natural and built environments. Lastly, the department congratulates several of its members on securing research grants. Dr. Alexander Koiter and Dr. Peter Whittington were each awarded a NSERC Discovery Grant. Dr. Lowitt was awarded a SSHRC Insight Development Grant. Dr. Rachel Herron has received substantial support to establish a new Centre for Critical Studies of Rural and Remote Mental Health. Rachel was also the recipient of PCAG's Early Career Award for her "Significant Scholarly Contributions to the Discipline and Demonstrated Exceptional Achievement in Teaching." Not least, long-serving Emeritus Professor Roderick McGinn was honoured with the Warkentin Award for his "Outstanding Scholarly Contributions to the Geography of the Western Interior."

Lakehead University

In the past year the Department of Geography and the Environment warmly welcomed a new faculty member. Dr. Muditha Heenkenda was hired as a full-time tenure-track professor in geomatics. Muditha received her Master's degree in Geo-information Science from Wageningen University in the Netherlands, and her PhD degree in GIS and Remote Sensing from Charles Darwin University, Australia. Muditha joins our team of geomatics professionals in the delivery of undergraduate and graduate-level curriculum, our Certificate in Geomatics, and geomatics-based research programs, and in steering the direction of our Geospatial Data Centre. In September 2019, the department hosted the Climate Con 2019 Climate Change Symposium. The theme of this year's event was "Climate change impacts and adaptations in the Lake Superior Basin: Insights and perspectives from the North Shore of Superior."

University of North Dakota

The Department of Geography and GISc experienced an eventful year. Career changes saw Dr. Chris Atkinson depart for Melrose, Minnesota, and Dr. Michael Niedzielski return to Warsaw, Poland. Our thanks and best wishes were extended to Cindy Purpur who retired after 30 years' service as departmental administrative assistant. In Cindy's place we welcomed Pam Nielsen, formerly of the Anthropology Department. Dr. Bradley Rundquist, a former chairperson of the department, was appointed Dean of the College of Arts & Sciences.

Over the academic year, 14 undergraduates received baccalaureate degrees. Master's degrees were awarded to Dana McVeigh (MA), Jacqueline Amor (MSc), Nels Anderson (MSc), Earl Klug (MSc), and Eliot Peltier (MA). Eliot is now a doctoral student in UND's Earth Systems Science and Policy Department.

Dr. Douglas C. Munski and Dr. Laura B. Munski attended the PCAG Hecla Island meeting where they presented co-authored posters including one with Dana McVeigh. Faculty and students of the department attended the AAG Great Plains-Rocky Mountains meeting at Manhattan, Kansas. The department is pleased to report that Phoebe Eichhorst and Zachary Seeger received the top undergraduate poster prize for their co-authored poster on rural food deserts of North Dakota. Phoebe and Zachary were supervised by Dr. Enru Wang, the department's new graduate director and graduate GISc certificate director.

Sadly, Dr. Roland (RD) Mower, a past chairperson and emeritus professor of the department, passed away on July 8, 2019 at the age of 90. Dr. Mower's life experiences included service with the US Navy at the end of World War II and a commission in the US Air Force during which he served in Vietnam. He was a recipient of geography degrees from University of Utah (BSc), Oklahoma State

University (MSc), and University of Kansas (PhD). Upon retiring from the USAF, Dr. Mower joined the faculty at Grand Forks and remained there for 14 years before starting the third phase of his professional life as the Academic Dean at Embry-Riddle University in Prescott, Arizona. Dr. Mower remained engaged in promoting the study of geography throughout his retirement.

The department is now handling the administration of UND's Environmental Studies degrees (BA and BSc), reflecting the ongoing evolution of the department in emphasizing human-environment interaction. Also, a GIS minor for undergraduates has been approved, thereby demonstrating continuing attention to provide geospatial technology education on campus. Finally, the university has a new president and is undergoing a period of administrative and structural change. How the department will be affected by these changes remains uncertain. Stay tuned!

University of Regina

During the 2018 to 2019 academic year, the Department of Geography and Environmental Studies celebrated the convocation of 23 undergraduate and graduate students in our Geography, Environmental Studies, and Environmental Geoscience programs. The department responded to students' desire to have greater recognition of their geospatial studies by introducing a new minor in GIS. The department continued to apply the recommendations contained in the Academic Unit Review of 2017, focusing particularly on restructuring programs and their requirements to reflect changes in our faculty and recent trends in geography and environmental studies. In June 2019, long-serving department member Dr. Randy Widdis retired and moved back to his native Ontario.

University of Saskatchewan

This has been a very busy and productive year in the Department of Geography and Planning. Dr. Alec Aitken took over as Head in July. New faculty member Dr. Martyn Clark was welcomed into the department. Dr. Clark's research focuses on developing innovative approaches for simulating hydrological processes; methods to improve streamflow forecasts; and understanding the impacts of climate change on regional water resources.

Awards were received by faculty and students in numerous areas. Dr. John Pomeroy received the Miroslaw Romanowski Medal awarded by the Royal Society of Canada for "Outstanding Contributions to Environmental Science." The award recognizes his exceptional contribution to snow research and the cold-season hydrology of mountain regions. Global Institute for Water Security (GIWS) Executive Director, Dr. Jay Famiglietti was honoured with a Distinguished Achievement Award from Tufts University Alumni. Dr. Ehab Diab, who joined our faculty last year, was awarded a NSERC Discovery Grant in the field of transportation network planning.

Student award recipients included Carolyn Aubry-Wake, PhD candidate, the first recipient of the newly created IACS-IGS Graham Cogley Award for best presentation at the IUGG conference in July 2019. The award is given annually to recognize excellence in cryospheric research. Zhibang Lv, PhD candidate, received the Wiesnet Medal for his presentation at the 76th Annual Eastern Snow Conference in June 2019. Dr. Daniel Karran received the Graduate Thesis Award – PhD Social Sciences for his thesis titled "The Engineering of Peatland Form and Function by Beaver (Castor spp.)." Peter Lawford, PhD candidate, received a College of Graduate and Postdoctoral Studies Graduate Scholarship and the departmental J. H. Richards Graduate Award. Nipa Dutta, MSc candidate, received the International Association for Impact Assessment Award. Jeff Harder, MSc candidate, received a NSERC CGSM scholarship for his thesis topic "Drivers of Wildfire Occurrence in Saskatchewan's Boreal Plain Ecozone." Rhys McMaster, MSc candidate, received a College of Arts and Science Aboriginal Graduate Scholarship.

The past year has also witnessed a number of achievements in providing service to the community and the discipline. Dr. Pomeroy co-chaired the World Meteorological Organization's High Mountain Summit in Geneva, Switzerland. He also met with climate activist Greta Thunberg to discuss glacier decline. At the University's first globally broadcast TEDx conference, Dr. Corinne Schuster-Wallace presented a talk titled "Building Bridges to Improve Maternal Health: A Water Story" which focused on how academics can work with universities and NGOs in East Africa to enhance capacity and improve practice for better maternal health outcomes. Dr. Bram Noble became a co-director of the Community Appropriate Sustainable Energy Security (CASES) project. This is a $2.5 million SSHRC funded USASK-led northern energy planning partnership tasked with researching ways to transition northern communities to energy self-sufficiency. Dr. Robert Patrick and Dr. Krystopher Chutko, received financial support from Crown Indigenous Services Canada, to assist numerous First Nations install a dozen climate stations as part of an Indigenous climate monitoring network across Saskatchewan. Dr. Chutko and Dr. Aitken have been instrumental in establishing a new hydrology program which will become operational in 2020.

University of Winnipeg

The Geography Department congratulates Dr. Matt Dyce for his leadership organizing the successful Canadian Association of Geography's 2019 annual meeting held on our campus. We are also pleased to announce that Dr. Nora Casson has been awarded the Canadian Research Chair II in Environmental Influences on Water Quality (2019–2024). With funding from the Public Health Agency of Canada and Health Canada, Dr. Danny Blair and Dr. Ian Mauro of the Prairie Climate Change Centre are developing health-related

content for their Climate Atlas of Canada (2019). Dr. Patricia Fitzpatrick has received a research grant from Innovation, Science and Economic Development Canada to collaborate with the Public Interest Law Centre of Manitoba on the role of public participation and consumer engagement in regulatory proceedings. A total of 13 undergraduate Geography students were awarded $9,000 in UW scholarships. There were also opportunities for student summer research internships with Kayla Villebrun-Normand participating in the UW Indigenous Summer Scholar Program, and collaborating with Dr. Gina Sylvestre on the project, "Aging in a Food Desert: Exploring the Role of Community Meals in Winnipeg's North End." With funding through QE-II, Mitacs Global Links and a UW Student Travel Grant, Brent Murray spent three months at CSIRO in Melbourne, Australia, supervised by Dr. Joni Storie and Dr. Neil Sims (CSIRO), mapping mangroves in Fiji. Other research activities include Dr. Joni Storie as the Principal Investigator for the new project, "Automated Land Use/Land Cover (LULC) Mapping and Change Detection for the High North Regions of Canada and Norway." Dr. Bill Buhay is a co-investigator on a project examining the cultural diversity of Cuba's early inhabitants to determine processes of migration and interaction amongst these agricultural Indigenous groups, as well as their status at the time of colonial contact. With the appointment of Dr. Chris Storie as the Director of the UW Institute of Urban Studies, new collaborative synergies are being explored between this research unit and the department to enhance expertise and provide research opportunities for both faculty and students. Finally, Mark Krawetz retired after 33 years of dedication to Geography education.

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

About the Authors

Jacqueline Binyamin is a climatologist and Associate Professor in the Department of Geography, University of Winnipeg. Her research interests include radiation climatology, numerical modelling, bioclimatology, climate change and variability, severe weather, surface-atmosphere interactions and boundary layer processes, and the surface energy budget of northern lakes.

Katie Doke Sawatzky is a graduate of the University of Regina's School of Journalism. Her master's research project, "The Prairie Commons Project," examines the state of prairie grassland in Saskatchewan, governmental policies that threaten this eroding landscape, and the grassroots groups and individuals who organize to protect it. Katie lives in Regina and is currently communications officer for Mennonite Church Canada.

Hồng Thị Hà is a graduate student in the School of Agriculture and Environment at the University of Western Australia in Perth, Australia. During the project reported in this volume, she was a program officer, researcher, and teaching assistant for the Advanced Education Program at Thái Nguyên University of Agriculture and Forestry (TUAF) in Thái Nguyên City, Vietnam.

Don Huisman is a retired Parks Canada employee with 37 years service, the last 11 of which were as the Townsite and Realty Manager at Riding Mountain National Park. Don has spent 16 years on the Executive of the Riding Mountain Biosphere Reserve. Since retirement he has served for eight years as a municipal councillor for the Municipality of Clanwilliam-Erickson. Don is a geography graduate of the University of Winnipeg.

Yossi Katz is a Professor in the Department of Geography and Chair of the History of the Jewish National Fund at Bar-Ilan University, Israel. In 2106, he received the Israeli Prize in Geography and Land of Israel Studies. With John Lehr he is the author of *Inside the Ark: The Hutterites in Canada and the United States* (University of Regina Press, 2014).

Aaron Kingsbury is an Assistant Professor at Maine Maritime Academy in the United States and a regular visiting scholar at Thái Nguyên University of Agriculture and Forestry (TUAF) in Vietnam. He served as an Assistant Professor of geography at Mayville State University in North Dakota during the first part of the project reported in this volume.

John Lehr is a Senior Scholar in the Department of Geography, University of Winnipeg, where he was formerly a Professor. His research interests focus on the role of ethnic and religious groups in settling the Canadian West. With Yossi Katz he is the author of *Inside the Ark: The Hutterites in Canada and the United States* (University of Regina Press, 2014).

Joseph Piwowar is a Professor in the Department of Geography and Environmental Studies, University of Regina. His research focusses on the extraction of change information from long-time series of remote sensing images with an emphasis on studying the impacts of climate change on Arctic sea ice and on the native grasslands of the northern Great Plains of North America.

Hailey C. Robichaud is a Bachelor of Science graduate of the University of Winnipeg. Currently, Hailey is a Master's student in the Department of Geography and Planning, University of Saskatchewan. Hailey's research interests include climatology, climate change and variability, and hydrology.

Christoph Stadel is a Professor Emeritus of the Department of Geography and Geology, University of Salzburg. Between 1968 and 1992, he served as a Professor of Geography at Brandon University. His research interests focus on comparative mountain geography, rural development, and protected areas in settings as diverse as the tropical Andes, the European Alps, Kenya, and the Canadian prairies.

Bernard D. Thraves is an Independent Scholar whose research interests focus on population geography, urban geography, and the islands of the Commonwealth Caribbean. During an academic career spanning 35 years he served in geography departments at University of Edinburgh, University of Windsor, and University of Regina.

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David John McDowell
17 September 1938–18 June 2019
Source: Manitoba Historical Society

David John McDowell 1938–2019

Dave McDowell was born in Brandon but grew up on a farm in the Brandon area. After completing Grades 1 to 9 in a one-room country school he moved to Brandon to attend Brandon Collegiate. One year of teacher training at Brandon College followed, after which he taught at Moore Park School. In 1967, he returned to Brandon College to obtain a BA, where he worked as a research assistant for John Tyman in the preparation of his book *By Section Township and Range: Studies in Prairie Settlement*. Heavily influenced by Tyman's approach to geography, Dave later obtained a MA in geography from the University of Manitoba with a thesis on "Settlement and arboreal vegetation change in the Carman-Morden area of Manitoba."

Dave was a dedicated teacher and a strong advocate of the place of geography in the provincial social studies curriculum. For decades he was a member of the Manitoba Social Science Teachers' Association, serving on the executive and as President. For years he edited the *Manitoba Social Science Teachers' Association's Journal*. He was a long-standing and active member of the Manitoba Historical Society serving as President from 1976 to 1978. Dave was equally passionate about heritage preservation. He was the Manitoba representative of the National Trust for Canada, and for decades was a leader in the fight to protect Winnipeg's historic buildings. He was a board member of Heritage Winnipeg, serving as its Chair for two terms: 1981 to 1985 and 2001 to 2003. He received Heritage Winnipeg's Distinguished Service Award in 1993. Dave was also an enthusiastic supporter of the restoration of Winnipeg streetcar No 356.

With John Lehr, in 2011, he co-authored *Trailbrazers: The lives and times of Michael and Muriel (Smith) Ewanchuk*. Dave's contributions were recognized by the PCAG in 2012 with the John Welsted Award for Service to Geography in the Western Interior. Dave helped to organize the PCAG meeting held at Morris in 2017, ran the field trip, and subsequently published the field trip guide in *Prairie Perspectives*.

Dave passed away on June 18, 2019. He leaves to mourn his passing his wife Linda, with whom he shared his life for over 50 years, and many close friends and relatives.

John C. Lehr
University of Winnipeg