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University of Manitoba
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TABLE OF CONTENTS

Anthropogenic disturbance extraction using object-oriented image classification software: A comparison of Overwatch Feature Analyst and Definiens Developer
T. Olowokudejo, J. Piwowar.....1

Geospatial indicators for mapping potential hydrologic storage sites for flood mitigation in southern Manitoba
S. Fraser, J. Storie 10

Biophysical characteristics of coastal vegetation in Bird Cove, Churchill, Manitoba
A. Werner, C. Enns, J. Storie, S. Fraser, J. Sewell, G. Berard.....24

Low-income Aboriginal women's foodscapes: Moving towards geography of food dignity
C. Sobie, J. Masuda.....34

Building respectful research relationship: Lessons from a community based participatory research project with Dakota Tipi First Nation
J. Drabble, J. Masuda, H. Castleden.....45

Intensification and neoliberalization: A case study of planning policy in Winnipeg, Canada, 1990-2013
T. J. Wideman, J. Masuda.....55

Anthropogenic disturbance extraction using object-oriented image classification software: A comparison of Overwatch Feature Analyst and Definiens Developer

Titus Olowokudejo[1]
The Environmental Research and Response Applications (TERRA) Laboratory
Department of Geography and Environmental Studies, University of Regina

Joseph Piwowar
The Environmental Research and Response Applications (TERRA) Laboratory
Department of Geography and Environmental Studies, University of Regina

Pixel-based classifications of remotely sensed image data have considerable difficulty dealing with the rich information embedded in high resolution imagery. The object-oriented classification paradigm has the potential to overcome these difficulties by using the spectral, spatial and contextual characteristics of groups of pixels. Over the past decade, several object-oriented classification software tools have been developed, each with their own capabilities and shortcomings. In this research we compare two of these techniques - Definiens Developer (eCognition) and Overwatch Feature Analyst - for the extraction of anthropogenic disturbance features in high resolution colour infrared images of the boreal forest. Procedurally, Definiens Developer segments an image into objects of various sizes and then classifies them using a rule set based on user-defined attributes. The Feature Analyst software, on the other hand, uses training samples, hierarchical learning cycles, and algorithm settings to extract objects in the image. We demonstrate that both methodologies are effective in extracting areas of anthropogenic disturbance in images dominated by the natural environment. We conclude that the Definiens Developer software can provide better results for extracting and classifying the disturbance features when multiple scenes are involved.

Keywords: segmentation, object-oriented classification, anthropogenic disturbance, colour infrared image.

Correspondence to: Joseph Piwowar, Department of Geography and Environmental Studies, University of Regina, SK S4S 0A2.
Email/*Joe.Piwowar@uregina.ca*

[1]Now with International Geospatial Consult Inc, 14 Coral Springs Circle NE, Calgary, AB T3J 3P4

Introduction

Anthropogenic disturbances in natural environments are of concern because of their environmental, economic, and social impacts (Godfrey-Smith 1979). Environmental stewards are concerned because such disturbances destroy wildlife habitats and upset ecological cycles. Resource economists take note because of changes in the economic potential of the disturbed area. Such landscape changes are also an issue to society at large because of the intrinsic values we place on wilderness areas. Our ability to map the extent of such disturbances is often hampered by the vastness and remoteness of the natural environments in which they occur. The repetitive, synoptic, and non-contact perspective afforded by remote sensing technologies makes them an ideal source of data for mapping human impacts in remote areas. However, the detection and delineation of anthropogenic disturbances in remotely sensed imagery is still an imperfect science (Ranson *et al.* 2003).

The development of accurate algorithms for the extraction of human disturbance features (linear and polygon) from remotely sensed imagery has long been a focus of remote sensing research (e.g. Fischler *et al.* 1981; Gruen *et al.* 1997; De Kok *et al.* 1999; Witztum and Stow 2004; Kaiser *et al.* 2004; Hiker *et al.* 2009). Among the most frequently used unsupervised and supervised classification algorithms are the parallelepiped, minimum distance and maximum likelihood techniques (Piwowar 2005). Out of these, the maximum likelihood algorithm is preferred because of its higher accuracy (Curran 1985; Campbell 2007). However, as higher resolution imagery becomes more available, these pixel-based classification algorithms become less useful because of their difficulties dealing with the enhanced spatial information (Blaschke and Strobl 2001; Myint *et al.* 2011).

A better way to extract spatial information from high resolution imagery is with object-oriented classification methods. Unlike pixel-based classifications, object-based classifications segment images using spectral, spatial and contextual information inherent in the data (Baatz and Schape 2000). An object-based classifier makes inferences about the size and shape of objects in a scene by examining them in the context of their surrounding objects (Benz *et al.* 2004). For example, Kim *et al.* (2009) used an object-oriented classification to map specific forest types from satellite-based IKONOS imagery while Yang (2003) applied the method for detecting urban land-cover changes using Landsat TM/ETM+ and aerial photography. Some other examples of object-oriented classification can be found in Geneletti *et al.* (2003), Shackelford *et al.* (2003) Wiseman *et al.* (2007), Yu *et al.* (2006), Mitri and Gitas (2002), Volker (2004), and Mirik and Ansley (2012).

Two of the principal algorithms for object-oriented classification – image segmentation and machine learning – have been implemented in the commercial software packages Definiens Developer (also known as eCognition) and Feature Analyst, respectively. In this article we evaluate the effectiveness of Definiens Developer and Overwatch Feature Analyst for extracting anthropogenic disturbance features from remotely sensed imagery.

Objectives

Within the context of developing a semi-automated approach for identifying spatial features in high resolution imagery over a large area, we compared how well Definiens Developer and Overwatch Feature Analyst could extract anthropogenic disturbances in digital colour infrared air photos. Specifically, our objectives were to:

- Evaluate the suitability of colour infrared air photos as a data source for the extraction of disturbance features using an object-based method;
- Compare the effectiveness of the image segmentation and machine learning algorithms, as implemented in Definiens Developer and Overwatch Feature Analyst, respectively, in extracting disturbance features; and
- Establish the applicability of these methods for regional analyses where multiple images are required.

Study area

Saskatchewan, one of Canada's Prairie Provinces, is situated near the centre of the North American landmass. It covers an area of 588,239 km^2. The population of the province is estimated at 1,033,381 (Statistics Canada 2012), with people living predominantly in the southern half. The sparsely populated provincial forest dominates the boreal ecozones of northern Saskatchewan and covers an area of approximately 343,000 km^2 (Saskatchewan Ministry of Environment 2009). Increased interest in exploiting the tree and fossil fuel resources found in the forest is putting pressure on this natural environment (Schneider *et al.* 2003). Anthropogenic disturbances such as trails, seismic lines, transmission lines, forest roads and forestry cut blocks are becoming common, affecting natural ecosystem processes (Heilman *et al.* 2002). In order to assess the extent of such anthropogenic disturbances a detailed inventory is required.

In order to evaluate the effectiveness of the object-oriented classification software, three test sites were selected from the inventory of mining activities within the Boreal Shield ecozone of the province (Figure 1).

Data

Colour infrared airphotos were obtained from the Saskatchewan Geospatial Imagery Collaborative (SGIC; www.flysask.ca). These images were acquired in 2008 and 2009 at a resolution of 60cm under leaf-off and ice-off conditions (Figure 2). The digital image data are composed of 3 spectral bands: green, red, and near-infrared and each scene had a default enhancement applied.

Methods

Both Overwatch Feature Analyst 5.0 (Overwatch Systems Ltd.) and Definiens Developer 7.0 (Definiens AG) software systems

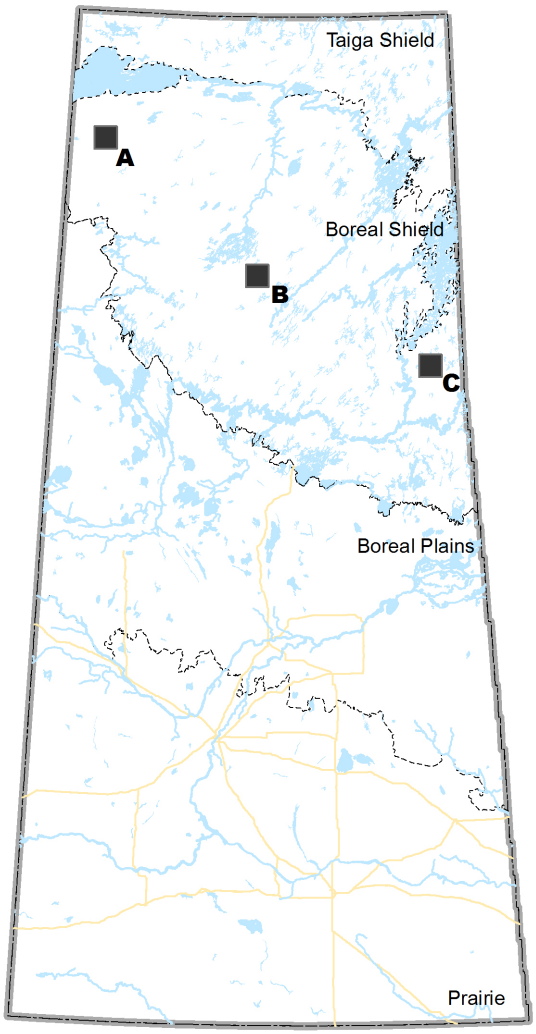
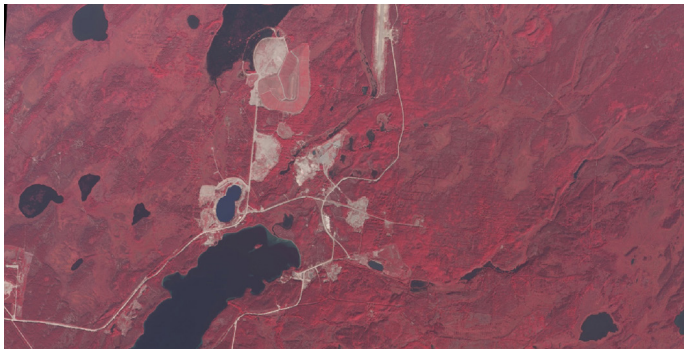


Figure 1
Location of study areas.

Study Site A: *October 1, 2008*

Study Site B: *September 13, 2009*



Study Site C: *May 28, 2008*

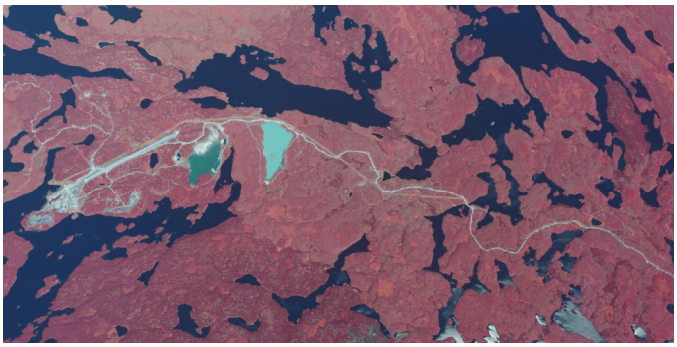


Figure 2
Colour infrared airphotos of the three study sites.

were used to locate anthropogenic disturbances in each of the three study sites. As described below, the parameters of each program were adjusted in order to achieve the best possible results (i.e. to minimize errors of omission and commission). The efficacy of each approach was visually assessed against a manual interpretation of the aerial photographs.

Feature Analyst

From a user's perspective, Feature Analyst works in a fashion similar to a supervised classification of multispectral imagery. The user first creates training samples to recognise similar objects in the image. The software analyzes the features in the training samples and develops rules (analogous to spectral signatures) to describe their properties. These rules are then applied to each pixel to classify the entire scene. However, this is where the similarity with multispectral classification ends.

Feature Analyst's rules characterize image objects not only using their spectral properties but also using various spatial algorithms, such as "narrow linear feature", "wide linear feature", "natural feature", "small man-made feature", "man-made feature", "land cover feature", "water mass feature", and "building feature". Each algorithm has different parameters, or criteria, for extraction of features/objects from imagery. The software then classifies each pixel based on the trained samples created using knowledge based recognition.

The initial training results are improved through a process called the "hierarchical learning cycle". In the cycle the user fine-tunes the classification by iteratively selecting correct and

incorrect examples from the initial result. The output features are then aggregated, smoothed and converted to vector format.

We developed a workflow of iterative training for object extraction (Figure 3). For each image, 15 training samples, were digitized since multiple training samples are required if more than one type of feature is to be extracted. We concentrated our training samples on those areas where disturbances were evident. The following criteria were found through experimentation to optimize the feature extraction across all three of the study sites: a) using the three multispectral bands from each airphoto; b) employing the "man-made feature" algorithm; c) setting the input representation: pattern width to be 25; and d) ensuring the "aggregate" and "smooth" output options were selected. The supervised learning tool was then activated to facilitate the fine-tuning of the ruleset parameters and criteria. Two cycles of hierarchical learning were found to produce the best results.

Definiens Developer

Definiens Developer begins with a process called "segmentation" where an image is divided into a multitude of image objects based on four criteria: scale, colour, smoothness, and compactness. The scale parameter determines the threshold of image object heterogeneity, i.e. how similar features need to be in order to be contained in a single image object. The size of the image objects found is dependent on the scale parameter: higher values result in larger image objects, while lower values produce smaller image objects. The concept of object homogeneity is defined by the other three criteria: colour, smoothness and compactness. For example, more homogeneous objects will have less colour variability, tend to have larger patches of the same colour, and have a more circular shape. Parameters for each of the four criteria are typically enumerated interactively by testing their effectiveness on different image subsets. The criteria can be combined in various ways to optimize the homogeneity of the image objects.

From among the different segmentaton algorithms that Definiens provides (the list includes chessboard, quadtree based, contract split, multiresolution, spectral difference, and contrast filter segmentations) the most commonly used approach is multiresolution followed by spectral difference. In this method, the image is segmented multiple times at different spatial resolutions and the resulting image objects are subsequently merged based on their spectral similarities with the spectral difference algorithm.

After segmentation, the resulting image objects are labelled with their real-world identities (e.g. seismic line) through a classification process. The classification depends on a set of rules that operate on the spectral and spatial characteristics of each object.

In this research, we used multiresolution and spectral difference segmentations to delineate and extract disturbance features from the air photos following the workflow outlined in Figure 4. The estimate scale parameter (ESP) tool (Drăguț *et al.* 2010) was used to optimize the scale parameter at 110. Similarly, the associated shape and compactness values were set at 0.6 and 0.5, respectively.

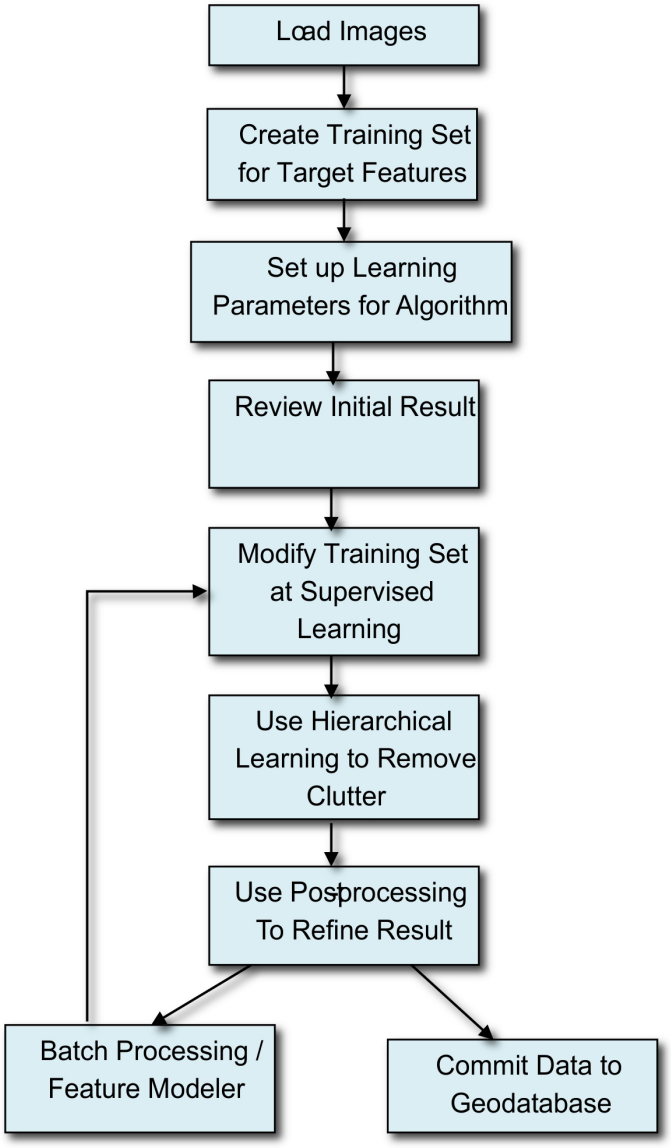


Figure 3
Workflow of Feature Analyst.

The following rules were defined to classify the segmented objects:

- If the red band value was less than 135, then classify as water and lake areas.
- If all three bands had values less than 140, then classify as vegetation.
- If the image object's size was less than 3 ha, then classify as non-disturbed.
- If the relative border (tonal change) between the image object and a vegetated area was less than 0.8, then classify as non-disturbed.
- Else, classify as disturbed.

Following the classification, the individual features that were classed as disturbed were merged into larger disturbance units.

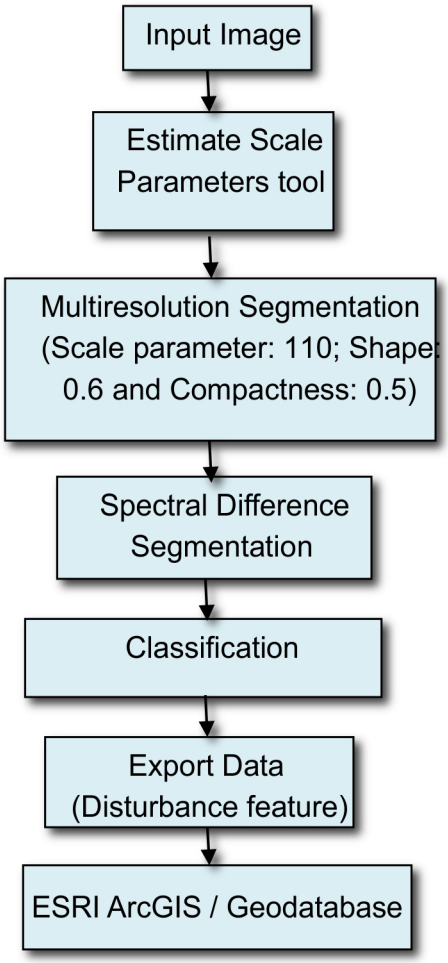


Figure 4
Workflow of Definiens Developer.

Results and discussion

Baatz and Schape (2000) showed that the human eye is acknowledged as a strong and reliable source for evaluating segmentation techniques and image classification. It was not part of our objectives to provide a quantitative comparison of the two methods; however, a visual assessment against a manual interpretation of these sites revealed that both algorithms accurately represented the disturbed areas, albeit in very different ways.

Following two cycles of hierarchical learning, the anthropogenic disturbances identified by Feature Analyst are shown in Figure 5. Definiens Developer uses the segmentation method to construct a hierarchical network of image objects that represents the image information for the spectral, spatial, and contextual attributes (Figure 6). Although the results of both processes appear to be very different, in reality they both satisfy the objective of extracting disturbance features using an object-based method.

Definiens Developer (eCognition) software is a powerful development suite for image processing. However, there is a steep learning curve for acquiring the skills required to effectively use and understand how the software works. High accuracies have been reported for the delineation of cut blocks (Flanders *et al.* 2003) and shelterbelts (Wiseman *et al.* 2009). In this paper, we were also able to qualitatively determine a high level of accuracy. In order to establish the applicability of this software for regional analyses, we tested the transferability of a rule set across several scenes. A rule set was built using one of the images and was subsequently applied to the other scenes. We demonstrated that we were able to also classify the disturbance features in other scenes at a relatively high accuracy based on the ruleset derived from an external scene.

The Feature Analyst software has the demonstrated capacity to extract vector features from high resolution imagery. Feature Analyst follows an established image processing paradigm (supervised classification) and thus is easy to learn within a short time frame. It uses training samples and algorithm settings to classify the image. When appropriate training data are used, Feature Analyst has the capacity to produce accurate results. For example, Miller *et al.* (2009) recorded an overall accuracy of 92% when extracting impervious and pervious features in a multispectral image. We tested the transferability of the final training sample across scenes and obtained very poor results. Consistent with the findings of Aksoy *et al.* (2010), we concluded that image specific training samples were required to produce acceptable results for each image to be analyzed.

As documented in Figure 2, the test images were acquired in different seasons and years. It is interesting to note that both algorithms were able to cope with these differences.

Conclusion

In this work, we compared the efficacy of object-oriented image analysis algorithms for the extraction of anthropogenic disturbance features from digital colour infrared airphotos of a boreal forest region. The high resolution of the colour infrared images used proved to be highly effective for detecting and extracting disturbance features from the imagery. Two object-oriented feature extraction algorithms were tested. Both Definiens Developer (eCognition) and Overwatch Feature Analyst demonstrated high capabilities for locating disturbance features in our test sites. Definiens Developer is much better at transferring its rulesets across multiple images. However, this was not the case for the Feature Analyst software. It required fresh training samples for each new image that was added to the study. The rule set classification could be used for further feature extraction in other parts of the province. Thus, for large area disturbance analyses, Definiens Developer has demonstrated superiority over Feature Analyst and is therefore the tool to use.

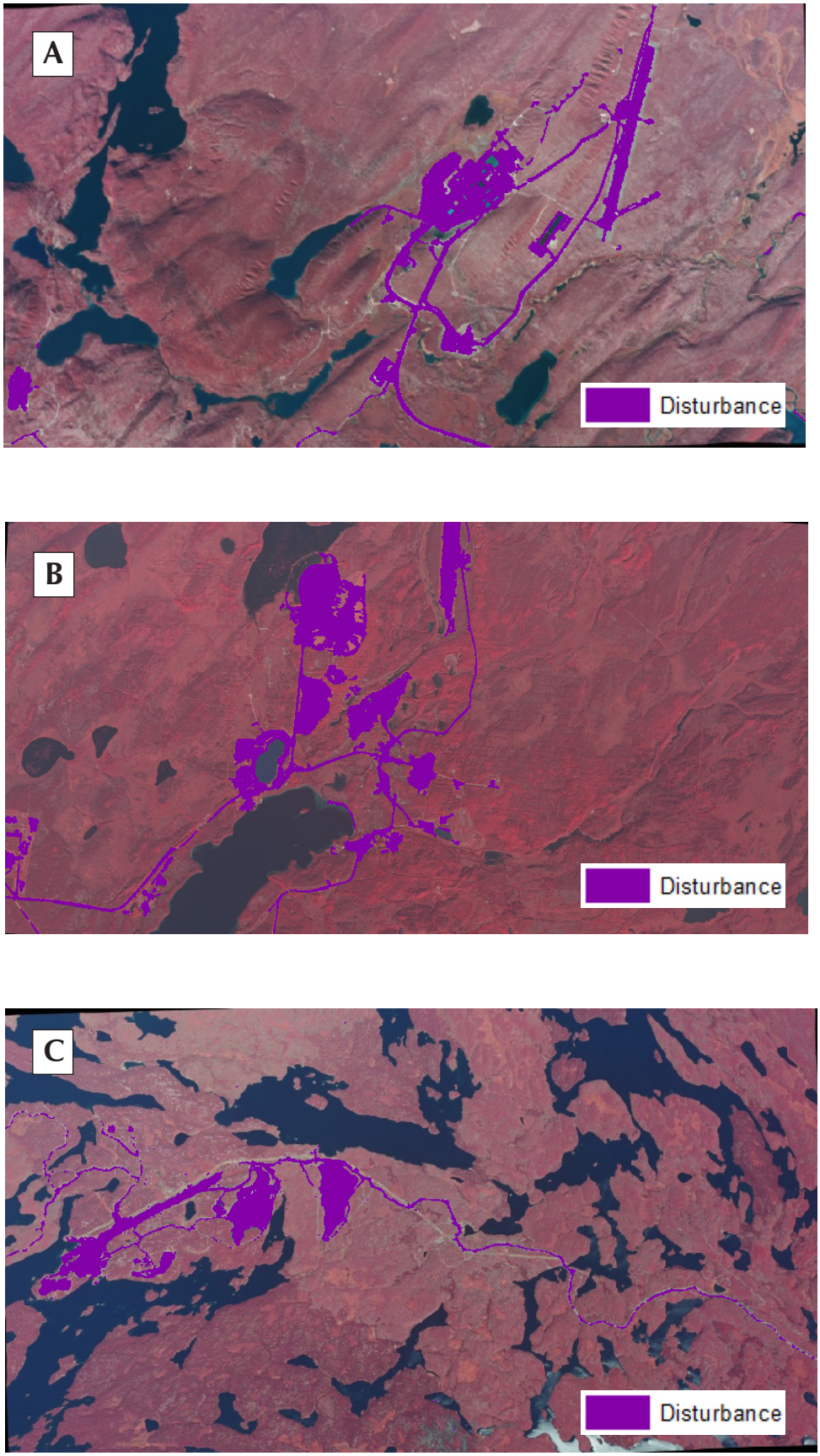


Figure 5
Disturbance features detected by Feature Analyst.

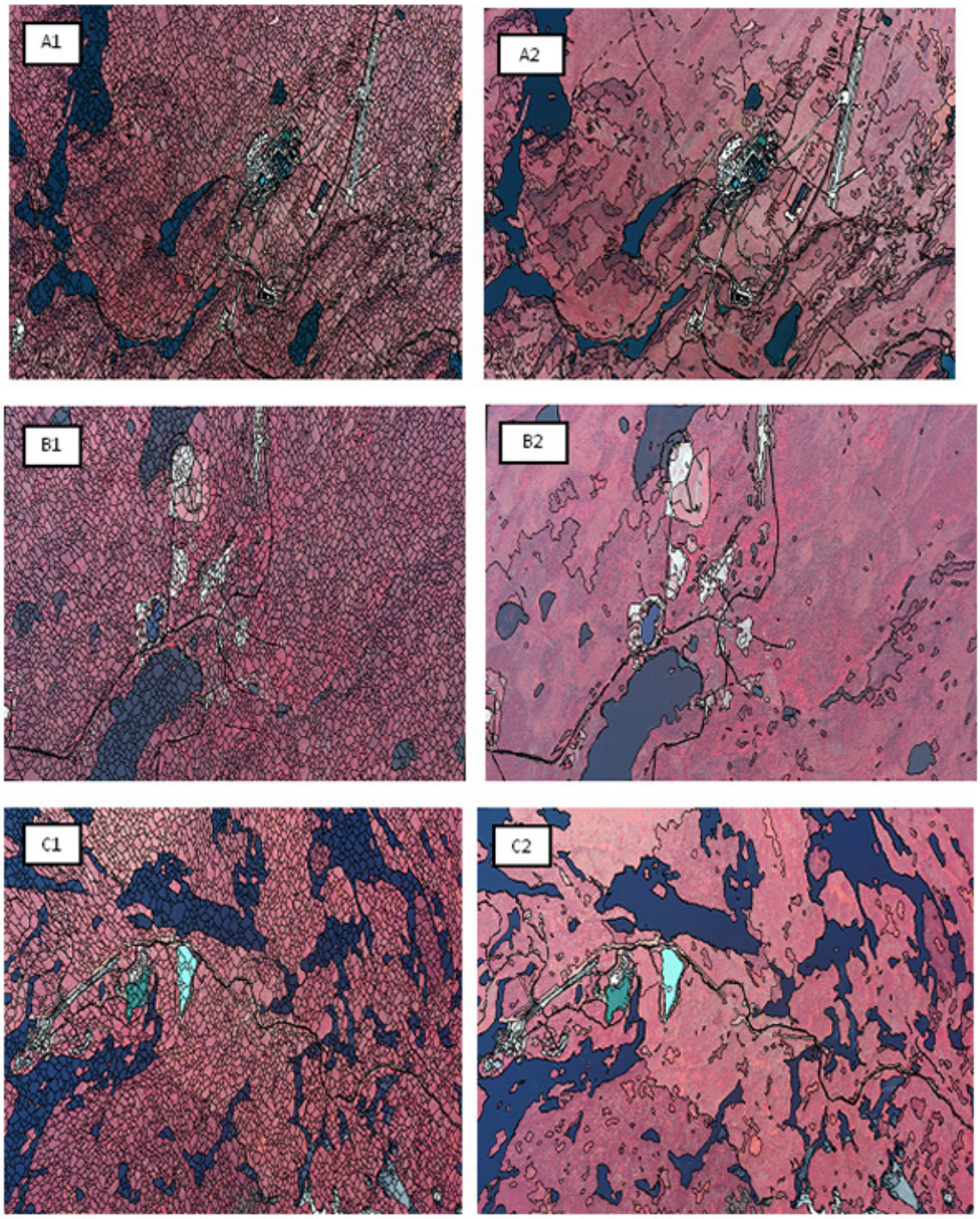


Figure 6
Definiens Developer multiresolution segmentation (left) and spectral difference segmentation (right).

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Geospatial indicators for mapping potential hydrologic storage sites for flood mitigation in southern Manitoba

Samantha Fraser
Department of Geography, University of Winnipeg

Joni Storie
Department of Geography, University of Winnipeg

Since 1870, much of the increased flood risk in southern Manitoba has been due to the change of land-use, specifically the drainage of wetlands for agriculture and urbanization. As a part of the Province's new water management strategy, restoring or creating new wetlands for flood management was identified as a priority. The long term goal of this project is to map potential wetland sites for flood mitigation along the Red River in southern Manitoba using geospatial indicators. The first two objectives to meet this goal, and the focus of this article, were to (a) identify remote sensing and GIS indicators of potential wetland sites, and (b) develop a framework for the determination of potential wetland locations that would be effective at reducing downstream flood volume as well as be cost efficient. The list of geoindicators identified included land assessed at low economic value, pasture or other low-valued agricultural land, clay or hydric soils, potential for precipitation accumulation, surface flow to topographic depressions, high soil moisture content, close proximity to streams, minimum and continuous site size, and land area required for 20% reduction in flow. These geoindicators were incorporated into a framework modified from McAllister et al., (2000). Changes in the framework included use of Canadian and Manitoba data standards and data availability, and addressing the known indicator gap in the framework.

Keywords: wetlands, hydrology and agriculture, SAR applications, geomatics in natural hazards

Introduction

Wetlands have a tremendous capacity to store and gradually release water making them ideal for flood management; wetlands naturally function as a place for flood water to go and reduce flooding downstream by intercepting surface runoff (Mitsch and Gosselink 2000). Benefits of wetlands can relate to hydrologic, ecologic and/or water quality functions. Ecological benefits of wetlands include filtering of sediments and nutrients, carbon storage, wildlife sites, recreation and tourism (Costanza 1997; Dahl and Watmough 2007); however, this article is focused on the hydrologic benefits as they pertain to the Red River basin in southern Manitoba.

The Red River basin was shaped by the Wisconsin Glacial Period during the late Pleistocene epoch and includes features such as the glacial Lake Agassiz plain and numerous pothole wetlands (Hanuta 2006). Since the late nineteenth century, extensive artificial drainage structures were introduced that removed ninety-eight percent (98%) of the wetlands in the Red River basin for agriculture and urban land use purposes (Sierra Club: Agassiz Basin Group 1998). Based on historical Dominion Land Survey data, Hanuta (2006) estimated that in the late nineteenth century, 10% of southern Manitoba's land area was wetland, compared to less than 1% today. The drainage of wetlands has resulted in increased transport of surface water, de-

Correspondence to: Joni Storie, Department of Geography, University of Winnipeg, Winnipeg, MB R3B 2E9. Email/*j.storie@uwinnipeg.ca*

crease in water storage, and overflow of nearby channels during flood events (McAllister *et al.* 2000).

In the Provincial throne speech from October 2011, the Manitoba Government announced that the Province was going to initiate a new province-wide surface water strategy. Manitoba's new Surface Water Management Strategy will "address the management of water across the province in a holistic way that considers the diversity of human needs and the importance of water to sustain the health of our natural environment" (Hildebrand and Dyck-Pankratz 2012). The Province use of Integrated Water Resource Management (IWRM) approach aims to address flooding through engineering solutions (e.g., floodways and dams) as well as through the use of existing and potential wetlands to collect and store water from surrounding region during rain or snow melt events. The long term goal of this research will assist the Province in meeting this agenda by using geospatial data to identify potential IWRM wetland sites along the Red River floodplain south of Morris, Manitoba. In order to complete this goal, the first two objectives, identification of geoindicators and a method framework, were first completed and are the focus of this article.

The term wetland is commonly used in the literature to describe sites for hydrologic storage, water quality filtering, and/or ecological purposes (Mitsch and Gosselink 2000). This article presents a review of the literature on geospatial indicators used to identify potential wetland sites for hydrologic functions, and a modified framework for the detection of potential wetland sites in southern Manitoba. The regional focus of this research is the Red River basin south of Morris, Manitoba, thus the significance of these indicators for mapping in low relief environments was a determining factor. The geoindicators are presented in the context of a modified framework after McAllister *et al.* (2000). The resulting geospatial products and final map of potential wetlands sites will be presented in a future manuscript.

For use in our research, we modified a framework for the detection of potential wetland sites that was originally developed by McAllister *et al.* (2000). The framework adaptation addressed a gap in knowledge that was identified by McAllister *et al.* (2000), and proposed the use of RADAR data to replace or augment elevation data in the framework. The use of RADAR data, instead of high resolution elevation data, would allow for a larger region to be modelled outside the Red River floodplain in Manitoba. Although the modifications were proposed for implementation in the southern Manitoba portions of the Red River basin, the use of this framework will continue to allow for direct comparison between results obtained for the Red River basin in the Canadian and USA projects.

Study site

As with many research projects, the location and characteristics of the study site determined the importance of the indicators for mapping potential wetland sites in this region. The study site is a subsection of the Red River basin, south of Morris, MB (Figure 1). This site was chosen for a number of reasons: it allows for direct comparison with the McAllister *et al.* (2000) study in the USA-portion of the Red River basin; the Morris area is regularly inundated with flood waters; it is representative of the Canadian portion of the Red River basin; the methods developed within the floodplain can be applied outside of the floodplain; and because of the availability of geospatial data.

Southern Manitoba is a part of the Lake Manitoba Plain ecoregion within the Prairie ecozone; an ecozone which is naturally characterized by more than 50% prairie grassland with the remaining land made up of wetlands, aspen parkland and broadleaf deciduous forests (National Ecological Framework for Canada 1995). This region exhibits a continental climate with long cold winters, mild to hot summers and moderate precipitation (Hanuta 2006).

The Red River slowly meanders from south to north through the low relief of the lacustrine plain left behind by glacial Lake Agassiz. The soils in the area range from silty-clay (study site) in the main Lake Agassiz basin to sandy soils in the near shore and fluvial deltaic soils in the surrounding areas (Teller 1976). In the Red River basin, the change in elevation is less than 42 m over the 200 km distance (calculated using LiDAR data with +/- 40 cm horizontal accuracy) from the Canada-US border to the southern tip of Lake Winnipeg. During the retreat of glaciers, stagnant ice processes formed a high density of wetlands in the Canadian prairies called the Prairie Pothole Region (PPR). The negative hydrologic budget in the region combined with low topographic relief resulted in a landscape that did not form lakes but closed depressions (a.k.a. potholes) where water was effectively held on the land and evaporated before it could reach the river networks. Although not commonly included in many studies of the PPR, the potholes do extend to the south-western portion of Manitoba which is more subtle (less deep) because they exist in the ancient lake bed (Figure 1). Therefore, methods that have been developed for the PPR can be used in our study site as they are closed depressions.

The regional landscape underwent a significant transformation in the 1870s associated with agricultural colonization that was actively promoted by the government. Prior to European settlement, the land was covered by native prairie grasses interspersed with islands of deciduous trees and wetlands. The dominant land use in this region is now agriculture, representing 54.6% of Manitoba's total land area south of Winnipeg. The increase in agriculture corresponded with the decrease in wetlands, from 10% of the land prior to 1870s settlement to less than 1% of the land cover today (Hanuta 2006). Despite the hydrologic, ecologic and water quality benefits of having wetlands and farmlands coexisting, government policy taxed farmers on their entire properties as potential farmland which provided more incentive to remove of wetlands (Kooten 1993; Hanuta 2006). Thus, wetlands were drained and/or filled for agricultural production which resulted in large volumes of water directed off the land and into major river networks such as the Red River (Hanuta 2006).

Significant floods have been recorded since the early 1800s and "in the past 60 years, the floods in 1950, 1997, 2009 and 2011 have caused substantial damage, especially along the Red

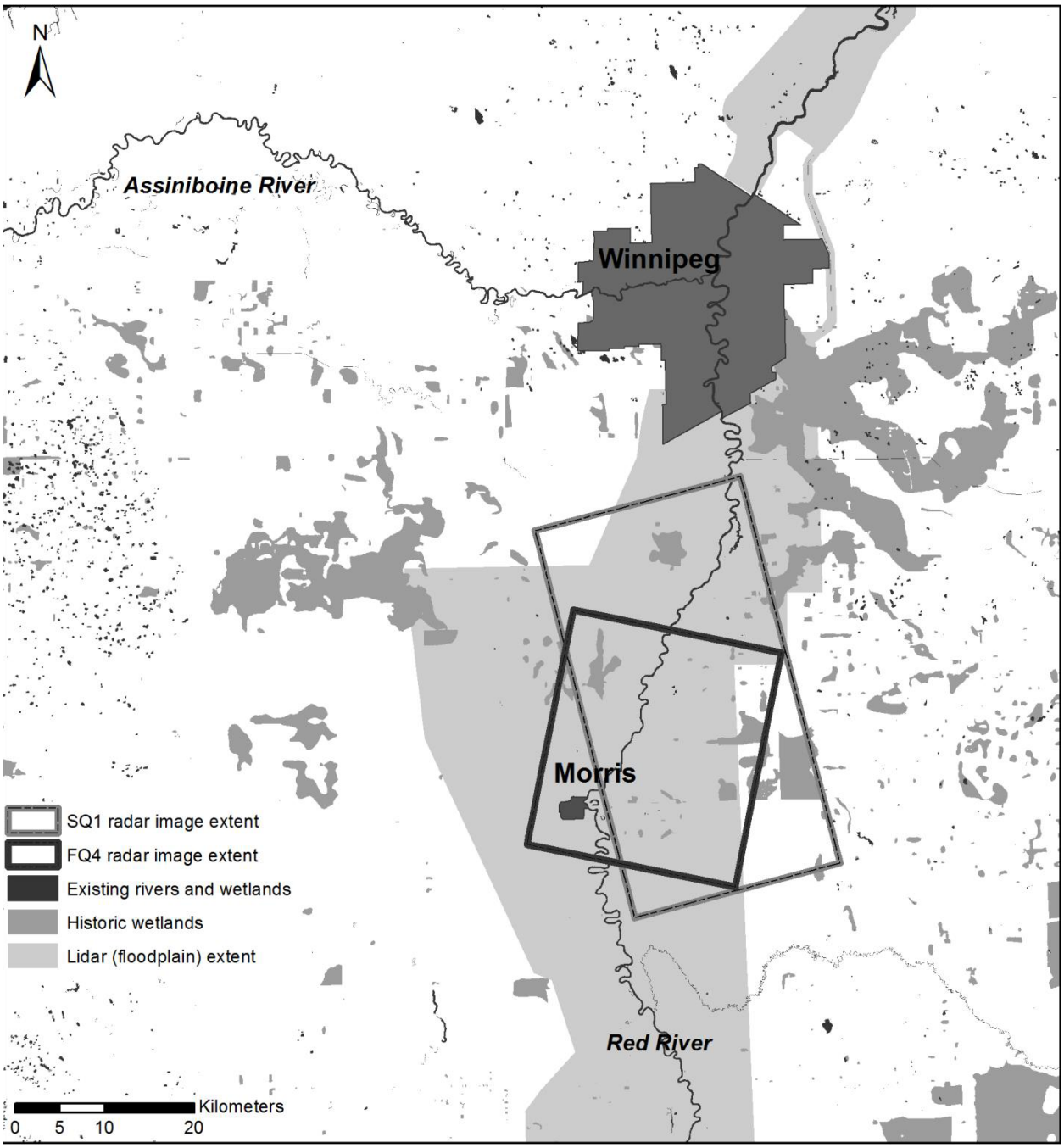

Figure 1
Study site near Morris, Manitoba defined by the intersection of the two RADARSAT-2 images (SQ1 and FQ4). The Red River floodplain is defined by the extent of the LiDAR imagery and historic wetlands of the region are shown.

River and Assiniboine River basins" (Government of Manitoba 2013). The 1826 Red River flood resulted in the highest natural spring discharge (225,000 cfs; 6,371 m^3/s) on record. The most memorable flood in recent history, the 1997 Red River flood, is ranked third in quantity of natural spring discharge at 165,000 cfs (4,672 m3/s). In addition to discharge volume, the frequency of flooding has also increased in the Red River basin. Of the largest natural spring discharges recorded along the Red River, three were recorded in the 1800s, one in 1950, two in the 1970s, two in the 1990s and three in the 2000s.

In today's figures, it was estimated that the 1950 flood resulted about $1 billion in damages in Winnipeg, the most populated city in Manitoba (Oliver and Wiebe 2003). As a result of the 1950 flood, the Red River Floodway was constructed to divert floodwaters around Winnipeg. The floodway was put to the test

during the 1997 flood and was recognized to mitigate $6 billion worth of damage (Oliver and Wiebe 2003). Flooding along the Red River or the Assiniboine River has an effect on both urban dwellers and agricultural land production. The Assiniboine River flood in 2011 reached the 1-in-300 year flood levels, cost over $2 billion in federal and provincial expenditures and resulted in significant losses to agriculture production (Gerrard 2012).

Flood events, such as those in the Red River basin, demonstrate why it is important to reduce the extent and impact of future floods. In the future, it is believed that the Red River basin will be particularly sensitive to changes in precipitation, evapotranspiration and land cover because the River exists along the transition from semiarid (west) to humid forest to the east (Rannie 1998). Gerard (2012) noted that southern Manitoba has experienced increased precipitation over the past 15 years and predicts this region will continue to experience increased precipitation amounts compared to historical averages. The inheritance of a glacial landscape, the drainage of wetlands, and climatic uncertainty all point to an increase in the frequency and severity of major flood events in southern Manitoba in the future.

Framework

The aim of the Red River Basin Natural Resources Framework Plan, developed for the Red River Basin Commission (RRBC) in 2005, was to achieve an integrated management approach for the Basin which included the effects of drainage on wetland and hydrologic function (RRBC 2011). The RRBC has identified two primary management strategies to control the amount of flooding within the Red River basin: (a) introducing wetland storage areas that mitigate drainage; and (b) supporting initiatives that promote land-use practices to retain water where it falls on the landscape. The RRBC is currently implementing these flood management strategies in North Dakota, South Dakota and Minnesota. In addition to extensive research by the RRBC, the US Environmental Protection Agency's (EPA) Landscape Function Project has developed a synoptic approach to provide wetland restoration as a priority for this landscape (McAllister *et al.* 2000).

The EPA approach, developed by McAllister *et al.* (2000), presented a framework for identifying potential wetland sites which improved upon work by Abbruzzese and Leibowitz (1997) by providing a better mathematical basis for combining indicators to evaluate functional performance. In this article, we present a modified version of this framework to be used for the southern Manitoba portion of the Red River basin (Figure 2). Although the framework developed by McAllister et al., (2000) was applied on a synoptic scale, the authors recommended that this framework should also be applied on a regional scale, which is the case in this research.

Figure 2 shows the three major components for the siting of potential wetlands for hydrological storage: (1) restored wetland per restoration dollar, (2) decrease in drainage volume per area of restored wetland, and (3) decrease in total downstream flood volume per decrease in drainage volume. See McAllister et al., (2000) for a full description of these components. The four indicators identified to estimate these components include (1) Cost of Land; (2) Total Runoff Depth and Storage Potential (modification); and (3) Drainage Density.

McAllister *et al.* (2000) acknowledged a known gap in the original framework which did not include an indicator for the component "Wetland Drainage Basin Area per Area of Restored Wetland". Our work proposes to adapt this component to "Storage Potential" (identified in dark grey in Figure 2). Storage Potential can be calculated in two ways, first by incorporating topographic depressions and flow paths (e.g., using LiDAR data) to identify potential wet sites, or by incorporating measured surface soil moisture information (from RADAR data).

According to McAllister *et al.* (2000), many of the decisions for the development of the original framework were based on data availability and national data standards for all of the contiguous US (e.g., standards, scale, resolution, national datasets). In addition to addressing an indicator gap in the framework (storage potential), this work adapted the framework for southern Manitoba by using Provincial and Canadian national standards for geospatial data (Government of Canada 2013; Government of Manitoba 2013).

Indicators

The proposed surface water management strategy for the Province includes the identification of potential wetland sites for flood mitigation (Hildebrand and Dyck-Pankratz 2012). The location of potential wetland sites for flood management cannot be directly measured; therefore, a number of indicators have been identified by researchers. In this article, these indicators have been organized based on the four indicators outlined in Figure 2: Economics (cost of land); Total Runoff (land-use/land-cover, soil characteristics and hydric soils, precipitation); Storage Potential (elevation and soil moisture); and Drainage Density (water networks). The review was focused on articles that addressed the creation and restoration of wetlands for flood management, specifically those published after reviews by Mitsch and Gosselink (1993 2007). In addition to identifying more current research, this article incorporates the use of RADAR data for terrain modelling where the two reviews by Mitsch and Gosselink focused on elevation data for modelling surfaces.

Economic analysis

The feasibility of completely mitigating flooding in the US portion of the Red River basin was deemed cost prohibitive, thus a management strategy was devised to address uncertainty in future flood conditions that would also be cost effective (RRBC 2011). The RRBC determined that a 20% reduction in the peak flow, on a sub-watershed basis, could be accomplished through storage capacity improvements in the Red River basin. Increasing the number of wetlands was considered a key component

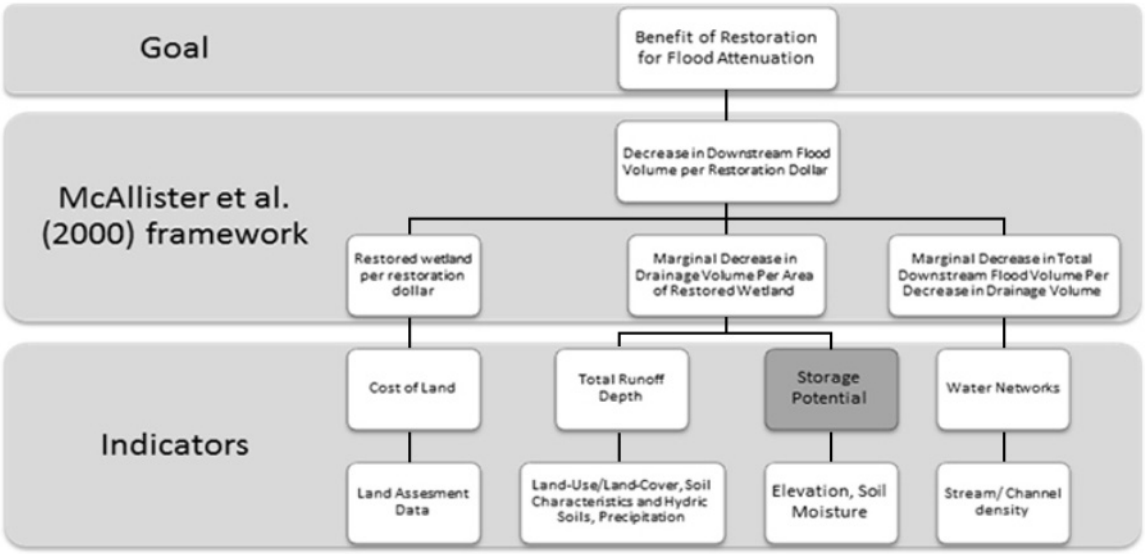

Figure 2
McAllister *et al.,* (2000) framework modified for Canadian study, addressing the missing indicator with "storage potential".

for improving storage capacity in this area. It was noted that the lower the frequency of the flood (e.g., 500 year floods), the less effective upstream water storage becomes since larger floods would require too much land area for water storage. The 20% reduction of peak flow was specifically chosen to mitigate higher frequency floods up to a 100-year flood scenario.

In order to minimize the land acreage costs and to address their hydrologic management goals, the RRBC has put into place tiered incentives that encourage: (a) the use of privately owned, marginal lands for water retention, wetlands habitat and carbon sequestration; and (b) conversion of marginal agricultural lands into natural cover, water retention and wetlands habitat areas. The cost of the land is considered a significant factor when deciding where to locate potential wetland sites (Notebaert *et al.* 2009; McAllister *et al.* 2000). It was recommended that a full economic analysis be completed that includes the costs of taking agricultural land out of production, the cost of restoring the wetlands, and the cost of wetland maintenance and monitoring (Juliano and Simonovic 1999). Three approaches have been used for estimating these costs: (a) Land-Use Land-Cover (LULC) data; (b) land assessment data, and (c) cost per acre (Leitch and Fridgen, 1999; Leitch *et al.* 1999; Juliano and Simonovic, 1999).

The existing Land-use/Land-cover (LULC) of a region has been used as an economic indicator or a proxy for estimating the cost of wetland restoration (Palmeri and Trepel 2002; Van Lonkhuyzen *et al.* 2004; White and Fennessy 2005; Newbold 2005; Moreno-Mateos *et al.* 2010). When the researchers had no access to land assessment data, they estimated land value based on LULC maps with the assumption that certain land-cover had more economic value than others. For example, pasture lands had less value than other agricultural croplands (e.g., wheat, soybean, corn). Taking a pasture field out of production was not only deemed less costly, but by doing so also meant that the more economically valuable agricultural land was not taken out of production and was protected from flooding. Other LULC categories were considered too expensive to be used for hydrology mitigation because they required the removal of infrastructure (e.g., tiling) or resources (e.g., forest, timber) before a wetland could be introduced.

For the McAllister *et al.* (2000) study, they used the American land assessment data which is based on the dollar value for farmland from the US Census information. In Manitoba, the Provincial land assessment data is determined using sale value, soil productivity, location, drainage, topography and erosion when assessing arable farmland (Government of Manitoba, 2013). Pasture land is not considered arable in Manitoba and is therefore assessed at a lower rate. Actual land assessment data, when available, have the advantage of identifying economic differences from field to field when the region is dominated by one or a limited number of LULC categories.

The RRBC compared the cost of grated flood impoundments (US$1000 per acre-foot; $123/ha-m) to the cost of wetland creation. Based on this cost comparison alone, the authors concluded that the economic benefits of upstream wetland storage were evident. In two case studies by Leitch and Fridgen (1999), the authors showed the full cost for restoring wetlands for flood mitigation in the Red River basin to be US$45 per acre-foot ($5.6/ha-m) of storage per year. This was calculated based on loss of agriculture output, restoration and maintenance costs. However, the value of $45/acre-foot ($5.6/ha-m) does not take into consideration the variability in agricultural land value. The RRBC also did cost-benefit ratios for the reduction of flood flow that included the cost of upstream storage and the cost of actual flood damage. In this economic analysis, US$100 per acre ($40.5/ha) was estimated for areas flooded in the spring and US$300 per acre ($121/ha) for summer floods (based on 1978 data). This would

amount to US$2.7 billion to cover an area that corresponded to a 100-year flood and US$6.2 billion for a 200-year flood scenario in the US-based portion of the Red River basin.

The advantage to LULC data for determining economic value is the freely available satellite data (e.g., Landsat) and LULC maps in the USA and Canada. Therefore, use of suitable/not suitable LULC has provided an effective economic ranking system for many models in the past. However, using LULC data as an economic land assessment indicator is problematic in homogeneous LULC regions (e.g., agriculture) and assumes that the maintenance and monitoring costs are equal for all potential wetland sites. Therefore, use of assessment data, when available, is recommended in regions dominated by a single LULC, i.e., agriculture at assessment data provides variable costs for different agricultural land. Land assessment combined with the full cost of wetland creation/restoration allows for better decision making in site selection.

Runoff factors

The second component of the McAllister *et al.* (2000) framework was "Wetland Drainage Basin Area per Area of Restored Wetland" which is calculated using runoff depth and storage potential. Runoff depth, defined as "the negative of the volume of water drained per area of drained wetland" describes the water retention potential of a prospective wetland site. To assess the potential storage capacity of a wetland, runoff depth is calculated using one of two methods: the rational method (Randolph 2004) and Curve Number (Kent 1973). In the rational method, a runoff coefficient (c) would be calculated based on LULC, topography and soil texture (non-antecedent conditions). The rational method assumes that peak flow will most likely occur when the entire basin is contributing to the flow (long storm not necessarily large storm). This method is most suitable for small watersheds or urban applications and it can also be modified if spring snowmelt is treated as a very long storm event. The advantage of the rationale method is its simple to use; the disadvantage is that the model was not designed for large basins to be explored for one period of time.

Curve Number was developed by the United States Soil Conservation Service to predict the amount of runoff from a storm (Kent 1973). The advantage of this method is it incorporates more variables of value for exploring large basins dominated by single LULC (e.g., agriculture). The variables include agricultural crops (e.g., row crops versus small grains), crop management practices (e.g., crop rotation, permanent versus harvested crops), soil texture and antecedent moisture conditions (McAllister *et al.* 2000). A review of literature showed that many researchers explored LULC, crop type and soil characteristic to determine runoff depth and wetland site suitability.

LULC was used for the detection of potential wetland sites by a number of researchers (O'Neill *et al.* 1997; Russell *et al.* 1997; Palmeri and Trepel, 2002; Van Lonkhuyzen *et al.*, 2004; Klemas, 2001; Newbold, 2005; Moreno-Mateos *et al.* 2010). In addition to economic value, researchers used LULC to provide area estimates for surface runoff, hydrologic condition and general suitability (i.e., a combination of some or all purposes). Table 1 shows the LULC categories that were considered suitable or not suitable for potential wetland sites. Common LULC types that were considered appropriate for wetland site selection included agricultural fields (low value agricultural fields, pasture lands), herbaceous vegetation (abandoned fields-herbaceous dominants, grasslands, lawns, pasture lands), woodland (abandoned fields-woody dominants), riparian vegetation and vegetation indicating wet/moist areas (moist herbaceous, mire, swamp), disturbed vegetation and bare ground (O'Neill *et al.* 1997; Russell *et al.* 1997; Palmeri and Trepel 2002; Van Lonkhuyzen *et al.* 2004; Klemas 2001; Newbold 2005; Moreno-Mateos *et al.* 2010). These LULC categories were deemed to be suitable because they were associated with wet areas that could potentially support a wetland, or they were inexpensive land (e.g., low human activity, no forest to clear), or locations where wetlands would protect other land with more value.

LULC also provided information for setting priorities of where wetlands were least needed for hydrological storage potential. LULC classes unsuitable for potential wetland sites included urban areas, economically-valuable forests and agricultural fields, land that has undergone significant artificial landscape changes or LULC with great ecological benefits (Table 1). Lin *et al.* (2006) stated that urban areas offered little to no practical potential for wetland restoration because of significant human populations, expanse of impervious surfaces and extensive artificial alterations to the natural systems. Forests

Table 1
Suitable and unsuitable land use-land cover types as defined by literature.

Author	Data	Appropriate LULC	Not Appropriate LULC
O'Neil et al. (1997)	Color infrared, 1:30,000	Riparian Vegetation, bare ground, moist herbaceous cover and agricultural fields	Upland vegetation including trees, shrubs and grass
Russell et al. (1997)	Landsat	Bare land, scrub or agricultural fields	Urban areas
Palmeri and Trepel (2002)	Based on human population density	Non-urban	Urban/industry
	Digital land cover map ATKIS	Water, mire, swamp, grassland	Farmland, forest, urban/industry
Van Lonkhuyzen et al. (2004)	Field survey data and digital orthophotography	Abandoned fields (herbaceous dominants), abandoned fields (woody dominants), mowed lawn and disturbed vegetation	Deciduous forest, pine plantation, wetland/open water, existing buildings, and roads, etc.
White and Fennessy (2005)	Landsat Thematic Mapper	Agriculture/open urban, shrub, wetland and barren/bright surface (Strip mines, quarries, sand and gravel pits, and beaches)	Wooded land, Urban and water areas
Newbold (2005) [water quality of wetland restoration]	California Department of Water Resources land use survey and the US Fish and Wildlife Service's National Wetlands Inventory	29 types of land use, including ten types of agriculture and six types of urban lands, data used from several other sources to estimate the nutrient application rates for each agricultural land use type, irrigation application rates for each agricultural land use type and combined sewer and storm water runoff and nutrient concentrations in runoff for urban land use types	
Moreno-Mateos (2010)	0.5 m aerial photography	Wetlands, irrigated farmlands, Rain-fed farmlands, Abandoned lands	Erosion deserts, Dry shrub land/grasslands, Irrigation channels, Livestock farms and Urban areas, Woodland

and other mature/valuable habitats were not considered as an appropriate LULC for conversion to wetlands because they represented abundant ecological value, had higher associated costs for conversion, or had upland locations (O'Neill *et al.* 1997). Other sites were deemed less suitable because they did not meet the expectation of permanence on the landscape or could not be protected from future development or impacts such as soil contamination (Van Lonkhuyzen *et al.* 2004).

Lin *et al.*, (2006) did not consider existing or historical wetlands as suitable for the introduction of a new wetlands because a wetland already existed at that location. However, most studies did include existing or historic wetlands because they represented the ideal wetland location and thus could be used as validation sites for models (Palmeri and Trepel 2002; Van Lonkhuyzen *et al.* 2004; White and Fennessy 2005; Moreno-Mateos *et al.* 2010). These researchers recognized that restoring previous wetlands could bring back important lost hydrologic and water quality functions (Kruczynski 1990; Richardson and Gatti 1999; Van Lonkhuyzen *et al.* 2004; Weinstein, Teal, Balletto, and Strait 2001).

The first step to establishing a wetland for flood control was to determine where wetlands had existed in the past (Mallinis *et al.* 2011). Wetland restoration was generally considered more feasible than wetland creation if the proper hydrology still exists today (Mitsch and Gosselink 2007). The existence of suitable wetland hydrological conditions (e.g. soils and water flow) saves time, effort, expense, and uncertainty when altering a site (Lin *et al.* 2006). If maps of the historic wetlands existed for the region of interest, the use of historical wetlands was considered a straight forward solution (Van Lonkhuyzen *et al.* 2004). Based on historical maps from the 16th century, Timár *et al.* (2008) concluded that historic marshlands coincided with the extent of current floodplains. Obtaining such maps, however, was generally considered difficult, so researchers often turned to other forms of historical data to infer where wetlands have existed in the past. O'Hara (2000) used data on abandoned channels, point bars and back swamps as indicators of wetlands in their model. These authors consider abandoned channels as the best location for potential wetlands because they were located at the lowest point of the local elevation and were inundated more frequently. O'Hara (2000) then ranked back swamps and point bar/valley trains as less suitable because they were at higher elevation. Other authors have located historical wetland locations based on the existence of peat soils and close proximity of water bodies (Palmeri and Trepel 2002).

In summary, the LULC that were found to be favourable for potential wetland sites include past or existing wetlands, low value agriculture, pasture, herbaceous, abandoned woodland, riparian, disturbed vegetation or bare ground. Criteria to determine their suitability included economic or ecological value, potential to support wetland function, and/or ability to protect other highly-valued LULC. LULC information was obtained from field surveys, aerial photography or Landsat imagery (Table 1). The expected classification accuracy of a LULC map for six classes or less should be >95% (McCoy 2005); however, an expected accuracy of 85% should be obtained if the researchers use the nine Level 1 LULC categories (urban, agriculture, rangeland, forest, water, wetland, barren land, tundra, and perennial ice and snow) as per Anderson *et al.* (1976). A caveat is that the classification accuracy of a LULC map will still vary depending on the spatial, spectral, radiometric and temporal resolution of the remote sensing imagery used (Russell *et al.* 1997).

The second indicator of runoff depth explored in the literature was soil characteristics which are considered integral to determining a potential wetland site. Mitsch and Gosselink (2007) identified soil order, series, permeability, texture, stratigraphy, and hydric/non-hydric soil discrimination as key indicators. In the McAllister *et al.* (2000) framework, soil texture was used to generate the CN values based on the soil's ability to allow surface water to permeate below the surface. Other researchers used soil texture, soil type, water-holding capacity in the determination of potential wetland sites (Diggory 2008; Lesta, Mauring, and Mander 2007; Mitsch and Gosselink 2007; Newbold 2005; Palmeri and Trepel 2002). Clay soils were prioritized as being the most suitable for hydrologic storage because they allow less percolation of water below the surface thus minimizing groundwater flow to already overflowing rivers (Newbold 2005; Lesta *et al.* 2007; Palmeri and Trepel 2002). In comparison, sandy soils were associated with more percolation of surface water which corresponded with subsequent water transport to already overflowing rivers during high precipitation events or snow melt.

The soil type chosen depended on the soil classification used. Moreno-Mateos *et al.* (2010) identified potential wetland sites based on the World Soil Classification system (Food and Agriculture Organization 2014). The authors ranked Fluvisol soils as best for potential wetland sites as these soils occurred in close proximity to streams and typically had high water tables (as long as they did not accumulate a lot of gravel sediment). Solonetzic soils were the next highest ranked soil because they were found in areas highly affected by salinization or sodification. The loss of structure caused by the salts made the soil less suitable for agriculture and increased their capacity for water storage. Other researchers that used the US or Canadian soil systems, suggested that peat soils and/or gleyed soils were suitably soil categories for potential wetland sites (Lesta *et al.* 2007; Moreno-Mateos *et al.* 2010; Diggory 2008).

A further criterion used to determine the soil suitability for potential wetland locations was if the soils were classified as hydric. Hydric soils, by definition, are appropriate for potential wetland sites since hydrologic conditions have existed at these locations in the past or present, or can be easily restored in the future (Diggory 2008; Mitsch and Gosselink 2007; Lin *et al.* 2006; White and Fennessy 2005). White and Fennessy (2005) used the presence of hydric soils as a constraint for wetland locations, using only those soil series that were classified as either hydric or containing hydric inclusions. Diggory (2008) further differentiated hydric soils by classifying them as water, Order 2, Order 3, wet spots, clay spots, and marsh spots. Order 2 hydric soils were derived from detailed hydric soil map units and Order 3 hydric soils were identified from soil complexes.

In summary, world system Fluvisols and Solonetzic soils, and peat or gleyed soils of the Canadian/US systems are appropriate for potential wetland sites, particularly hydric series of each soil. Authors did provide cautionary notes when using mapped soil data because they often lacked updated soil information in most regions and there has been significant soil alteration due to modern agricultural practices since the soils were last surveyed (Diggory 2008). To overcome these limitations, many studies used hydric soils in conjunction with other topographic indicators for the optimal siting of potential wetlands (Diggory 2008; White and Fennessy 2005). The hydric soils were ranked high or desirable for potential wetland sites and non-hydric soils were ranked very low or less desirable (O'Hara 2000; Van Lonkhuyzen *et al.* 2004; White and Fennessy 2005).

Once the appropriate LULC and soils were established for runoff potential, the input of precipitation is required for final calculations. One approach is to use precipitation amounts from direct contributions (e.g., spring rain) along with indirect contributions of stored water for future runoff when temperatures rise (e.g., snow accumulation in winter; October to May in the northern hemisphere). McAllister *et al.* (2000) used the average annual precipitation with LULC/Soil runoff conditions because the authors concluded this combination could effectively determine the runoff depth for a particular area. This approach will be used in the southern Manitoba study because it is effective, the average annual precipitation amounts are readily available from local weather stations, and it would allow for direct comparison to the USA Red River basin study.

Storage potential factors

McAllister *et al.* (2000) acknowledged a gap in the original framework for "wetland basin area per area of restored wetland", because they were unable to adequately map wetland basins. In our modified framework, we proposed combining runoff with a simplified, alternative term of "Storage Potential". Storage Potential incorporates gross drainage area versus effective drainage area. Gross drainage area is defined by Stitchling and Blackwell (1957) as the area enclosed by the topographic drainage divide. Effective drainage area, a subset of the gross drainage area, is defined as the area which was most likely to contribute to runoff in an average year (Stitchling and Blackwell 1957).

The closed depressions, which typified our study area in the past, are examples of closed lakes and PPR wetlands that do not contribute water into the basin system, thereby reducing the effective (contributing) drainage area relative to the gross drainage area. Since this effective-gross drainage area relationship effectively represents the hydrology in pothole or closed lake landscapes, this relationship should also provide a good indicator of how much a potential wetland could decrease the effective drainage area for the Red River. Geospatial data that are used to map the potential decrease in the effective drainage area include elevation, relief and soil moisture.

Digital elevation models (DEMs) were the most ubiquitous tools used to determine elevation and relief variables for hydrologic extent and function in studies on wetland restoration (Huang *et al.* 2010; Moreno-Mateos *et al.* 2010; Diggory 2008; Lin *et al.* 2005, 2006; McCauley and Jenkins 2005; Palmeri and Trepel 2002; O'Hara 2000; O'Neill *et al.* 1997; Russell *et al.* 1997). Table 2 presents the data commonly used by researchers when generating DEM products for identifying topographic depressions and other elevation indicators. In the USA, elevation data were often obtained from the U.S. Geological Survey (USGS) with topographic information extracted from DEMs, digital line graphs, digital raster graphics and digital orthophoto quadrangles. Other studies have obtained elevation data from the Shuttle Radar Topography Mission (SRTM) 90-m DEM data, National Elevation Data (NED) 10-m, 0.6-m elevation contours derived by photogrammetric methods using 1995 digital ortho-photography and survey data.

DEMs were used to generate elevation, slope, relief, and land position products. Hydrologic indicators, such as topographic depressions, wetness/saturation indices, or flow path of surface water, were derived from these products. Topographic depressions are areas in the landscape that are lower in elevation, surrounded by features at higher elevation. Depending on the soil type, depressions can have a surface outflow that is not sufficient to drain the area; there is a higher likelihood that any water entering the depression may be retained until it evaporates or groundwater seepage occurs, thus hydrologically sustaining

Table 2
Elevation data used to generate topographical indicators.

Data	Horizontal Resolution	Vertical accuracy	Author
Shuttle Radar Topography Mission (SRTM) DEM	90 m	10 m	Huang et al. 2010
DEM (not specified)	50 m		Palmeri and Trepel 2002
USGS 7.5-minute digital elevation models (Level 1 and level 2)	30 m	1 m (rms error of 7 m, no greater than 15 m)	Russell et al., 1997 McCauley and Jenkins 2005 O'Neill et al., 1997 Richardson and Gatti 1999
DEM (not specified)	20 m		Moreno-Mateos et al. 2010
USGS 1:24,000 digital line graph hypsography (1998)	10m		White and Fennessy 2005
USGS 1:24,000 quadrangle maps	10 m		O'Hara 2000
New York State Adirondack Park Agency DEM	10 m		Diggory 2008
USGS 7.5-minute quadrangle map (1946)	1.5 m		Van Lonkhuyzen et al., 2004
Derived by photogrammetric methods using 1995 digital orthophotography		0.6 m elevation contours	Van Lonkhuyzen et al., 2004
LiDAR data collected by an Optech Airborne Laser Terrain Mapper (ALTM) 3100 sensor	0.50 x 0.57 m		Southee et al., 2012
Source not identified in paper - ground survey data			Palmeri and Trepel 2002

the wetland (Lin *et al.* 2006; McCauley and Jenkins 2005). Wetness/saturation indices were used as a relative measure of saturation (wetness) of an area as compared to its surrounding landscape (Lin *et al.* 2006). Surface slope, upslope drainage area, and, in some cases, soil transmissivity have been used to define a wetness/saturation index (Russell *et al.* 1997; O'Neill *et al.* 1997; O'Hara 2000; White and Fennessy 2005; Newbold 2005; Diggory 2008). A shortcoming of wetness/saturation indices is that they were only a measure of potential wetness and they do not provide seasonal or annual variability in soil moisture content.

The effectiveness of topographic data to classify the location of depressions or produce a wetness/saturation index was found to be limited by the spatial resolution of the DEM data from which they were derived (Palmeri and Trepel 2002; O'Hara 2000; Russell *et al.* 1997). Digital elevation models were commonly available at scales ranging from coarse resolution SRTM-90 m data (Huang *et al.* 2010), medium resolution SRTM-30 m data (O'Neill *et al.* 1997), 20 m data (Moreno-Mateos *et al.* 2010), and finer resolution 10 m DEM data (Diggory, 2008). The ability to predict flow pathways was directly proportional to the relative relief of the area and higher spatial resolution of the DEMs. McCauley and Jenkins (2005) found that a 30 m DEM generated more false positives (i.e., non-depressions) than those found from a 10 m DEM data. They concluded that a DEM resolution of 10 m or finer was required to accurately identify depressional wetland sites and a higher accuracy was only achieved where significant topographic relief was present. Similarly, Moreno-Meteos *et al.* (2010) found that, for regions with small catchments or low relief, 3 m spatial resolution data were required to adequately generate topographic products for identifying potential wetland sites.

In addition to extracting elevation and topographic information from DEMs, this information was also derived from interferometric RADAR images. Interferometry is a method of using two remote sensing Synthetic Aperture RADAR (SAR) images, taken with a time delay and cross-track parallax, to infer height information (e.g. elevation). The accuracy of DEM products derived by SAR interferometry was dependent on the configuration of the satellites used to acquire the images, with 3-20 m accuracy range generated (Toutin and Gray 2000). However, SAR-extracted DEM data were unreliable in regions with significant vegetation or moisture variability making interferometry unacceptable for wetland site selection.

Most of the data available for generating elevation (e.g., SRTM, NED, RADAR) did not meet the 3 m spatial resolution that would be required to model depressions in low relief, lake basin physiographic regions (Moreno-Meteos *et al.* 2010). The only two methods that could capture subtle changes in relief were ground survey or from LiDAR data. Ground survey is considered to be labour-intensive and expensive. Today, Light Detection and Ranging (LiDAR) is the data of choice for generating DEM information because of the high spatial resolution and high vertical accuracy. Notebaert, *et al.* (2009) compared products derived from regional LiDAR imagery, ground surveyed data and historical elevation data to assess their suitability for mapping low relief (e.g., a few centimetres to 1 m) along rivers in Belgium. In their study, Notebaert, et al. (2009) concluded that LiDAR data (1 m spatial resolution raster data with 5-8 points/m^2) had the best detection capabilities for low relief regions due to resolution and sampling density options. Ditches and small depressions with horizontal dimensions of the same order of magnitude as the LiDAR ground resolution data were easily detected. Also, larger landforms with relatively small height differences, such as levees, were clearly visible. However, finer spatial resolutions did not give the best results. A comparison between 2 m, 5 m, 10 m and 20 m resolution LiDAR datasets determined that products derived from a 5 m resolution dataset was found to have the best correlation with in situ data in a forested environment (Southee *et al.* 2012).

Using elevation data, wetness indices or flow path models used to generate topographically-derived soil moisture are limited because they identify potential wetness rather than estimates of surface soil moisture at a particular period of time. By estimating surface soil moisture, the seasonal and annual variability contribution to wetland functions can be incorporated into the analysis. Surface soil moisture maps can also be used to confirm flow path models and understand the impact of artificial drainage on the flow path. Radio Detection And Ranging (RADAR) data acquired from satellite platforms has been used to map surface soil moisture (McNairn *et al.* 1996). RADAR backscatter is a response to the target structure and dielectric constant (permittivity and conductivity), with dielectric constant highly dependent on the moisture content of soils or plants (McNairn *et al.* 1996). The measurement of surface soil moisture using RADAR data has been shown to be useful in low relief areas or deranged drainage systems due to glaciation where the lowest elevation was not always the wettest (Devito *et al.* 2005; Sass and Creed 2008). The measurement of surface soil moisture using RADAR accounts for unknown or uncertainty in contributing variables beyond topography (used in wetness indices).

To obtain a usable estimation of soil moisture, the surface roughness or structure must also be taken into account (McNairn *et al.* 1996). According to Ulaby *et al.* (1981), if surface roughness conditions are unknown, the detection of surface soil moisture using RADAR data requires that remote sensing system parameters must be carefully chosen to minimize the effect of the surface roughness while maintaining strong sensitivity to the moisture content. These RADAR system parameters include a steep angle of incidence (~ 10°), a frequency in the range of 4–5 GHz and a cross-polarization (HV) configuration (Ulaby, Moore, and Fung 1981). The cross-polarization criterion was based on data collected in a region with only volcanic soils (Ulaby *et al.* 1981). Although data collected at the ideal incidence angles of approximately 10° are not available with satellite sensors, satellite-based data with incidence angles of <30° and co-polarization ratio have been found to minimize surface roughness while optimizing soil moisture detection (McNairn *et al.* 1996). Recent studies conducted in the agricultural regions of southern Manitoba and Ontario identified co-polarization (HH, VV) images as having the highest correlation with in situ soil

moisture measurements (Sokol *et al.* 2002; Sokol, McNairn, and Pultz 2004).

Surface soil moisture is best detected on bare soils, defined as soils with <15cm of vegetation (Ulaby, Dubois, and van Zyl 1996) or in landscapes with homogeneous vegetation cover. Filho et al., (1995) found that in homogeneous pasture fields, in situ soil moisture data collected within 3 hours of the acquisition of the ERS-1 image resulted in a high correlation between the VV backscatter and average soil moisture content. Although data collected at the ideal incidence angles of <20° are not available with satellite sensors, satellite-based data with incidence angles of <30˚ and co-polarization images have been found to minimize surface roughness while optimizing soil moisture detection (McNairn *et al.* 1996). McNairn *et al.* (1996) also noted that the use of RADARSAT-2 HH co-polarization data allowed for comparison with historical data acquired using RADARSAT-1. If in situ soil moisture data is not collected coincident with RADAR acquisition, backscatter values associated with varying soil moisture conditions can be estimated based on graphs published by Ulaby *et al.* (1996).

To conclude this section, there was a gap component in framework used by McAllister *et al.* (2000) for calculating decrease in downstream drainage volume per area of restored wetlands. This work proposes to address that gap using Runoff Potential and Storage Potential; storage potential is represented by surface soil moisture indicator, measured with RADAR remote sensing data (<30°, co-polarization image, bare or homogeneous vegetation cover). Although many studies used DEMs for determining potential wetness indices, the use of RADAR-generated surface soil moisture allows for seasonal and annual variability to be incorporated into the model. Regions with high surface soil moisture represent a high Storage Potential. The landscape features that have high surface soil moisture or store water, such as pot holes or depressions, will slowly lose the water through evaporation. This means that potholes and closed lakes do not contribute to the basin system thus reducing the effective drainage area to the gross drainage area ratio. RADAR data is also available for a larger portion of southern Manitoba thus allowing this framework to be applied in other basins in the province.

Drainage density factors

The final component of the framework is the drainage density relative to the area of the proposed wetland; drainage density incorporates hydrologic and/or LULC adjacency indicators. The density and proximity of drainage determines the "marginal decrease in total downstream flood volume per decrease in drainage volume" (McAllister *et al.* 2000). The purpose of this hydrologic adjacency indicator is to optimize the reduction in downstream flood volume based on the drainage volume that was being directly introduced. LULC adjacency was commonly determined using ranking, density or weighted measure of the surrounding land-cover as it contributes to a potential wetland site (Moreno-Mateos *et al.* 2010; Palmeri and Trepel 2002; Van Lonkhuyzen *et al.* 2004; Russell *et al.* 1997). For example, LULC adjacency was evaluated based on proximity to seed sources (for ecology), roads, public lands, streams and open water, or size of area. This article focussed on proximity to streams, channel density and size of area as these indicators most improved hydrologic functioning.

The proximity to streams increases the likelihood that a surrounding area will hydrologically support a wetland, which in turn, lowers the implementation costs (Palmeri and Trepel 2002; Moreno-Mateos *et al.* 2010). In addition, a wetland site that was located in close proximity to a stream was more likely to attenuate water during a flood year, thus slowing or moderating the flooding downstream (McAllister *et al.* 2000). Van Lonkhuyzen *et al.* (2004) found that wetland sites located within 6 m of local depressions and 15 m of water bodies and streams were best for hydrologic function of wetlands.

In addition to stream proximity, stream density was identified as a governing factor to optimize hydrological function of wetlands (McAllister *et al.* 2000). As stream density increased, the probability that the interception of runoff by wetlands also increased; this relationship occurred in both natural streams and artificial drainage channels. However, Palmeri and Trepel (2002) found that existence of artificial drainage limited the ability to estimate discharge compared to natural drainage systems. In their study, the estimation of discharge in a catchment model using a 50 m DEM was compared to the river network and basin maps derived from aerial photographs and large scale maps to verify discharge. Palmeri and Trepel (2002) concluded that the spatial and spectral resolution of the DEM data input into the model appears to have a significant impact on reducing accuracy estimates of runoff interception by artificial drainage. Researchers used stream length per unit area to estimate stream density and a buffer zone of these streams to estimate stream proximity (Van Lonkhuyzen *et al.* 2004; Palmeri and Trepel 2002; Moreno-Mateos *et al.* 2010; McAllister *et al.* 2000). Data were obtained from remote sensing imagery and/or digital hydrologic data, for example, airphoto interpretation of 1995 digital orthography (Van Lonkhuyzen *et al.* 2004), 50 m DEM with aerial photographs with knowledge of water pumping or other anthropogenic activity (Palmeri and Trepel 2002), field observations (Moreno-Mateos *et al.* 2010) or EPA WATER Reach File (USEPA1994), and 1992 national resource inventory (USDA 1994; McAllister *et al.* 2000).

The second term needed to estimate the drainage density indicator, beyond density and proximity, is the size of the wetland area required for effective hydrologic function; the wetland must be large enough to attenuate a flood wave (Mitsch and Gosselink 2007). Adequate land area for wetland functions has been roughly calculated based on the discharge into a potential site, retention time and depth (Palmeri and Trepel 2002). Calculating the required versus available area was found to be effective in determining if sites were suitable on a water budget basis. In Russell *et al.* (1997), sites that were ranked high or medium for potential wetland locations using other indicators, were eliminated if the site area was smaller than 1 ha in size as these were deemed inadequate for hydrology functions. In another study, sites of approximately 2 ha were eliminated from the highly suit-

able category if the sites lacked contiguous areas (Van Lonkhuyen *et al.* 2004). As a result, these authors concluded that careful inspection of map results was required to make sure that only highly suitable, connected sites were included (Van Lonkhuyzen *et al.* 2004).

The drainage density component in the framework is determined based on the potential wetland sites' ability to attenuate flood water using proximity, density and size. These wetlands should be within 6 m of depressions or 15 m of lakes or streams to be hydrologically supported. They also should be located where there is high stream density which will increase the potential of runoff interception by the wetlands. Natural stream density is better estimated than artificial drainage networks, but this will be dependent on the resolutions of the geographic data used. Therefore, in regions such as southern Manitoba which have a significant number of artificial drainage, high spatial resolution data or large scale data should be used to adequately detect artificial drainage. The potential wetland sites should be a minimum of 1 ha in size and also contiguous (up to 2 ha in size) to be effective at hydrological function.

Discussion and conclusions

The long term goal of this project is to map potential wetland sites for flood mitigation along the Red River in southern Manitoba using geospatial indicators. This goal aids the province in meeting its IWRM strategy for a holistic approach to surface water management. The first objective accomplished to meet this goal, and the focus of this article, was to identify geospatial indicators for modelling potential wetland sites. To accomplish this objective, a literature review was conducted that built upon publications that were focused on the creation or restoration of wetlands for hydrologic functions; most articles were published after reviews by Mitsch and Gosselink (1993; 2007).

These indicators were reviewed within a framework developed for Red River flood management in North Dakota, South Dakota and Minnesota by McAllister *et al.* (2000). The four components and associated indicators required to determine the suitability of a potential wetland site are (a) Economics (cost of land); (b) Runoff (Land-Use/Land-Cover, soil characteristics and hydric soils, accumulated precipitation); (c) Storage Potential (elevation, soil moisture); and (d) Drainage Density (water networks).

The McAllister *et al.* (2000) framework is appropriate for our study because it includes both economic and hydrological indicators, it represented the indicators discussed in literature, it is mathematically robust, and it will allow for comparison between the Canadian and USA portions of the Red River basin. The framework was modified to include the use of Canadian and Manitoba data standards, and overcome a missing indicator (storage potential), acknowledged by McAllister *et al.* (2000). In southern Manitoba, most of the input geospatial data for this framework can be obtained for free (Table 3). The exceptions are the LiDAR or RADAR data which are required for runoff and storage potential modelling, specifically flow path or measuring soil moisture, respectively. Similar to McAllister *et al.* (2000), selection of geoindicators and choice of data selection are based on literature reviews, the characteristics of the landscape (e.g., low-relief) and data availability (e.g., standards, scale, resolution, national datasets).

One of the strengths of this framework is that it incorporates both economic and hydrologic indicators. Property value is an important part of the site selection, thus models developed for management purposes should include a form of cost-benefit analysis (Notebaert *et al.* 2009). The prevalence of a single land cover type, i.e., agriculture, within the study site will require the use of land assessment data as a model input. Although many studies do use LULC maps as a surrogate for cost of land, this method is not appropriate in regions with homogeneous LULC because land value estimates would lack subtle economic variability on a per-field basis. In this project, geospatial Provincial Land Assessment data (Table 3) is available for southern Manitoba with assessment of arable farmland (cost per square kilometre) calculated using sale value, soil productivity, location, drainage, topography and erosion. The total assessment, which includes both land and building assessment value, will be used to reduce the potential of land with structures being designated as suitable for wetlands (due to much greater costs associated with conversion to wetlands). Land assessed at a lower value will result in a higher ranking of this site for a potential wetland.

The next two components, Runoff Depth and Storage Potential, are used to estimate the decrease in drainage volume per acre of restored wetland. The Curve Number method provides an accurate and effective method of representing a combination of indicators found to be important in the literature including LULC, soil characteristic and precipitation. Curve Number requires the user to make a series of selections that are appropriate for their region of study including crop characteristics (small grain versus row crops), management (crop rotation), permanency of cover (harvested versus pasture), soil characteristics (type, hydric), vegetation cover (contoured versus straight row),

Table 3
Anticipated indicators and criteria to be used to identify optimal potential wetland locations.

Fulfilment of Framework	Primary Data Layer	Secondary Data Layers	Source of Data	File Name/ Description
Cost of Land	Land Assessment		Local Government (2012)	Tax parcels with assessment
Total Runoff Depth	Hydrologic Soil Group (CN)	Land-use/Land-cover	Landsat-8 (2013)	30m multi-spectral scenes
		Soil permeability	MLI (2002)	Provincial soil series dataset
	Precipitation		Government of Canada (2013)	Historic climate data (Emerson)
Storage Potential	Soil Moisture		RADARSAT-2 (2013)	SQ1 and FQ4 (standard and fine beam, quad polarized scenes); C-band
	Closed Depressions		International Water Institute (IWI) - Red River Basin Mapping Initiative	IWI Red River Basin Mapping 2008-2010 - LiDAR
		Land-use/Land-cover	Landsat-8 (2013)	30m multi-spectral scenes
Water networks	Stream/Channel Density		MLI	Stream and Channel Networks

and hydrologic condition (poor to good, proportion of row crops, soil moisture conditions).

The most ubiquitous method of generating a LULC map for runoff potential is to use Landsat satellite imagery (available for free) to discriminate between Level I categories (water, urban, agriculture, rangeland, barren, forest, and existing wetlands). An overall classification accuracy of 85% is expected for this map (Anderson *et al.* 1976). The agricultural LULC should be further classified into small grains, row crops and pasture fields (input criteria for CN) using multi-temporal images from different phonological stages. Other LULC Curve Number inputs are uniform for the entire study site, specifically crop rotation, straight row vegetation cover, and poor hydrologic conditions because of the high proportion of row crops. In our study, historic wetlands can also be included in the LULC classification as this information is available for southern Manitoba based on work by Hanuta (2001; 2006). Hanuta (2006) used the original Dominion Land Survey (DLS) township diagrams from the 1870s to characterize pre-settlement wetland locations for a significant portion of the Red River basin. In this work, Hanuta (2001) reconstructed and mapped wetland locations in 100 townships in southern Manitoba with wetlands representing 1,098 km^2 land area (Figure 1). Hanuta's map shows the spatial distribution of historic wetlands prior to extensive drainage (1871-1875) in southern Manitoba.

Soil type, permeability, texture and hydric characteristics can be obtained through provincial (soil series) and national Canadian (soil order) geospatial data available from Agriculture & Agri-Food Canada and Atlas of Canada, respectively. All of the soils within the Morris study site are Vertisolic which corresponds to high clay content; however, sand and fluvial-deltaic soils exists in other parts of southern Manitoba. Within the Vertosolic soil series data, the soils are categorized as being poorly drained and very poorly drained which corresponded to soil classifications of "C" and "D", respectively in the Curve Number selection (McAllister *et al.* 2000). Application of the framework outside of the Red River floodplain is expected to be more impacted by variation in soil type including Vertosolic, sand ridges left by glaciation or fluvial-deltaic soils. Since our study region is dominated by clays, the use of hydric soils will be used to rank high suitability and non-hydric soils ranked very low suitability (O'Hara 2000; Van Lonkhuyzen *et al.* 2004; White and Fennessy 2005).

The landscape features (suitable LULC, row versus small grains, permanent versus harvested fields, hydric soils) determine how runoff will occur, but runoff potential also requires input of precipitation amounts expected for the study site. Average annual precipitation is considered to be acceptable for regional studies (McAllister *et al.* 2000), and this data can be obtained from the Emerson Auto Manitoba Weather Station (Station ID 48068).

Storage potential can be estimated using DEMs (e.g., from LiDAR data) but this provides only one storage potential value whereas measured surface soil moisture can provide seasonal and annual variability input for storage potential; however, both LiDAR and RADAR data contribution are at significant cost. In southern Manitoba, RADAR data can be used to estimate surface soil moisture and has the potential to cover a larger land area compared to the LiDAR elevation data, which is currently only available for pockets of Manitoba (e.g., LiDAR data available for the Red River floodplain but not for the Pembina Valley). Surface soil moisture estimates will be obtained from RADARSAT-2 HH image as the average backscatter from co-polarization images has the highest correlation with in situ soil moisture measurements in southern Manitoba (Sokol *et al.* 2002; Sokol *et al.* 2004). RADARSAT-2 images were acquired for the study site in June, July and August, 2013 using SQ1 beam (30 m; 18.4°-20.4° incidence angle range) through the SOAR program funded by the Canadian Space Agency and MDA. It would be preferential to have an image acquired earlier than June; however, the May image requested was not acquired because of user conflicts (e.g., Department of Defense or Flood Forecasting image requirements that have priority over our acquisition).

After the indicators for runoff and storage potential are determined, the CN method is used for calculation of runoff potential which combines these two indicators. These calculations will be done under the wettest of conditions, i.e., under both storm and melt conditions, where the ground is impervious to water because it is either saturated or frozen. The CN method was chosen because it incorporates more variability (row crops, land cover) for a region that is dominated by a single LULC, agriculture.

Stream/Channel Density is a simple and effective indicator to calculate the potential of reducing downstream flood volume. Within a GIS software environment, the density of hydrologic features are simple to produce and this indicator is only limited by the accuracy of the hydrologic data available. The scale of the hydrology data is important in our study as southern Manitoba has a significant number of artificial drainage requiring large scale data. Drainage density estimations will use stream density and proximity as well as size of wetland to determine adequate hydrological functioning sites. Sites that have a higher density of streams and closer to streams (<15m) in the region will be more suitable as there is a higher probability that runoff will be attenuated by a wetland. Potential sites must also be at least 1 ha in size, and contiguous if less than 2 ha in size.

Each term (cost of land, runoff potential, stream density) will be combined using the equations described in McAllister *et al.* (2000). The resulting map will be evaluated to determine what area is required to reduce 100-year flood peak flow by 20% as per RRBC (2005). This will determine how much land area in the study site will be required to attenuate flood waters and hopefully enough land area to make selection decision more flexible (e.g., so that individual land owners do not feel targeted). This 20% reduction of peak flow is economically feasible and under existing management conditions, can address uncertainty in future flood potential.

Once the final site selection map with potential wetland sites to mitigate 20% of floodwaters (100-year flood) near Morris is generated, the results will be compared to McAllister *et al.* (2000) map for the USA portion of the Red River basin. This will determine the global applicability of this framework when using different geospatial data (standards, scales, resolutions)

but in the same basin. In addition, a future step will be to apply this framework outside of the Red River floodplain to explore the potential of attenuating low frequency floods (e.g., 500 year floods) by increasing hydrologic storage capacity in the surrounding region.

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Biophysical characteristics of coastal vegetation in Bird Cove, Churchill, Manitoba

Adrian Werner
Department of Geography, University of Winnipeg

Charles Enns
Department of Geography, University of Winnipeg

Joni Storie
Department of Geography, University of Winnipeg

Samantha Fraser
Department of Geography, University of Winnipeg

Jeremy Sewell
Department of Geography, University of Winnipeg

Genevieve Berard
Department of Geography, University of Winnipeg

Improving the ability to assess the change in shoreline position is needed for measuring annual sea level variability which is an important input for climate change and hydrology models. This research proposes the use of the coastal vegetation transition zone, called the homogeneous-heterogeneous vegetation line in this article, as a biophysically-sound geocoding feature for multi-temporal analysis in non-human settlement regions. It is proposed that the homogeneous-heterogeneous vegetation line is more stable from year to year compared to other coastal features (e.g., high tide, erosion cliffs, deposition beaches) and this surface feature can be detected using the temporal resolutions available with many remote sensing systems. This article presents the results of the first stage of the project, the identification of Bird Cove's vegetation communities and the relationship between biophysical landscape characteristics with the observed changes in coastal homogeneous-heterogeneous vegetation. As a result of data collection, the Bird Cove region was found to have two vegetation communities, salt marsh and strand communities. Results showed that the vegetation transition boundary observed in the field was related to changes in plant species within the vegetation communities as well as the statistically significant differences in percent cover and elevation. Other biophysical variables, such as soil salinity or depth of A horizon, were significantly different for some sites but not others. This research concluded that the homogeneous-heterogeneous vegetation line was representative of some coastal biophysical landscape variables in this region. The next stage is to explore the use of this homogeneous-heterogeneous line as a feature for geocoding multi-temporal remote sensed images for shoreline change detection.

Keywords: wetlands, coastal vegetation, heterogeneous vegetation, remote sensing, subarctic

Correspondence to: Joni Storie, Department of Geography, University of Winnipeg, Winnipeg, MB R3B 2E9. Email/*j.storie@uwinnipeg.ca*

Introduction

It has been estimated that summer sea ice extent has declined by 15-20% in the past 30 years due climate change (Hassol 2004). This change has been observed to be most dramatic in the subarctic, with some models predicting that sea ice will be gone from Hudson Bay by the middle of the 21st century (Gough and Wolfe 2001; Derocher *et al.* 2004). The Intergovernmental Panel on Climate Change (IPCC 2007) further estimates that there has been a larger than average decrease in sea ice in coastal regions (between 22% and 33%). In addition to changes in sea ice extent, the break-up of the annual sea ice now occurs approximately 2.5 weeks earlier that it did 30 years ago in western Hudson Bay (Stirling *et al.* 1999; Derocher *et al.* 2004; Serreze and Francis 2006; Walsh 2008). One of the significant impacts of changing spatial and temporal sea ice is the northwest passage of Canada has become fully navigable in 2007, the first time in recorded history (Cressey 2007). The loss of sea ice, both spatially and temporally, in Hudson Bay is predicted to cause an increase in land temperature from -7.5°C to -2.4°C, a 42% reduction in permafrost distribution (Gough and Wolfe 2001) and greater rates of coastline erosion (Beaulieu and Allard 2003).

Improvements to longitudinal studies are required to more accurately monitor the environmental response of the Hudson Bay region to climate change. When quantifying shoreline position, many longitudinal studies have used remotely sensed images to monitor change over the last forty years. The change detection of shoreline position requires multi-temporal images to be accurately geocoded with each other. In human settlement areas, this is a relatively easy task to do because of the number of stable, detectable features to use for geocoding (e.g., roads, trails, airport runways). However, detecting stable features in regions with little or no human settlement evidence on the landscape makes this a challenging task. When detecting changes in shoreline position for all of coastal Hudson Bay, a region which has little to no human settlement patterns evident on the landscape, it is challenging to accurately detect stable features for geocoding multi-temporal images (Boak and Turner 2005; Pajak and Leatherman 2002). Without consistency and relative stability of features for geocoding, there are significant locational errors when estimating shoreline position over time and this reduces the accuracy of sea ice extent estimates.

This article presents the results of the first step of a larger project to use homogeneous-heterogeneous vegetation as a detectable, stable feature for geocoding remotely sensed images to improve detection of shoreline position for monitoring change. Subarctic coastal vegetation has a short growing season (June to September) and as a result, the distribution and composition of vegetation is assumed to change little from year to year. This makes coastal vegetation more stable than geomorphic shoreline (which changes year to year) and the temporal resolution of satellite sensors (e.g., Landsat every 16 days) is appropriate for the detection of homogeneous-heterogeneous vegetation.

The goal of this research was to validate observed changes in vegetation cover from the homogeneous to the heterogeneous zone in Bird Cove, Hudson Bay. To meet this goal, the first objective was to create a vegetation classification scheme based on in situ coastal vegetation data where the transition between homogeneous and heterogeneous vegetation cover was observed. The second objective was to independently validate the observed changes in vegetation cover using biophysical variables (e.g., elevation, salinity, depth of A horizon, grain size and plant area index). If differences in biophysical variable for the two zones were found to be statistically significant, it would confirm that observed difference in homogeneous-heterogeneous vegetation does objectively exist and that it is representative of landscape conditions. If the change in vegetation cover is validated, the next step of the project (future manuscript) is to detect the changes in heterogeneous and homogeneous cover using remotely sensed data.

Background

The detection of shoreline position is important for estimates of sea ice extent which contributes to climate and hydrology models. However, accurately estimating the shoreline position along Hudson Bay is significantly complicated by four factors: sea level rise, isostatic rebound, permafrost distribution, and change in deposition and erosion features. From 1993 to 2009, the estimated mean rate of sea level rise was between 2 to 3.3 mm/year, and this is projected to accelerate over the next century (Douglas and Peltier 2002; Nicholls and Cazenave 2010). Currently, thermal expansion of the ocean due to warming temperatures accounts for an estimated 30% of global mean sea level change (Nicholls and Cazenave 2010). However, the sea level rise due to ice melt and thermal expansion is counteracted by land isostatic rebound which is approximately 1 m/century rise in the Hudson Bay region (Ritchie 1957; Johnson *et al.* 1984).

These counteracting forces that impact estimation of sea level are further complicated by changing permafrost distribution because of climate change, and changing shoreline deposition and erosional features as a result of annual sea ice variability and river discharge events (Pajak and Leatherman 2002; Beaulieu and Allard 2003). Near Churchill, spring flood events from the Churchill River and Nelson River contribute 43% and 18%, respectively, to the annual fluctuations in sea level (Gough and Robinson 2000). Furthermore, changes in sea ice thickness and distribution of permafrost are expected to cause dramatic changes in the stability of slopes, coastal erosion rates, vegetation distribution, and wildlife habitat, in terrestrial and marine ecosystems (Rouse *et al.* 1997; Ford and Smit 2004).

Since the Hudson Bay shoreline position is impacted so significantly by coincident and counteracting forces, (e.g., sea level rise, isostatic rebound, permafrost distribution, and changing depositional and erosional features), more accurate estimates of the shoreline position are needed to better understand the impact of climate change in this region. Change detection of shoreline position requires the use of stable features for geocoding that can also be detected using the resolutions of remotely sensed images (e.g., temporal, spatial, spectral and radiometric). Although this is a relatively easy task in urban environments, it is chal-

lenging to find stable, detectable features in regions with little or no human settlement patterns. These patterns need to be evident on the landscape and be detectable at the spatial, spectral and temporal scale of remote sensing systems designed for region or synoptic mapping.

Geospatial data and tools, such as GIS and remote sensing, have shown promise for mapping shorelines susceptible to slow erosion processes, rising water levels, and changes in subarctic vegetation composition (Stow *et al.* 2004; Ahmad and Lakhan 2012). Today, multi-temporal satellite images are used to map surface features for monitoring long-term coastal behaviour (Maiti and Bhattacharya 2011). However, there are challenges to mapping shoreline position over time due to the dynamic nature of the boundary between land and water, as well as systematic requirements of satellite-based image collection (Boak and Turner 2005; Maiti and Bhattacharya 2011).

Since shoreline position is challenging to detect, the use of indicators of shoreline locations are used in mapping. Two shoreline indicators used to map shoreline position are High Water Line (HWL) and Mean High Water (MHW). HWL is a feature that is visibly discernible in remote sensing imagery while MHW represents the intersection of a tidal datum with the coastal profile (Boak and Turner 2005). When researchers attempted to establish a rate of change for shoreline position to predict future shoreline positions, there was a significant degree of uncertainty in the precise timing of the water surface level (e.g., HWL, MHW) due to tides, mismatch of timing between tide and image collection, and image geometry errors (Li *et al.* 2001). In addition, very few images are available to monitor tide at a singular height, i.e. HWL, which is required for meaningful change detection comparison (Ahmad and Lakhan 2012).

Therefore, alternative indicators of shoreline position are required (Pajak and Leatherman 2002; Beaulieu and Allard 2003; Boak and Turner 2005). The proposed solution is to use a shoreline indicator that is seasonally and annually stable so shoreline advancement or retreat can be more precisely mapped and monitored. This indicator must also be observable over a period of several years or decades using remotely sensed images. This feature must be detectable on the surface and representative of other biophysical characteristics of that landscape. A landscape is considered an integration of climate, rock, soil, vegetation, fauna, water, and anthropogenic features (Zonneveld 1979; Schroevers 1983). However, not all of the landscape features can be detected using remotely sensed imagery because satellite systems can only 'see' the surface of the Earth. Thus, vegetation is often used in remote sensing research as it is often found to be representative of changes in landscape ecological properties (Schmidt *et al.* 2004). For the purposes of this research, we propose the use of the homogeneous-heterogeneous vegetation line as a stable feature which may be detected using remotely sensed imagery. This vegetation transition, if detectable, can be used as a feature for geocoding multi-temporal images and may also be shown to be a proxy for changes in other landscape characteristics (Boak and Turner 2005).

The homogeneous-heterogeneous vegetation line is defined as the decrease in vegetation percent cover from continuous vegetation (100% cover) to discontinuous vegetation (<90% cover) as observed in the field. The terms homogeneous and heterogeneous vegetation come from remote sensing literature (Bartlett and Klemas,1980; Curran 1980; Asner and Heidebrecht 2002). Once the homogeneous-heterogeneous vegetation change was observed in the field, plant species and biophysical data were collected in each vegetation zone to independently validate the observed changes in vegetation cover. The advantages of the homogeneous-heterogeneous vegetation line are that it often represents landscape ecological properties (Schmidt *et al.* 2004); surface vegetation can be detected using remotely sensed imagery; the temporal resolution of remote sensing orbits is appropriate for mapping vegetation; and it represents a relatively stable geocoding feature compared to annually changing geomorphic shoreline features.

Study site

Figure 1 shows the location of Bird Cove study site which is located in the Hudson Bay Lowlands near Churchill, Manitoba (58° 47`N., 94° 11`W). This site was chosen because it represents the interface between the Arctic tundra, boreal forest and Arctic marine biomes. It has approximately 400 different native vascular plants (Johnson *et al.* 1987) that represent seventeen vegetation communities found in this region (e.g., strand, salt marsh, open dune, stable dunes, damp dune hollows, sandy pools, lichen-heath, ledge and crevice, white spruce scrub, thicket, white spruce forest, ice ridge, hummocky bog and muskeg, black spruce-larch, freshwater meadow-marsh, sedge meadow, and willow-bog birch). The Hudson Bay Lowland region is underlain by calcareous Paleozoic limestone and dolomite, both considered soft rock with 3 to 4.5 values on the Moh's hardness scale, are significantly altered by annual sea ice advance and retreat, and seasonal storms (Ritchie 1957; Johnson *et al.* 1987).

This study site exists within "polar bear alley" so the four sites were chosen based on their proximity to road/track access which allowed a safety-retreat vehicle to be located nearby. The Bird Cove site is commonly used by Churchill Northern Studies Centre (CNSC) researchers, thus this project is contributing to the overall knowledge of the physical landscape of this area. In Figure 1, Site 3 appears to be floating in Hudson Bay. This is a result of the accuracy of the GPS unit (+/-10m) but also the accuracy of the shoreline position on the basemap. This further emphasizes the need for more precise mapping of shoreline position as input into models.

Methods

The biophysical variables collected in the field were chosen based on an understanding of the coastal environment and the ecological literature on the Hudson Bay Lowlands (McClure 1943; Ritchie 1957; Kershaw 1976; Johnson *et al.* 1987; Houle 1996; Imbert and Houle 2000; Brook 2001; Gagne and Houle 2002). In addition to collecting plant species to identify vegeta-

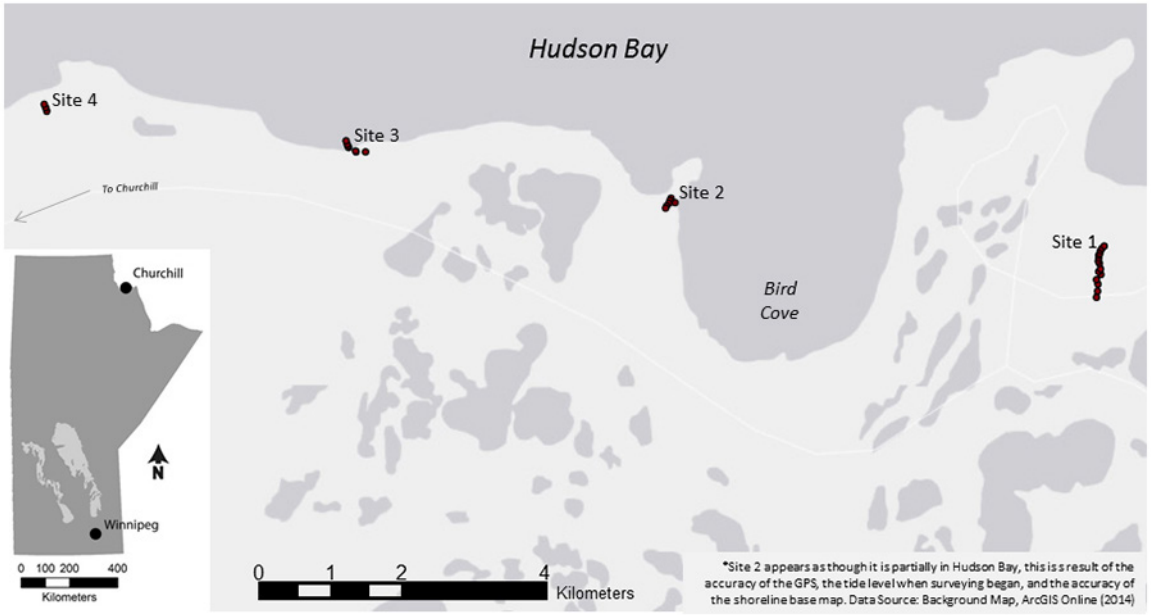

Figure 1
Location of Bird Cove test site and transects for in situ data collection, east of Churchill, Manitoba on Hudson Bay. (Map data: ©2013 Esri, DeLorme, NAVTEQ, survey data courtesy of the authors)

tion communities (Johnson *et al.* 1987), the location and biophysical variables collected included: geographic location, elevation, soil type, A horizon depth, soil salinity, sediment grain size and Plant Area Index (PAI). Table 1 provides a list of these variables along with a summary of the collection procedures for each variable. For discussion purposes, only Sites 1 (salt marsh) and 3 (strand community) were included in this article.

In another study, homogeneous and heterogeneous vegetation was found to be most significantly different in August, still statistically separated in July but not significantly different in June for the Bird Cove region (Berard 2014, unpublished). Therefore, field data were collected in late August 2012. Transects were used to map each of the four sites to represent the transition from homogeneous to heterogeneous vegetation cover. All of the four transects terminated at the high water line (fucus line), and were started in close proximity to a road for safety and access. The transects varied in length from 202 m to 765 m with a maximum elevation of 9 m asl.

Stratified random sampling designs were employed for the collection of field data using two methods, one for the homogeneous zone and a second for the heterogeneous one. The start of these transects were selected at random and were located at least 20 m from the road or trail (Figure 1). In the zone of homogeneous vegetation, plots of 10 m x 10 m plots were sampled at least 15 m apart with the geographic coordinates of the southwest corner recorded using Garmin eTrex GPS units (horizontal accuracy +/- 10m). This level of locational accuracy was deemed acceptable because this research explored the relationship between the vegetation transition and underlying biophysical features collected at the same time. There were a total of 19 plots sampled within the homogeneous vegetation zone.

When the change in vegetation cover from homogeneous to heterogeneous was observed, the sampling design was altered to better represent the change in vegetation. Like the homogeneous zone, the heterogeneous zone was sampled in 10 m x 10 m plots; however, the plots were sampled side by side, i.e., no distance between the plots. The continuous sampling of data in the heterogeneous zone was done to best represent the narrow zone of heterogeneous vegetation and the gradation from 90% cover at the transition line to 0% cover as we approached

Table 1
Data collection methods used for biophysical variables.

	Vegetation Community	Elevation	Salinity	Depth of A Horizon	Soil Great Group	Min and Max Grain Size	Biomass (Miller)
Unit of Measure	n/a	m asl	mmhos/cm	cm	n/a	mm	n/a
Data Scale	Nominal	Interval	Ratio	Ratio	Nominal	Ordinal	Ratio
Method of collection	Visual classification from Johnson (1987)	From DEM	1:2 Extract method	Rapid Core and Ruler	Visually using Canadian System of Classification	Visually	CanEYE software
n (transect 1)	5	15	8	10	10	12	120
n (transect 3)	2	8	7	8	10	8	64

Figure 2
Homogeneous vegetation cover (left) and heterogeneous vegetation cover (right).

the shoreline. There were 13 plots sampled in the heterogeneous zone.

The sampling design for plant identification and biophysical characteristics was the same in both zones. Within each plot, samples of all plant species were collected and identified later at the CNSC. Plant species were aggregated into vegetation communities using archetypal species outlined in Johnson et al. (1987). A soil core was taken at a random location within each plot which was used to identify the A horizon of the soil (extracted from the centre of the core) and subsequent soil salinity analysis was done at the University of Winnipeg. The soil great group was identified using soil maps and observed A horizon depth and texture of rapid core samples. Minimum and maximum grain sizes within the soil core were recorded based on their relative size using class boundaries defined by Scott (2010).

Hemispherical photographs were taken in the field to provide measures for Plant Area Index (PAI) values. The hemispherical photographs were taken using a Canon EOS60D camera with a Sigma 10mm fisheye lens. The photographs were sampled using a random walk method at Site 1, and this method was slightly modified for the remaining three sites in order to collect representative samples of plant colour (e.g., green and red) which is evident in late August in this area. To calculate PAI, we followed the standard protocol by collecting eight hemispherical photographs within each plot. Once back in the lab, the eight photographs for each plot were placed into a single file folder as per the CanEYE software requirements. CanEYE software was then used to calculate the average Miller's PAI coefficient for biomass and percent cover for each plot.

The elevation of each plot was determined using a digital elevation model (DEM) obtained from Geobase (30 m spatial resolution; vertical resolution +/- 1 m). The plot locations collected in the field were imported into ArcGIS and overlaid onto the DEM to extract elevation data for each 10 m x 10 m plot.

A database of observed and measured in situ data was created which allowed for the vegetation schema representative of the plant species collected to be developed. The vegetation characteristics, biophysical characteristics and the position of the visible homogeneous-heterogeneous transition were graphed to assist with visualization (Figures 3 and 4). In addition to observing changes in vegetation cover and biophysical characteristics, tests of difference for interval/ratio data were evaluated using a t-test ($p = 0.95$) while ordinal data differences were evaluated using a two sample Kolmogorov-Smirnov test.

Results

Site 1 was identified as a salt marsh community while Sites 2, 3, and 4 were identified strand vegetation communities. Salt marsh communities are generally flat, exist on sand or clay, are regularly flooded by tides, and classified into three zones based on the length of tidal inundation and the age of the land where the salt marsh community exists (McClure 1943; Kershaw 1976; Johnson *et al.* 1987). Strand communities occur from low tide to just above high tide on sandy beach areas and are dominated by Honckenya peploides (McClure 1943; Johnson *et al.* 1987; Laliberté and Payette 2008). Dominant plant types included low shrubs, forbs, graminoids, and nonvascular species.

In the course of data collection of plant species to represent vegetation communities, the boundary between homogeneous cover (100% cover) and heterogeneous (<90% cover with bare soil, clay or stone) vegetation was observed in field. Representative photographs of these two zones of vegetation cover are shown in Figure 2. Changes in biophysical characteristics between the homogeneous and heterogeneous vegetation zones at Bird Cove can be seen in Figures 3 and 4. Sites 1 and 3 were chosen for this article as these transects were best representative of the changes observed. Sites 2 and 4 are the smaller transects, i.e., smaller distance between the road and the shoreline, and as result they had fewer plots sampled. However, based on a qualitative comparison, these two sites have similar transitional characteristics as Site 3 (all strand communities).

The observed homogeneous-heterogeneous vegetation cover transition was shown to coincide with a change in species composition within the vegetation community, especially at Site

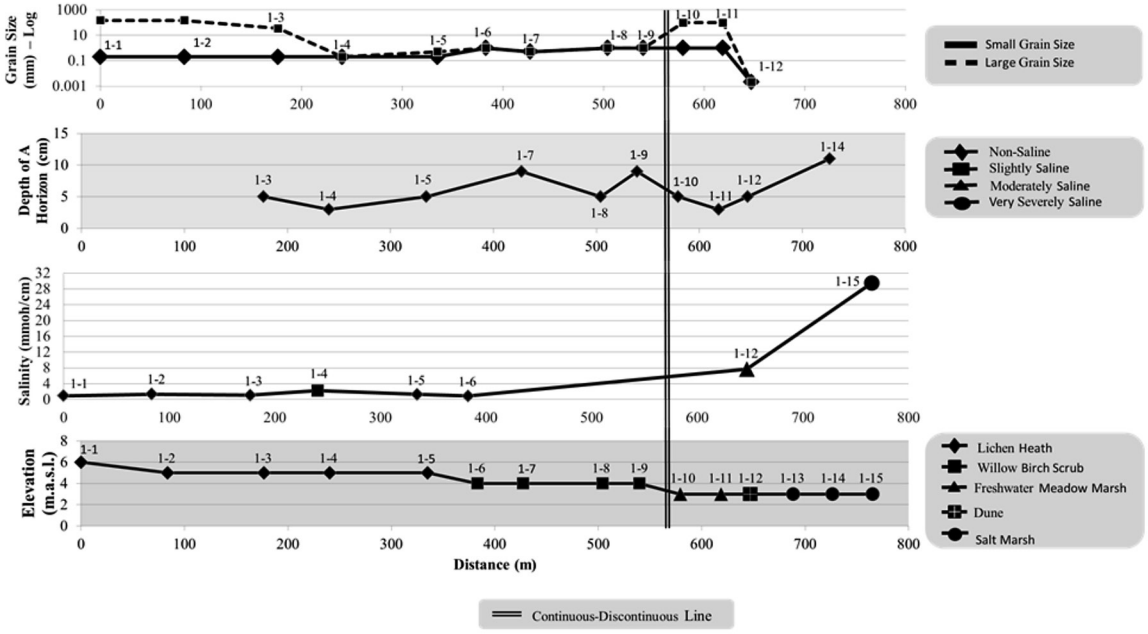

Figure 3
Transect 1 biophysical characteristics of the homogeneous and heterogeneous vegetation zones (grain size, depth of A horizon, salinity, and elevation).

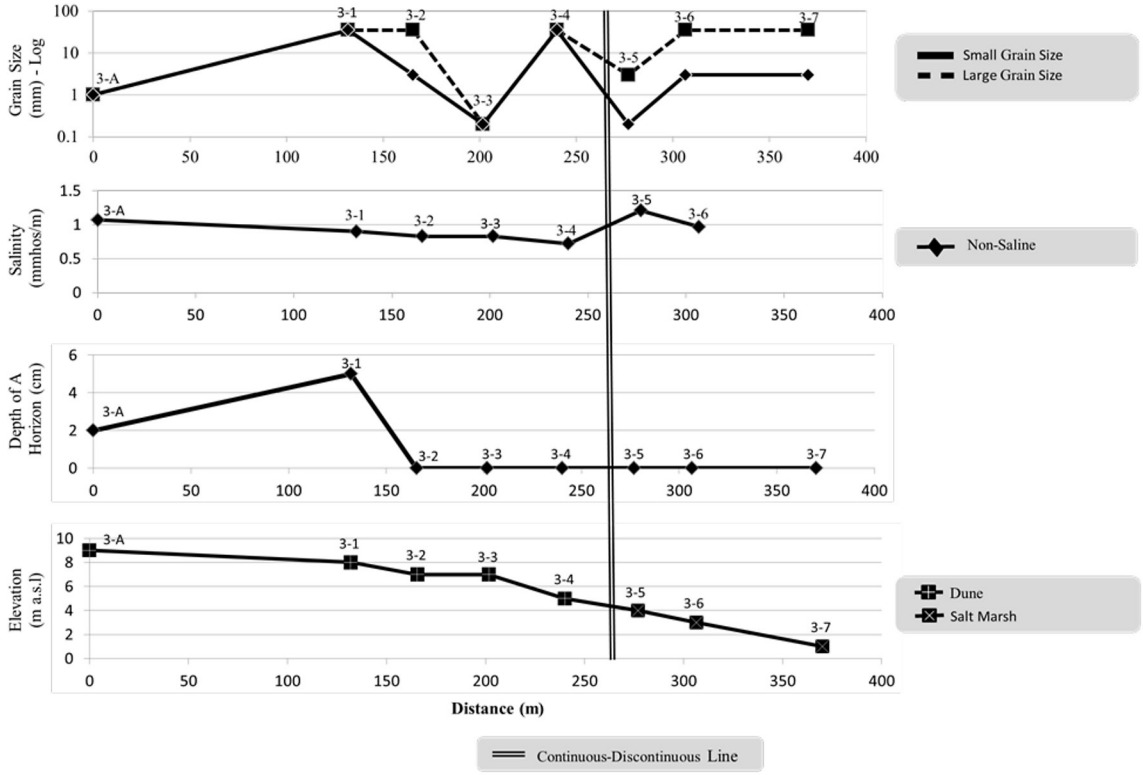

Figure 4
Transect 3 biophysical characteristics of the homogenous and heterogeneous vegetation zones (grain size, depth of A horizon, salinity, and elevation).

1. The transition between the two zones was easily located in the field because both an abrupt change in species composition and a corresponding reduction in vegetation percent cover were both observed. In Site 1, which is salt marsh community, the vegetation cover was reduced by 33% from the homogeneous to heterogeneous zone; the reduction in vegetation cover was 10.5% at Site 3 (strand community).

Biomass (PAI) values also changed from homogeneous to heterogeneous cover along transects at each of the sites (Figures 5 and 6). At the start of Transect 1, there was less biomass (lower PAI values) which was found to be associated with the dominance of lichen. A drop in biomass (decrease in PAI values) at Plot 1-6 was found to be related to an area that was very wet and lacked vegetation cover. The rise biomass (higher PAI values) that was observed in the middle of Transect 1 was found to be associated with willow-birch scrub and freshwater meadow marsh communities which consists almost entirely of vascular plants. The drop in biomass (lower PAI values) at the end of Transect 1 (after Plot 1-9) represents the transition between willow-birch scrub and salt marsh where there were small islands of willow (Salix sp) and sedges (carex sp) intermixed with bare ground.

There was no difference found in the depth of the A horizon between the homogeneous and heterogeneous vegetation zones for Transect 1, using either visual observations or statistical tests, but there was a difference found for Transect 3 (Figures 3 and 4; Tables 2 and 3). Data collected for Site 3 were found to display horizon development in soil profiles while no horizon development was observed in Site 1 soil profiles. However, there were significant differences found in soil salinity characteristics between the homogeneous and heterogeneous vegetation zones in Transect 1 but not for Transect 3. Soil salinity increased from slightly saline to moderately saline immediately before the homogeneous-heterogeneous transition line in Transect 1, which corresponds with results found in other studies (Smith *et al.* 2007). In Transect 3, soil salinity was observed to decrease from the beginning of the transect at road toward the transition line and increase again shortly before the transition zone; however, the observed variability in soil salinity was not found to be significantly different based on statistical tests.

The boundary between homogeneous and heterogeneous vegetation was found to be associated with elevation differences for all sites. At the start of Transect 1, a depression in elevation was associated with lichens while higher elevation closer to the coast corresponded with coastal dunes. For Transect 3, the decline in elevation just before the homogeneous-heterogeneous line coincided with vegetation changes from dune to strand. Grain size did not vary significantly between the two zones at any of the sites. For Transect 1, minimum grain sizes had more variability at the start of the homogeneous vegetation zone and less just before the boundary. However, the minimum grain size was most variable at the transition line. There was very little change in grain size for Transect 3.

Conclusion

Accurately estimating the shoreline position along Hudson Bay is significantly complicated by four factors: sea level rise; isostatic rebound; yearly coastal deposition and erosion by sea ice; and permafrost aggradation and degradation. The advantages of using the homogeneous-heterogeneous vegetation transition as an indicator for shoreline mapping include its potential to represent landscape ecological properties (Schmidt *et al.* 2004); the detection of surface vegetation using remotely sensed imagery; the temporal resolution of remote sensing orbits is appropriate for mapping vegetation; and it is proposed that this feature represents a more relatively stable geocoding feature compared to annually changing geomorphic shoreline features.

The first step in establishing homogeneous-heterogeneous vegetation transition as a potential indicator for shoreline mapping was to identify the vegetation community in the study site, and then assess if the observed transition in vegetation cover corresponded to biophysical characteristics of the landscape. It was determined that Site 1 was a salt marsh community and

Table 2
Kolmogorov-Smirnov test of difference for grain size.

Transect	Biophysical Variable	Observed Value	Critical Value	Hypothesis Accepted	Sig. Difference Between Cont. and Discont.?
1	Grain Size	0.333	0.5	Ho	No
3	Grain Size	0.4	0.548	Ho	No
4	Grain Size	0.333	0.408	Ho	No

Table 3
T-Tests of difference for salinity, elevation, and depth of A horizon.

Transect	Biophysical Variable	Sig (2-tailed)	Hypothesis Accepted	Sig. Difference Between Cont. and Discont.?
1	Salinity	>0.001	HA	Yes
1	Elevation	>0.002	HA	Yes
1	Depth of A Horizon	1	Ho	No
3	Salinity	0.28	Ho	No
3	Elevation	0.013	HA	Yes
3	Depth of A Horizon	0.226	HA	Yes
4	Salinity	0.361	Ho	No
4	Elevation	0.234	Ho	No
4	Depth of A Horizon	0.211	Ho	No

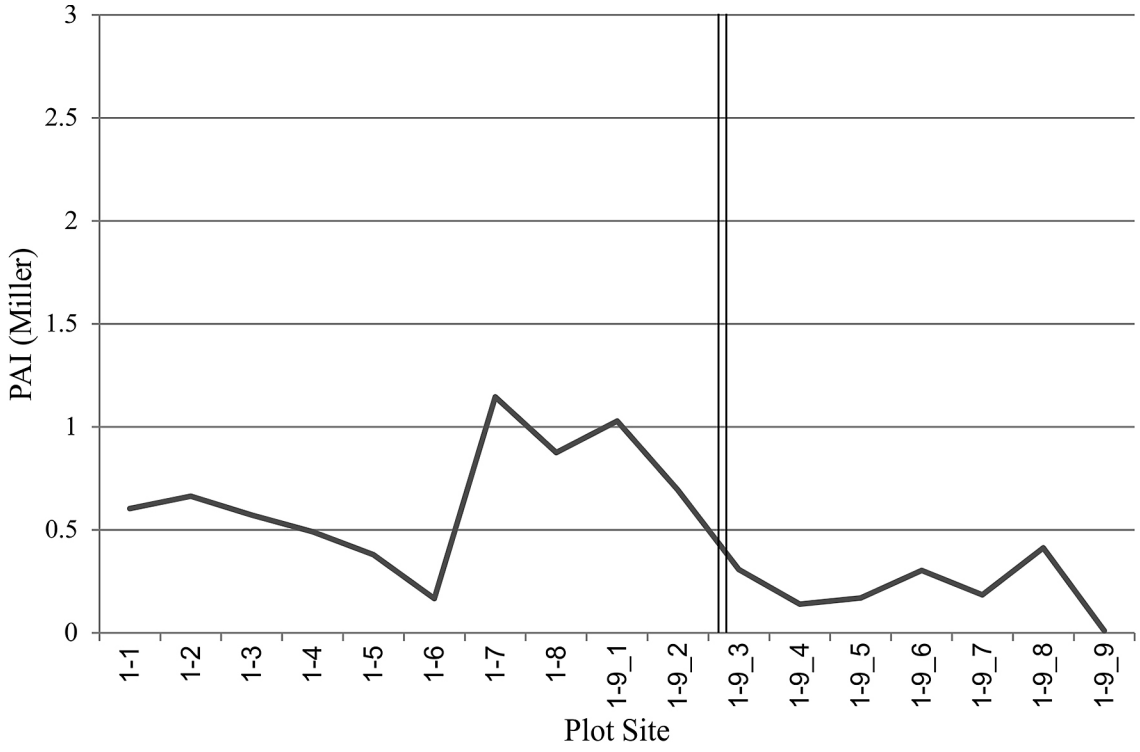

Figure 5
Plant Area Index (Miller) values for Transect 1with the homogeneous-heterogeneous vegetation line marked (between Plot 1-92 and 1-93).

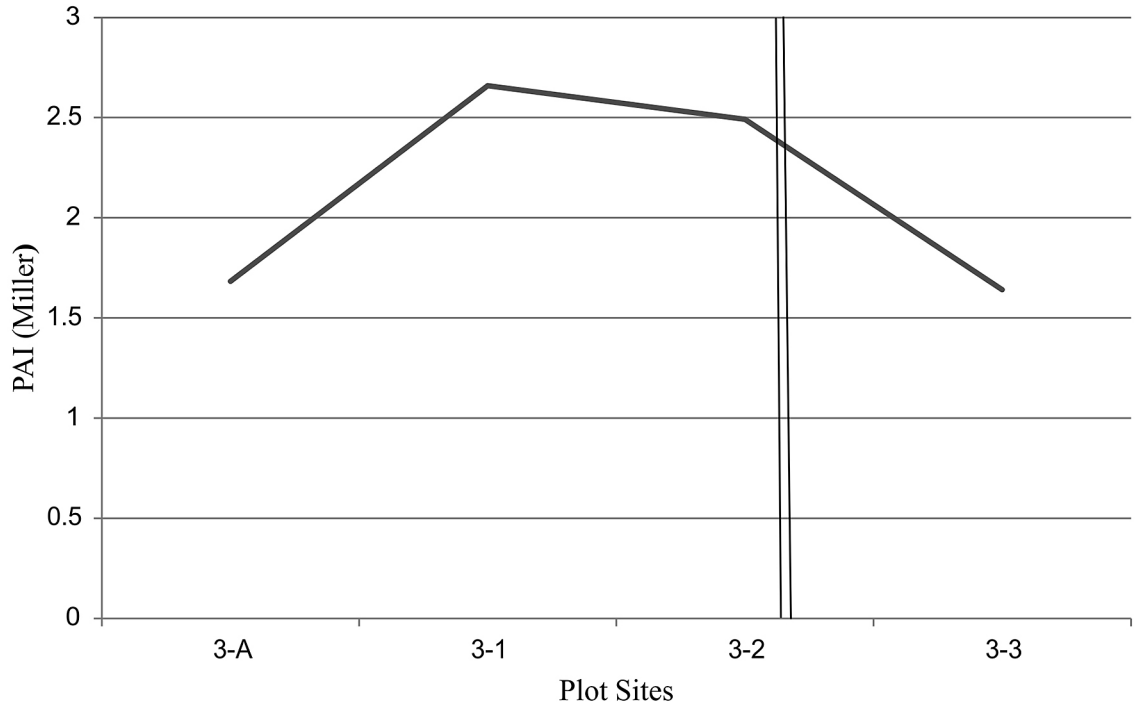

Figure 6
Plant Area Index (Miller) values for Transect 3 with the homogeneous-heterogeneous vegetation line marked (after Plot 3-2).

the other three sites were strand communities. The changes in species composition of the vegetation communities were found to correspond with the observed transition from homogeneous-heterogeneous vegetation cover from the road to the coast.

The change in vegetation cover from homogeneous to heterogeneous was also observed with changes in biophysical measures of underlying landscape characteristics. Specifically, changes in salinity, elevation, and percent cover were found to vary from the homogeneous to the heterogeneous zones, and these relationships were stronger in the salt marsh community compared to the strand community in Bird Cove. Thus, we conclude that the homogeneous-heterogeneous vegetation line observed in the field was independently verified using these biophysical variables. And this transition in vegetation is representative, at least in part, of the coastal landscape in this region.

It is recommended that further work be done to better understand the vegetation and biophysical landscape variability of Bird Cove. For example, changes in depth of the A horizon and the minimum and maximum grain sizes were visually observed to change at the homogeneous-heterogeneous line but these results were not corroborated using quantitative analysis. Although grain size and the depth of the A horizon were not found to be significantly different in the two vegetation zones for the sites, a cyclical fluctuation was observed. It is recommended that finer spatial resolution elevation dataset be obtained for future research. This would allow for the testing of a hypothesis developed in the field, that changes in grain size and depth of the A horizon may be related to beach ridge topography.

In addition, the key premise behind this work is that the subarctic vegetation distribution and composition is more stable than coastal geomorphic features that change annually (e.g., erosional cliffs, depositional beaches). Thus an evaluation of multi-year in situ data (e.g., plant species, PAI) needs to be done to confirm this supposition. Data has been collected in 2012 and 2013, and will be collected again in August 2014 to address this recommendation.

The conclusions from this work, that variability exists between the homogeneous and heterogeneous vegetation, and that this variability represents underlying landscape ecology in Bird Cove, do provide enough evidence for the next stage of analysis. Work has been completed and a manuscript is in development on the quantification of differences between homogeneous and heterogeneous PAI and optical data, specifically red-edge first derivatives from hand held spectrometer data collected in 2012. As a result of the field and spectrometer analysis done in 2012, both optical and RADAR satellite images were acquired along with in situ data in 2013. The first challenge to be addressed when mapping coastal vegetation is to improve detection of heterogeneous vegetation using moderate spatial resolution data.

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Low-income Aboriginal women's foodscapes: Moving towards geography of food dignity

Cheryl Sobie
Department of Environment and Geography, University of Manitoba

Jeffrey Masuda
School of Kinesiology and Health Studies, Queen's University

Aboriginal women in low-income Winnipeg neighbourhoods face combined challenges of ethno-racial and socioeconomic deprivation that contribute to food insecurity. Yet there is a lack of research that has investigated the totality of their food insecurity including the social and physical geographic effects as they relate to negative health outcomes as experienced by young Aboriginal mothers. This research study uses the concept of 'foodscapes' – that is, the total geography associated with the acquisition and consumption of food – to determine its utility in characterizing everyday neighbourhood settings of food insecure women in Winnipeg. A mixed methods approach was used to investigate foodscapes of students at Ka Ni Kanichihk (n=7) who self-identified as Aboriginal women, were under the age of 30, had one or more children, and were recipients of social assistance. Using a combination of two semi-structured focus group interview sessions, accompanied by observations of food providers in Winnipeg (n=9), the findings revealed multiple barriers related to accessibility, transportation, discriminatory food environments, poor food quality, and lack of affordable food, that women encountered during their food journeys. Underlying the discriminatory foodscapes of Aboriginal women in Winnipeg is the reoccurring theme that women's dignity is adversely affected in multiple ways during their food journeys.

Keywords: Aboriginal women, geography, foodscapes, food dignity, food insecurity, feminist research

Introduction

Food insecurity, defined as the inability to properly access a diet of adequate nutritional quality and quantity in a socially acceptable and dignified manner (Dietetics of Canada, 1993; Davis & Tarasuk, 1994), has been shown to contribute to chronic health problems such as obesity and depression in Aboriginal communities (Reading & Wien, 2009). In scrutinizing the prevalence of food insecurity among Aboriginal households in Canada, Willows et al. (2009) found that at least 33% of Aboriginal people living off reserve in Canada experience moderate to severe food insecurity compared to 9% of non-Aboriginal people. According to the 2004 Canadian Community Health Survey Cycle 2.2, Aboriginal women single parented households (living off reserve) were 53.1% more likely to suffer from food insecurity as compared to 27.5% of Aboriginal dual parent households (Health Canada, 2006).

Food insecurity as experienced by Aboriginal women is an inherently complex phenomenon involving both historical and geographic processes associated with the present-day effects of colonialism, patriarchy, and socioeconomic exclusion. The resulting socioeconomic inequities Aboriginal women experience as compared to non-Aboriginal women in Canada includes: higher rates of lone parenthood, higher poverty rates, and a lower likelihood of graduation with a post-secondary degree (Statistics Canada, 2011). A 2009 study of food insecure young urban Aboriginal mothers in Saskatchewan, reported that the combination of lone parenthood, insecure housing and lack of social

support, has left many Aboriginal women in Canada struggling financially to make ends meet, particularly when it comes to food security (Baskin et al., 2009). Lack of necessary income, in combination with inadequate neighbourhood infrastructure and social supports, has left many Aboriginal women in Winnipeg facing a daily struggle to purchase the necessary quantities of healthy food for their families.

Food security is a key social determinant of health (Mikkonen & Raphael, 2010). Yet to date, there has not been a robust geographic analysis of the inequitable physical and social causes and effects of food insecurity from the perspective of urban Aboriginal women, particularly in relation to potentially discriminatory environments and undignified experiences that women may encounter in attempting to access food for their families. This paper aims to address this gap by reporting on a study that investigated neighbourhood level geographic foodscapes of Aboriginal low-income single mothers in Winnipeg, Canada in order to promote a better understanding of the determinants of food insecurity in the city.

Background

Poverty, food insecurity, and mental health

According to the report, *Women's Poverty and the Recession* (2009), people living in racialized communities in Canada, particularly women, children, or Aboriginal peoples experience higher than average rates of poverty (CCPA, 2009). People who are vulnerable to poverty are often the most vulnerable to food insecurity (Travers, 1996). Peake and Kobayshi (2002) discuss the spatial effects of racism as it relates to poverty and how this can lead to the prevention of access to necessary social goods and services such as food.

The immediate response to food insecurity among vulnerable communities remains charitable donations (i.e. food banks, soup kitchens). However, the recent emergence of community food security initiatives such as community kitchens has attempted to reduce reliance on food charitable measures (Hamelin et.al., 2008). Although these responses have arisen in part due to the ineffectiveness of current social assistance levels required to meet people's basic needs, (Tarasuk, 2001; Travers, 1996) there is a need to further explore the underlying factors such as lack of response to reducing poverty, which allows income inequalities and thus food insecurity to be perpetuated (Travers, 1996).

Determinants of food insecurity in Canada have been conventionally characterized in relation to inadequate consumption of healthy foods such as fruits and vegetables (Ricciuto & Tarausk, 2007), reduced social assistance levels (Gurstein & Vilches, 2010) and lack of income to pay for food (Tarasuk & Reynolds, 1999; Travers, 1996). However, such characterization has had an individualizing effect (Travers, 1996), even when taking into account contextual parameters such as geographic access to food vendors and availability of healthy food choices.

An emerging body of literature is beginning to examine the mental health effects of food insecurity (see Jacobson et al. 2009; Heflin et al., 2001). This work increasingly identifies mental health implications of food insecurity as fundamentally connected to the social and physical geographic contexts of women's lives. For example, Jacobson et al. (2009), found that people in Toronto struggling to obtain resources, including food, felt their dignity was violated, thus leading to feelings of shame, identity damage and loss, apathy, and depression. Similarly, a Toronto study of food bank use among women and their families, found that the vast majority of participants felt shame, embarrassment, degradation and humiliation in association with food bank visits, particularly when it came to informing their children about their dependency on charity (Tarasuk & Beaton, 1999). Such studies point to inherent discriminatory geographies that are implicated in food insecurity, both in terms of concrete physical geographies of distance and time, as well as socio-spatial processes and relations involved in food journeys. Furthermore, food insecurity has implications for women's mental health, as they are obliged to confront humiliating and undignified encounters when providing food for their families.

Foodscapes

Recently, geographers have identified the foodscape concept as a useful approach to analyze the spatial relations between the human-food interface, particularly as it affects health and social well-being (Panelli & Tipa, 2005). For the purposes of this paper we define foodscapes as, "the total social and physical geographic context involved in the acquisition and consumption of food."

Physical geographical parameters include points of contact where food is grown, purchased and consumed, including grocers, convenience stores, restaurants, farmers markets, food banks, drop-in centres, and shelters (Winson, 2004). Social geographic parameters include the encounters, experiences, and observations of individuals as they interact with people and places during their food journeys (Panelli & Tipa, 2005).

In moving beyond typical instrumental problems of inequitable food access and distribution, Panelli and Tipa (2005) argue that foodscapes can expose the politics of food acquisition, including the structural inequities, discriminatory practices, and resulting inadequate nutritional and mental health effects on food insecure groups. For example, the decision regarding which vendors' women choose to purchase food at is not only a function of distance, but may also be influenced by factors such as the price, variety, and availability of desired food items at particular vendors (Ball et al., 2008). Thus, the foodscape concept can be a useful lens for the purpose of investigating the unique experiences of food insecure Aboriginal women who live in socioeconomically deprived neighbourhoods, as it provides a means to contextualize the discriminatory geographies of: food vendor distribution, food journeys, individual experiences within particular food settings, and food consumption.

Research Setting

This research was conducted in Winnipeg (pop. 778, 400), Canada's seventh largest city and capital of the Province of Manitoba (Statistics Canada, 2013). Winnipeg is made up of 236 diverse neighbourhoods (City of Winnipeg, 2010). Several low-income

neighbourhoods in the core area are characterized by varying depths of high levels of poverty, crime, and racialization. In recent decades, Aboriginal people have migrated en masse into Winnipeg as conditions on reserves and other rural and remote locations continue to worsen amidst continuing governmental neglect (Peters, 1998; Wilson & Peters, 2005; Silver, 2006). The migration of Aboriginal peoples into cities has contributed to a heightened level of race-based anxiety among the population, which has in turn contributed to the ongoing racial segregation of the core area from the rest of the city (Silver, 2006). Current statistics report that within Canada the largest number of urban Aboriginal peoples reside in Winnipeg, which also includes the highest proportion of Aboriginal females (Statistics Canada, 2010).

Aboriginal women in Winnipeg encounter numerous challenges that relate to a long history of colonization, including political oppression, forced cultural assimilation, gender-based stereotyping and displacement (see Aboriginal Justice Implementation Commission, 1999; Aboriginal Council of Winnipeg Inc., 2011; National Collaborating Centre for Aboriginal Health, 2013). Many Aboriginal women have been displaced from their home communities and now reside in Winnipeg's inner city in unsafe, overcrowded housing, often located in neighbourhoods that lack proper social supports such as reliable transportation and access to healthy foods (Silver 2006; Silver 2007). Disturbing statistics reveal that Aboriginal women living in Winnipeg are among the 43% of Aboriginal women in Manitoba who are living in poverty (Aulinger, 2000). As a result, they are at a higher risk of experiencing income related food insecurity as their food budget is diminished in order to pay for other living costs such as housing (Khosla, 2000). Thus, Aboriginal women living in low-income Winnipeg neighbourhoods face a number of unique challenges when it comes to food acquisition. Harsh Winnipeg winters, an inadequate public transit system, and a lack of affordable healthy food stores in women's neighbourhoods', all compromise women's efforts to obtain the necessary food for their families.

Research Partnership and Participants

This research was conducted in partnership with Ka Ni Kanichihk Inc., a community-based, non-profit organization located in the West Alexander inner city neighbourhood of Winnipeg. Ka Ni Kanichihk offers Aboriginal-led, culturally appropriate educational programming with the purpose of helping people recognize their strengths and supporting them to achieve wholeness and wellness through individual and community empowerment programming (www.kanikanichihk.com). In addition to offering youth and men's programs, Ka Ni Kanichihk offers several day educational programs for Aboriginal women.

The women participants recruited for this project were part of the *Honouring Gifts* education program, designed for young Aboriginal mothers to develop skills, determine a career or education plan, experience alternative career opportunities and to receive training in a culturally safe and appropriate environment. Interwoven in the Honouring Gifts program is an important life skills component, focused on traditional knowledge, addressing women's health and well-being, and caring staff that provide counseling and support services that assist women with leaving abusive relationships, addictions and treatment, health care, child care etc. All participants recruited (n=7) for this project self-identified as Aboriginal women, under the age of 30, had one or more children, and were recipients of social assistance.

Methods

Theoretical Framework

Feminist and post-colonial lenses were particularly important to the analytic position used in this research study. Aboriginal communities have been oppressed, exploited and misrepresented by scientific research for generations (Tuhiwai Smith, 1999; Absolon & Willet, 2005). Importantly, when conducting research within Aboriginal communities, it is imperative that researchers recognize the underlying power imbalance inherent in their relationship with participants to ensure they respect and use the knowledge that is shared with them appropriately and not exploitatively (Tuhiwai Smith, 1999). Through the resistance of colonizing research methods, we enable the development of new research methods that reflect Indigenous worldviews and create knowledge that is consistent with Indigenous ways of knowing and being (Absolon & Willet, 2005).

Previous feminist research has shown that women are often viewed in urban discourses as incomplete subjects in need of redemption, rehabilitation or reform (Kern, 2006). From this perspective, even women involved in research can be vulnerable to the effects of patriarchy and colonization (Frisby & Creese, 2011), which combine to produce a discriminatory environment in their urban experiences generally, and food acquisition journeys specifically. Importantly, feminist research methods aim to acknowledge and address the power imbalance between researchers and participants through a focus on inclusive and participatory approaches and bringing often excluded women's voices to the surface (Frisby et al., 2009). Crucially, feminist researchers must simultaneously reflect critically on how their own underlying biases, knowledge claims, and privilege may influence the research process (Frisby et al., 2009).

Procedures

The research study was conducted using a mixed methods approach to explore and characterize both the physical and social dimensions of foodscapes of low-income Aboriginal women in Winnipeg.

First, fieldwork for the project began by establishing a research partnership with Ka Ni Kanichihk Inc. The fieldwork was conducted in three steps over a five-month period that consisted of two focus group interviews and observational site visits of 10 food providers in Winnipeg. Their participation included two one-hour, semi-structured focus group sessions. A semi-structured style of focus group interview, was used as it is an invaluable tool to help gain information about people's lived experiences (Travers, 1996). The semi-structured nature of the focus group interviews consisted of the use of prepared direct ques-

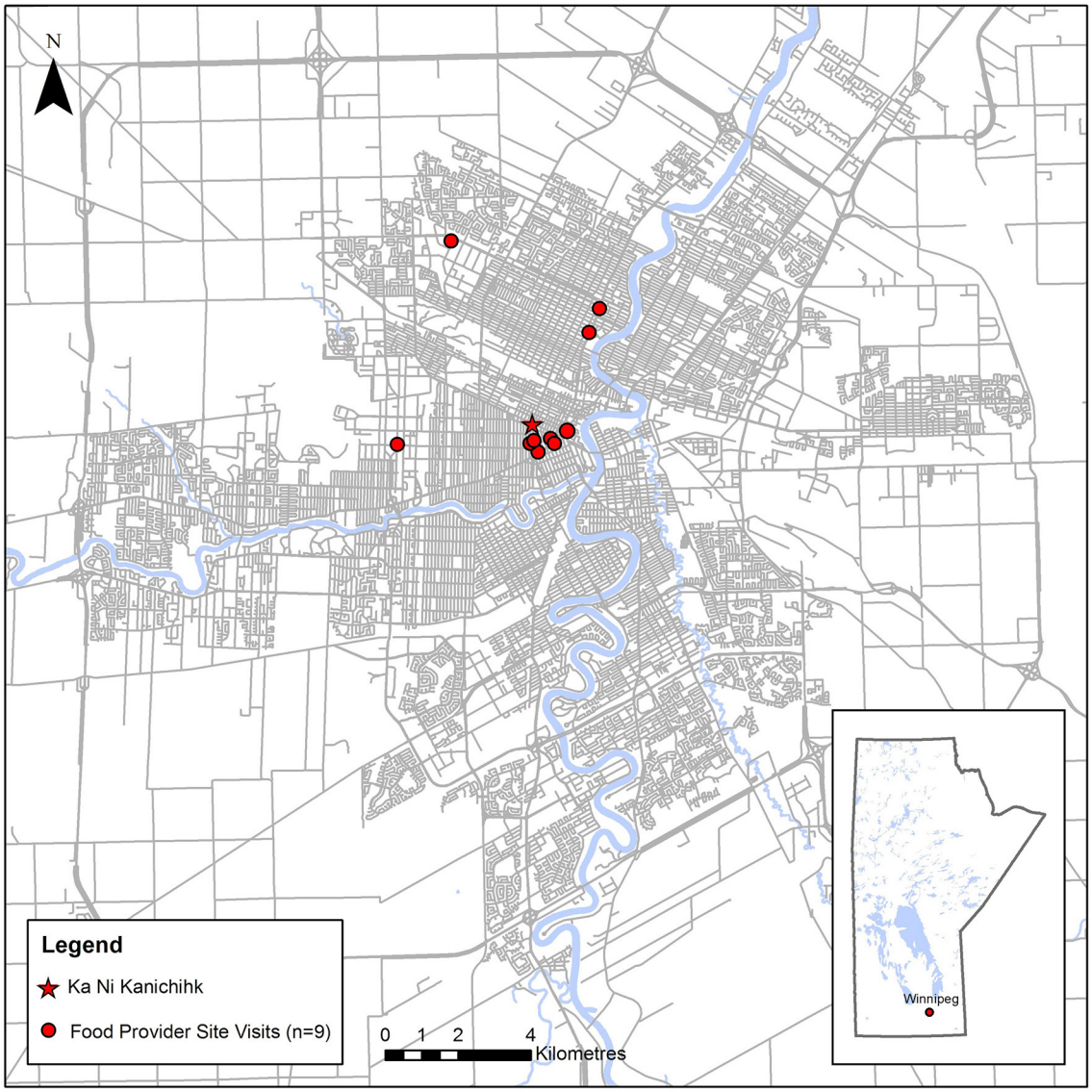

Figure 1
Map of observational site visits of Winnipeg food providers

tions that I presented in an open-ended manner, in addition to the use of prompts to clarify questions, or to facilitate discussion on an important point raised (DeWalt & DeWalt, 2011).

The first focus group concentrated on the following topics: (1) Locations and types of food providers used most often; (2) Women's experiences with particular types of food providers such as grocery stores and food banks; (3) Typical weekly/monthly food budget and food purchasing decisions; (4) Barriers to accessing food such as cost, transportation and income; and (5) Discriminatory effects of foodscape environments. The second step of the research involved the characterization of a sample of food providers (n=9) that collectively constitute the foodscapes of low-income neighbourhoods in Winnipeg. Observational site visits (n=9) were conducted primarily in the Downtown, Point Douglas, Inkster and St. James-Assiniboia regions of Winnipeg. Figure 1 displays a map of Winnipeg and the locations of food providers visited.

The food providers visited were identified during the first focus group interview as the locations that the participants normally visit to obtain food. These included grocery stores, discount grocers, convenience stores, and food banks. In order to conduct a thorough observation of these foodscapes, a checklist was created by the lead researcher consisting of eight categories including: store appearance, store layout, product placement, type of food in store, pricing, staff/security, typical shoppers, and overall conditions of the store. Within each category there were approximately 4-6 variables identified during the observational site visits. Some examples include: price comparisons of three standard products (e.g. Kraft Dinner, Macintosh apples and tomato soup), amount of prepackaged foods (measured in comparison to amount of fresh foods available), product loca-

tions (where packaged versus fresh foods are located) and store security (cameras, guards, or watchful store owners).

The final step in this research included a second focus group interview to share and confirm the credibility and appropriateness of the analysis of the first focus group interview and to assist in further contextualization of the site visit data. The discussion centered on reviewing participants' key barriers to accessing food; identifying any missing or misinterpreted information; discussing any additional food provisioning experiences in line with the key themes; and finally brainstorming ways we can take action and how we can share our research findings.

Data Analysis

All interview data were digitally recorded and transcribed. The researcher obtained observational site visit data using a checklist during site visits and through recording field notes. A constant comparative analysis (Hay, 2010) was used to analyze all transcripts and field materials. The linking of observational and interview data allowed for the identification of relationships between physical and social geographies, and inference of themes to develop preliminary ideas, concepts and observations (Dey, 1993). The observational data were analyzed by identifying common themes within each type of store visited and then analyzing and coding the field notes from each visit. Importantly, the observational site visit data contextualized the information gathered through the interview data. Finally, the thematic analysis revealed six key barriers that the women who participated in this study experience when accessing food in Winnipeg.

Results

Analyses of the interview data and observational site visits revealed numerous barriers embedded within the social and built environments that constitute women's foodscapes in Winnipeg. The difficulties women encountered were predicated primarily on the stigmatizing and individualizing effects of poverty, which were further exacerbated by reports of racial discrimination that they faced in their food journeys. Six key barriers emerged from the coding process, including: Transportation, Accessibility, Affordability, Food Environment, Customer Experiences, and Food Quality. Both physical and social geographies that constitute women's foodscapes are reported for each theme. Table 1 provides a summary of food provider descriptions and four key observations recorded at each type of food provider visited. Women's experiences and food provider site visit observations are further explored in the following sections.

Transportation

Women's methods of transportation on their food-provisioning journey often included multiple transportation modes such as walking, public transportation, and the use of taxicabs. None of the women involved in the study had their own personal vehicle to use for obtaining groceries. The women reported that they often took the bus to food providers located further away from their house and then they would often take a taxicab home with their groceries. The cramped and crowded city bus was not able to accommodate women's grocery shopping transportation needs due to lack of space for themselves and their groceries, or difficulties in carrying a large number of groceries on the bus. Rather, some women (n=5) chose to take a taxicab to get their groceries home.

The cold weather during Winnipeg winters often complicated women's food journeys as even waiting for the bus for 10 minutes or walking to the convenience store in their neighbourhood presented transportation challenges. One woman directly addressed the difficulty experienced by not having a car during the cold Winnipeg winters, by remarking:

> "It's harder in the winter than in the summer to get around. Because you can't walk anywhere when it's -40°C. Like come on now, the kids are fine but you're freezing!"

Accessibility

Women encountered both physical and social barriers in their food provisioning experiences including visits to multiple locations to obtain adequate food and difficulties experienced with food bank procedures, in particular the wait times. Women explained that there were an inadequate number of food providers in their neighbourhoods that allowed for easy access and that visits to multiple locations were required (participants typically listed three or four locations) to obtain all the food their families needed based on their limited budgets. Specifically, the women reported on the limited availability of fruits and vegetables at smaller convenience stores as compared to the larger supermarket or grocery stores.

Each of the women reported having to use a food bank at some point in their lives and revealed experiences associated with obtaining food from food banks which were negative, time consuming and undignified. Participants reported that food banks are only open for a short period of time (i.e. a few hours) once every week or two weeks, that there are often long wait times on the phone to register to receive food and that waiting then continues with long line-ups at the food bank. One woman explained her experience with a food bank:

> " I have used before too [food bank]. It's hard too…you go in there, you have to wait in line for a long time….They open at like 10 and then you are still waiting at like 12:30"

The women were clear in their explanations that not all food providers or food banks they utilized in their food journeys allowed for undignified experiences, only in specific locations. These results provide overwhelming evidence that location has a significant effect on a woman's ability to not only adequately access the food necessary to achieve a diet that meets her nutritional requirements, but to access these foods in a dignified manner.

Affordability

All the women who participated in this study were recipients of Social Assistance (SA) and reported a limited budget available

Table 1
Summary of food provider site visit observations

Type of Food Provider	Description of food provider type	Store Appearance	Amount of fruits and vegetables vs. Prepackaged food	Type of Security	Overall Experience
Supermarket	Large; offers fresh foods, deli, bakery, house wares, pharmacy, etc.; "big box" store; located in high traffic suburban areas	Dirty floors; aisles/shelves somewhat crowded; bright lights; large aisles and shopping carts;	Large fruit and vegetable sections but "junk" food often mixed in	Greeter at door in some locations; cameras present	Large stores with large parking lots; good variety of items; locations visited in suburban neighbourhoods (i.e. not inner city)
Discount Grocer	Grocery store that offers discounted prices for groceries, clothing, house wares, etc.	Crowded; dirty floors; boxes everywhere; stuff jammed in tiny aisles	Small fruit and vegetable in some; hard to locate	Walk-through security scanner; barred entrance windows	Aimed to appease budget conscious shoppers; extremely crowded store; low percentage of healthy food
Convenience Store	Smaller stores often located in highly accessible or lower income neighbourhoods ; offer range of goods but may be higher priced than traditional grocery stores	Floor dirty; stuff on floor; crowded aisles; no real organization of sections;	Mainly pre-packaged foods; mostly "unhealthy" foods (i.e. candy, chips, ice cream, pop)	Barred windows and doors; extra staff monitoring customers	Appear to be heightened security in inner-city locations; small selection of fresh foods (i.e. fruits and vegetables)
Food bank	Charitable food distribution system in Winnipeg; most located in churches or community centres	Small building; crowded tables with food boxes	Almost all prepackaged food; one wilted head of lettuce in boxes; some boxes had one banana or one apple	Friendly staff, helpful	Not enough food for amount of families in need; lack of fresh foods and quality nutritious foods

for food. The women discussed how the SA they receive is not enough to cover all their basic costs such as food, rent, childcare, utilities, etc., and that they often must choose between paying their phone bill or paying their rent. One woman remarked that all other costs seem to go up (housing, food, rent) but not SA levels. Another woman spoke about the daily struggle on a limited income:

> "You know like you're not supposed to live comfortable on assistance but come on, you're not supposed to struggle every day just to feed the kids and clothe them."

Due to their limited budget, participants noted that the cost of food at certain locations is prohibitive and although certain food providers, such as mainstream grocery stores, may be more convenient to shop at, they are often not seen as economically feasible. Women may seek out food providers if they have specific items on sale, or that are more affordable, thus adding time and inconvenience to their food journeys. For example, one of the participants explained that in addition to visiting grocery stores, she also visits a specialty butcher shop to purchase low-cost, quality meat. The site visits contextualized the women's reports of a proliferation of unhealthy food present at all types of food providers in highly accessible areas. As one women explained, it is often the snack foods that are on sale and thus the most affordable:

> "Brick cheese at every place is like $8.00 or $9.00. No matter where it is, it is all expensive. Most of that stuff is the same everywhere. The stuff that's on sale is drinks, chips."

Food Environments

Food environments, including the physical setting and layout of stores and other providers, affected women's foodscapes. Several women reported that the locations of essential food providers or food banks are inaccessible. They are often located in church basements that do not accommodate the long lines and wait times inherent with food bank use. The women revealed that certain food banks offer more dignified environments if they provide food that is prepackaged and ready for them to pick up. This is opposed to a common 'free for all' setting in the majority of food banks where there is no pre packing of food and women must compete for a limited amount of available food.

Additionally, the layout of food stores impacted the women's shopping experience. Women reported that certain food providers and food banks offer clean and inviting environments, whereas other spaces are cramped, dirty and uninviting. Paradoxically, often the providers that were most accessible and affordable were the least attractive. One woman shared her experience in a downtown Winnipeg convenience store where she shops:

> "And it's so jam packed in there and I mean it's so cluttered in there you can't even like walk around! You can't even bring your stroller in there or nothing"

Two convenience stores were visited in the downtown core of Winnipeg to observe the conditions reported by the women. During the first focus group interview, women revealed negative experiences connected to the layout of food convenience stores, such as overcrowding of aisles and dirty floors. Observations revealed that the locations the women discussed indeed were cramped, had dirty floors, messy shelves and the walls and doors were barred in three of the locations visited.

Customer Experience

Customer experiences during food journeys were affected by factors such as discrimination, lack of respect, and accusations of theft. Four women noted experiences that included undignified interactions with staff at food stores and food banks where they encountered racism, rude treatment, and disrespectful remarks. The women participants reported that it appears the food bank staff and volunteers often take the best quality food or give more to friends or family. Furthermore, they reported experiences at certain food providers or food banks made them feel discriminated against for perceived reasons such as race, income level, career or gender.

The participants explained that at some grocery store locations, staff treated them with the assumption that they had stolen something or anticipated they would steal something. The inner city stores visited (n=3) had various signs in the store windows indicating cameras were present, that all bags must be left at the front of the store, and had multiple security cameras and several staff members watching carefully. Several women reported incidences that confirmed the site visit observations of heightened security, including one woman's experience of unjust theft accusation at a major retailer in Winnipeg:

> "The woman [store clerk] said 'Oh, can I see what's in your stroller' and I'm like 'why, like I don't care, look in my stroller'…they think that every Aboriginal…it's Aboriginal people only it seems like because I see other people that are going in there…it's the Aboriginal/Native big thief or something…they look in your stroller and there is nothing in there."

Unfortunately this participant shared that this has happened on numerous occasions while out shopping with her kids and stroller.

Food Quality

Finally, the women reported that the quality of available food in stores and food banks within their neighbourhoods is lacking. The site visit observations revealed a lack of quality fruits and vegetables in inner city convenience stores, discount grocers, and food banks as compared to the amount of packaged foods available. Not only was there a limited selection of fruits and vegetables observed at the discount grocers and convenience stores, much of it appeared wilted and close to expiration. Site visit observations at the discount grocery stores revealed a limited fruit and vegetable selection often difficult to locate amidst the packaged foods in the store.

Most women (n=6) said that they often do not receive enough quality fruits, vegetables or milk from food banks to adequately feed themselves and their families. For example, a site visit of one food bank in the inner city found that the food packages consisted of one head of wilted romaine lettuce, while the rest of the food was prepackaged goods such as cereal, macaroni and cheese, and day old baked goods such as muffins. Conversations with the volunteers at the food bank revealed that the observed lack of fruit and vegetables was not out of the ordinary, as they do not receive enough fresh foods to provide for food bank users.

The results suggest that compared to the amount of packaged food offered, there is not an adequate selection of fresh fruits and vegetables needed for a healthy diet. Contrary to many stereotypes that often plague food insecure women, these deficiencies were not an outcome of a lack of women's knowledge or effort. For example, several women (n=4) reported that food obtained from food banks often does not meet basic quality standards as canned foods may be dented and the food given away at food banks is sometimes expired to the point that it had occasionally made them ill. One woman explained her experience with receiving expired food from a food bank:

> "Yeah they give you food [food bank] but sometimes it's expired. It's not healthy to eat."

The lived experiences shared by the women participants provide evidence of the complexity of food insecurity as experienced by a small group of low-income Aboriginal single mothers in Winnipeg. The racialized nature of food environments, inequitable charitable food distribution systems, transportation challenges and inadequate government systems and supports (i.e. Social Assistance) are perceived to contribute to discriminatory foodscapes in Winnipeg. The effects of discrimination as revealed through women's experiences while provisioning food for their families reveal how undignified experiences have the potential to negatively affect women's self-esteem, health and well-being.

Discussion

This research study has attempted to provide a geographically contextualized analysis of food insecurity that focuses on social and physical geographic characteristics that accompany food-provisioning experiences in one locale in Canada. The results provide an important geographic analysis of the social determinants of food insecurity as encountered by Aboriginal women such as inadequate income assistance, racialized grocery-shopping experiences, poverty, and under supported charitable food systems.

As revealed by the interview data, the women reported a lack of available income as one of the main determinants in their ability, or rather inability, to adequately obtain the food resources they needed for their families. According to Kirkpatrick and Tarasuk (2008), existing evidence reveals that in order to adequately address the income related causes of food insecurity we must implement better social assistance programs and increase minimum wage levels in order to improve people's capacity to purchase their own food.

The physical geographic context was revealed to play a significant role in women's food journeys. Ranging from the distance and transportation methods women utilized to obtain food to the physical layouts of stores and food banks, it is evident that women's dignity has the potential to be compromised. Women revealed the difficulties associated with using multiple modes of transportation and the associated monetary and weather-related challenges of traveling throughout the city to access food. Issues in transportation to access basic resources were reported in the Jacobson et al. (2009) study of low-income residents in inner-city Toronto, as they found the mode of transportation was important to one's dignity and walking was identified as the least dignified mode of transportation. Public transit may be considered a more dignified mode of transport than walking; however, issues still arise such as the affordability of a bus fare. Winnipeg Transit's rates currently set at $2.40 per trip for an adult (2011), can be a burdensome cost to low-income people.

Moreover, the results provide recognition of the underlying theme of human dignity that encompasses both the physical and social geographies of food journeys of Aboriginal women in Winnipeg. The lived experiences reported by the women in this research study revealed many undignified experiences were encountered during food journeys, ranging from racism encountered while grocery shopping, unjustified theft accusations while shopping, to rude comments received from food bank volunteers. Rooted in the food journeys of Aboriginal women in Winnipeg is preliminary evidence of the systematic racial and gender discrimination that women encounter within their neighbourhood environments that impact their ability to be food secure.

The findings of this study can be used to expand on the mental health effects of food insecurity that women experience as related to human dignity. As outlined in the *Social Determinants of Health: The Canadian Facts*, Mikkonen and Raphael (2010) note that food security is directly tied to a person's health and human dignity. The importance of dignity as a determinant of food security and health points toward potential policy implications that might address not only physical barriers, but also discriminatory environments and practices that constrain women's food journeys in the city. The concept of 'food dignity' can be used to explain how undignified food experiences manifest into negative health outcomes, which challenges the conventional approaches to food security such as measuring nutritional inadequacies (Tarasuk, 2001; Travers, 1996).

Importantly, the prolonged engagement with Ka Ni Kanichihk over a six-month time period provided a unique opportunity to come together to discuss ways that women can start to take action and make positive changes for themselves, for other mothers, and for members of their community. For example the women shared recommendations on making food banks easier to use such as offering more frequent pick up times, equitable distribution of food resources, and healthier food options. During our second focus group interview we discussed ways we

could share the finding of our research such as writing letters to grocery stores, transportation companies, phone calls to grocery store managers. (i.e. Winnipeg transit), and developing further reports. Additionally, the women shared resourceful information with each other such as community organizations that offer resources and assistance, food bank locations with good food and friendly staff, and even places to avoid (i.e. stores that sell expired food, undesirable food bank locations).

Issues such as accessibility and affordability are often measured by Euclidean distances in mapping proximity to food stores (Ball et al., 2009) or identifying food deserts (Larsen & Gilliland, 2008), but not often by the lived experiences that also constitute a key part of women's food journeys. Geographers such as Edward Soja (2010) have challenged these reductionist proclivities by calling for a re-invigoration of a theory of spatial justice within geography that enables the examination of space relations beyond instrumental definitions of distance and distribution. Following this vein, the concept of foodscapes can be viewed as a key component of spatial injustice as place (e.g. neighbourhood settings) affects, and is affected by, women's efforts to achieve a food secure status. The foodscape concept has been helpful in articulating both the physical and social geographies of women's experiences of food insecurity. This research study has provided an exploratory analysis of food journeys as experienced by a small number of Aboriginal women in Winnipeg, which helps us to understand the depth and complexity of the food insecurity they experience.

Limitations

Importantly, two key limitations for this study must be noted. First, this research investigation reports on the lived experiences of a small sample of low-income Aboriginal women living in Winnipeg. The results cannot be generalized to the entire population of low-income food insecure Aboriginal women in Winnipeg but suggest, rather, that these women are not alone in the experiences that they reported.

Second, the observational site visits were conducted to contextualize and provide a physical characterization of the locales the women discussed during the interview data. The women reported on their experiences within those places and, although the site observations confirmed the women's characterizations, it is important to note that each individual will interpret a locale and experience differently.

Conclusion

According to Raphael et al. (2008), we characterize health problems at the individual level rather than at the societal level in Canada. In order to adequately address the health effects of food insecurity, solutions must be focused on the structural changes needed to alleviate poverty (Tarasuk, 2001). To this end, the findings of this study provide insight into the discriminatory patterns of foodscapes in the city, which are useful for policymakers, food activists and communities in promoting healthier food options for Aboriginal women living in low-income neighbourhoods. Additional research can be used to expand on the 'foodscape' concept in relation to urban social justice and how this concept can be used to examine the social, cultural and political forces that underlie food insecurity, and the resulting negative consequences that affect the health, dignity and overall well-being of Aboriginal women.

The combination of gender and racial-based discrimination has created an atmosphere in Winnipeg where Aboriginal women are confronted with geographies of indignity in their everyday food journeys. Despite these challenges, women in the Aboriginal community of Winnipeg continue to be the strong, powerful voices that advocate for change in their communities.

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Building respectful research relationship: Lessons from a community based participatory research project with Dakota Tipi First Nation

Jenna Drabble
Department of Environment and Geography, University of Manitoba, Winnipeg, MB

Jeffrey Masuda
Department of Geography, Queen's University, Kingston, ON

Heather Castleden
Departments of Geography and Public Health Sciences, Queen's University, Kingston, ON

Community based participatory research (CBPR) is widely recognized as means to correct some of the power imbalances that have historically characterized relationships between (typically non-Indigenous) academic researchers and Indigenous peoples. The popularity of CBPR with Indigenous communities in Canada represents a step forward, yet there remains a lack of documentation on the feedback of community members who have participated in CBPR projects, which is helpful in ensuring that research relationships are rooted in respect and are benefiting all parties involved. This study represents an effort to address this gap by drawing on the feedback of community partners to evaluate a community-based participatory health research project with Dakota Tipi First Nation, a non-treaty Indigenous (Sioux) community in Manitoba. The results of two semi-structured focus group interviews with key community partners (n=7) revealed some of the strengths and weaknesses of the project as well as valuable insights into the cultivation of relationships between academic researchers and community members. This paper highlights some important aspects of developing and maintaining respectful research relationships with Indigenous communities in Canada and worldwide.

Keywords: community-based participatory research, relational ethics, Indigenous peoples, First Nations, Manitoba

Correspondence to: Jenna Drabble, Department of Environment and Geography, University of Manitoba, Winnipeg, MB R3T 2N2.
Email/*drabblej@myumanitoba.ca*

Introduction

Community based participatory research (CBPR) has been recognized by Indigenous and non-Indigenous scholars alike as a research methodology that helps to address some of the power imbalances that have historically characterized academic research in Indigenous[1] communities (Koster *et al.* 2012; de Leeuw *et al.* 2012; Mundel & Chapman 2011; Castleden *et al.* 2008; Christopher *et al.* 2008). CBPR is considered by many to have as its goal an inclusive and empowering alternative to the exploitative and culturally inappropriate nature of some academic research that has generated distrust and contributed to research fatigue among Indigenous populations (Maar *et al.* 2011). CBPR is a collaborative process that requires a high degree of cooperation between all parties involved, particularly as participants are encouraged to shift from traditional roles from an inquirer/inquired binary to a more relational status as co-inquirers. As such, mutually respectful relationships are at the heart of CBPR involving Indigenous communities; the development of transparent and authentic relationships between researchers and community members is crucial to the success of the work (Allen *et al.* 2012; Bergum & Dossetor 2005).

Due to repeated calls from Indigenous communities and scholars around the world for research that is culturally appropriate and contributes to self-determination (Tuhiwai-Smith 1999; Shnarch 2004; Louis 2007), there has been a considerable increase in the number of studies utilizing a CBPR approach. Although these studies represent a step toward more responsible and appropriate research, doing so requires constant attention on the part of a researcher to engage in critical reflexivity throughout the duration of the project while also seeking feedback from community partners in their assessment of the process-related successes and challenges of such collaborative work. Interestingly, this is a perspective that has largely been absent from CBPR literature (a noted exception, for example, is that of work coming from Macaulay and colleagues (2007)). Eliciting feedback from community partners throughout the duration of a CBPR project can help to strengthen the project by clarifying interpretations of research data, providing an understanding of how community members have perceived the project, and informing the approaches of future interventions (Macaulay *et al.* 2007; see also Castleden *et al.* 2008). This paper represents an attempt to help address this gap by illuminating the perspectives of community partners as they have considered the various phases of our project; our effort in doing so is to critically reflect on the development of our relationships in a community based participatory health research project on social support for asthma among First Nations children, identify key strengths, acknowledge failures, and report on lessons learned.

Background

Childhood asthma in Indigenous communities

The First Nations Regional Health Survey (FNRHS) is the first Indigenous-controlled national longitudinal health survey, which began in 1996-1997 in reserve[2] communities across Canada and has provided rich data on a number of health problems across the life course. For example, the results of this survey indicated that asthma was one of the most frequently reported conditions among First Nations children, at 12% (MacMillan *et al.* 2009). The lack of more recent statistics points to the need for more research and intervention in this area; at the same time, the pattern of rising asthma rates in the rest of Canada is an indication that asthma rates among Indigenous children may also be on the rise. Moreover, there is the additional challenge in many reserve communities of inadequate access to health care, resulting in underreporting of health conditions (Crighton *et al.* 2009).

The issue of substandard housing on Canadian reserves has been widely reported as a health determinant for Indigenous communities. The overcrowding, high humidity, and improper ventilation that characterize many reserve dwellings can trigger a wide range of health conditions, including asthma (Robson 2008). Almost one half of on-reserve housing contain mold at levels that are high enough to cause respiratory illnesses for residents (Optis *et al.* 2012). Not surprisingly, the Aboriginal People's Survey (APS) conducted in 2001 revealed that the rates of physician-diagnosed asthma (on- and off-reserve) were higher among children living in homes in need of major repairs (Crighton *et al.* 2009). The risk factors for childhood asthma that exist on reserves coupled with the lack of access to health care that many rural and remote communities face not only highlight asthma as a serious issue for on-reserve populations but point to the need for more research on the determinants and dispersion of asthma for on-reserve First Nations children, a point that has been raised by the few studies that have been done in this area (Crighton *et al.* 2009; MacMillan *et al.* 2009; Watson *et al.* 2012).

The relative lack of research in this area makes it difficult to make any informed statements about the experiences of First Nations youth living with asthma on-reserve. Furthermore, there are particular considerations that must be made when conducting health-based interventions in reserve communities. For example, Indigenous peoples have diverse cultures (e.g. worldviews, language, customs, values) – and this diversity exists across the 600+ First Nations in Canada) that need to be recognized in health research (Schnarch 2004). Any attempt to imple-

[1]In this paper, we use Indigenous, rather than Aboriginal (a constitutionally-recognized but also a colonial term), to refer to the three distinct Indigenous groups of peoples in Canada who have been here for millennia: First Nations, Inuit, and Metis. Doing so aligns with the UN Declaration on the Rights of Indigenous Peoples. Where appropriate, we refer to one or the other of the three distinct groups, and when referring to the CBPR project described in this paper, we refer to the specific First Nation that partnered with us in the research.

[2]In Canada, First Nations were (often forcibly) placed into small "reserves" of land, a fraction of their original traditional territories as the settler (mainly European) population expanded its population size and search for extractable resources.

ment a health intervention in an Indigenous community should, therefore, listen to community leaders and members about what works well in their communities (Castleden *et al.* 2012) and, where appropriate meaningfully incorporate local cultural traditions and teachings (Isaak & Marchessault 2008).

Academic research and Indigenous communities

Historically, Indigenous peoples worldwide have often resisted the presence of academic research in their communities. The widespread criticism that surrounds research in Indigenous communities relates to the ways that researchers, typically non-Indigenous peoples themselves, have conducted studies without the proper consultation, authorization or participation of the communities involved (Tuhiwai-Smith 1999; Schnarch 2004; Christopher *et al.* 2008). Communities have reported that data has been taken from them and never returned, or that the results of the research were never reported back to them, which has generated feelings of distrust, suspicion and resentment toward academic researchers, as well as a general sense of being over-researched and exploited (Castleden *et al.* 2008).

The need for CBPR in partnership with Indigenous communities in Canada has been increasingly recognized in light of the continued health inequities experienced by Indigenous peoples that stem from colonial policies and practices such as the residential school system, the Indian Act and forced assimilation into Euro-Canadian culture (Adelson 2005; Castleden *et al.* 2008). Over the last two decades, there have been calls for, and efforts toward, more inclusive and respectful research relationships between academic researchers and Indigenous communities from funding agencies (e.g. the 2007 CIHR Guidelines for Health Research Involving Aboriginal People), Indigenous organizations (e.g. the 2005 National Aboriginal Health Organization's Ownership, Control, Access and Possession Principles), and Indigenous communities themselves (e.g. the Mi'kmaq Ethics Watch, established in 1999).

CBPR is often understood as an academic approach to research that helps to correct the power imbalance in research relationships by establishing academic-community partnerships, utilizing local knowledge and expertise and building community capacity (Castleden *et al.* 2008). The research is ideally motivated by community-identified concerns and the goals of CBPR typically include building relationships with the participating community and advancing ideas that contribute to social justice and change. First and foremost, CBPR must have direct, tangible benefits for the participating community (Koster *et al.* 2012). The success of CBPR hinges on the development of relationships built on mutual trust and respect. This demands that researchers commit to investing considerable time in the community prior to the commencement of the research project (Bull 2010), something often difficult to do without adequate financial resources (Castleden *et al.* 2012).

de Leeuw *et al.* (2012) point out that despite the advancements that have been made toward more participation and inclusivity in research, there remains a need to be critical of projects utilizing a CBPR framework and not to assume their inherent 'goodness'. The authors contend that CBPR can, in fact, work against its own goals and retrench unequal research relationships. For example, the tendency to identify community members as 'partners' can have the effect of disguising the power imbalances that are often institutionally entrenched by virtue of university or funder norms and regulations. Similarly, the ethical and institutional demands on researchers for full consultation and participation, as well as the time investment that is requisite for developing meaningful relationships may also be at odds with the schedules and priorities of community members, becoming a burden for research partners/participants (de Leeuw *et al.* 2012). These are all factors that researchers must maintain an awareness of prior to, and during, their engagement in a CBPR project.

Research Setting & Context

This research was conducted with Dakota peoples, members of Dakota Tipi, a First Nations reserve community located in southern Manitoba, approximately 4 km from the city of Portage la Prairie. Granted reserve status in 1972, the community is made up of 368 people, 183 of whom live on-reserve. Sioux is the native language but English is the language of preference for most members of the community. The reserve has a health centre, band office and school on site; however, the school is not presently operational. Dakota Tipi presently organizes a number of community programs and events, such as a cooking program for youth and an annual Health and Wellness Fair. The leadership (Band Council) is working toward developing a comprehensive community plan that will contribute to the development of community capacity, self-determination and a vision for the future (Dakota Tipi 2012).

Several council members and staff from Dakota Tipi were responsible for assisting in the coordination of the Healthy Lungs, Healthy Environments program (herein referred to as HLHE). HLHE was funded and implemented as a component of a multi-site research study led by a researcher at the University of Alberta titled 'Engaging Aboriginal families affected by allergies and asthma in support-education program development'. The broader research team was made up of academics and community health practitioners, with support from the participating First Nations and Métis communities and guidance from Community Advisory Committees in Alberta, Manitoba and Nova Scotia. The purpose of the multi-site study was to assess the support needs and preferences of Aboriginal youth with asthma and allergies and their parents. Through the development of accessible, community-led and culturally appropriate support education interventions, the research team's goal was to identify implications for improved practice, programs and policies for asthma and allergy health interventions in First Nations and Métis communities.

In Manitoba[3], the HLHE after-school program was designed in collaboration with members of the Dakota Tipi community

with the goal of creating an intervention that would address the three themes of health education, support and cultural reclamation. The five-week program, which included interactive lessons, arts-based learning, games and traditional teachings, wove respiratory health education into the curriculum, which was delivered by professionals with traditional Dakota approaches.

Methods

The fieldwork stage of the research began by creating a partnership between the community of Dakota Tipi and the University of Manitoba research lead (second author). Initially, the research lead met with representatives of the Assembly of Manitoba Chiefs to introduce the idea of developing a community-led asthma intervention for youth on reserve and gain approval in order to connect with a First Nations community in Manitoba. The research team then met with three Dakota Tipi reserve leaders in the fall of 2010 to discuss the study. It was determined that the study, as a CBPR project with the previously-secured backing of the Assembly of Manitoba Chiefs and its research ethics supervisors, was safe and in line with the community's health and youth development goals. The research team in Manitoba was made up of four researchers from the University of Manitoba, including the research lead, one postdoctoral fellow, and two undergraduate students, including the first author and a First Nations project advisor who, by virtue of a pre-existing relationship with key members of the community, played important roles in securing the partnership and in liaising between research staff and community partners. In cooperation with an on-reserve research liaison in Dakota Tipi who recruited youth participants for the program, the University research team assisted in the design and facilitation of the research intervention.

HLHE took place once a week over the course of six weeks at the band council office in Dakota Tipi. The intention was to create a culturally appropriate, peer-support based asthma intervention for young people in the community, with the additional goal of eliciting a better understanding of the specific challenges faced by asthmatic First Nations youth and their peers who live on reserve. The program was comprised of interactive educational sessions about asthma and health delivered by health professionals from Winnipeg integrated with cultural activities and teachings such as dance, prayer, and traditional medicine, which were facilitated by elders and other members of the Dakota Tipi community. The community partners who helped with recruitment, meals and facilitation were all given a stipend for their work and the youth participants were also given a $20.00 honorarium for each session that they attended. The youth recruited for the program (n=10) were all from the community of Dakota Tipi and between the ages of 10 and 18.

Adhering to a CBPR framework was key to gaining approval by the Assembly of Manitoba Chiefs and of practical importance to all parties involved in the HLHE project. The community leadership appreciated the open-ended nature of the project, which allowed for a great deal of adaptability in both the focus and methods of the study. The team encouraged Dakota Tipi to take an active role in the design, undertaking and evaluation of the project. For example, as a component of project dissemination and policy transfer, one of the youth participants in the HLHE program and his mother attended and presented at the province-wide Enigok Respectful Research Relationships Health Research Ethics Conference in Winnipeg (February 2012) organized by the Assembly of Manitoba Chiefs. In short, community and university researchers worked hard to develop a meaningful educational intervention that would benefit the community, acknowledging the CBPR principle of equally distributing the benefits of research.

The data reported on in this paper involved 1) on-site participant observation, 2) detailed field notes by the lead author from each week of the program, and 3) after the intervention, two one-hour focus groups conducted by the lead author with key adult stakeholders associated with the project in order to observe and evaluate the process of implementing the community health intervention as well as to document the perspectives and feedback of these community partners on the research process. It is important to point out that the small size of the community as well as the intimate nature of the research meant that community participants often played multiple roles that blurred the distinction between inquirer/inquired. As mentioned above, this blurring of roles is in fact a central tenet of CBPR, yet it also introduces challenges in reporting on methodological decisions and strategies, which tend to be more iterative and less linear than traditional research designs.

In the first focus group, Cameron[4], a community member and parent of a youth participant in the program and Betty, one of the program facilitators and also a parent of one of the youth participants were interviewed together during the last HLHE session to get their initial impressions of the project as two of the key stakeholders. Three weeks after the conclusion of HLHE there was another opportunity to conduct a second, larger focus group with community stakeholders which also included Cameron and Betty, as well as Doug, a Dakota Tipi council member who helped to plan and facilitate the cultural teachings component of the HLHE program; Grace and Sharon, community health nurses who attended two sessions; Ian, a staff at the band office who assisted with the design phase of HLHE; and Maria, a parent of two of the youth participants in the program who attended all of the sessions with her children. Focus group participants were asked open-ended questions pertaining to their perceptions of the project and their relationship with the university, the benefits and risks of university research partnerships and how they would like to see the research carried forward. All focus group

[3]The Alberta and Nova Scotia sites had research leads who worked with their First Nations partners and local Community Advisory Committees to design site-specific interventions based on cultural preferences, protocols, and priorities (see, for example, Watson and colleagues 2012).

[4]Pseudonyms have been assigned to all interview participants in accordance with the ethics protocol for the project.

data was digitally recorded, transcribed verbatim and analyzed through a process of open coding by the first author. All research outputs, including raw data, transcripts and final reports were reviewed by the team investigator and returned to the community at the conclusion of the project.

Findings

Analyses of field notes, participant observations and focus group data revealed that while community partners perceived HLHE to be successful overall, though there were concerns on behalf of the university research team about the uptake of the research findings as well as the sustainability of the partnership amidst a highly dynamic political climate in the community. Significant efforts were made both within and beyond the project to solidify the partnership, including frequent meetings, exchanges, and visits between both the university and the community. The following results highlight some of the key aspects of these experiences, which relate to both the content of HLHE as well as the process of establishing a partnership between a university researcher (and his trainees) and the community.

Interactive programming

The community members communicated that when they were first approached about bringing HLHE into their community, they had hesitations about what they assumed would be the content of the program. They described feeling as though it would primarily be made up of information sessions and interviews with the youth, with less emphasis on interactive activities. There appeared to be a general assumption that a university affiliated project would use more formal methods that youth were accustomed to seeing in school, which, the community partners explained, could be "boring". However, these hesitations dissolved once the program started and they saw that the research team was interested in incorporating community perspectives into the program. During the program, there was an observable change in the attitudes of the youth and adult participants as the weeks went on. At the first session, the lead author observed that many of the youth seemed shy and reluctant to participate, particularly during a small focus group activity where they were asked questions about asthma and allergies by the university researchers. In the following weeks, the youth began to warm up to each other and to the researchers, particularly when given the opportunity to participate in hands-on activities and games. As Betty, a parent of one of the youth involved in the program as well as one of our community partners expressed:

> When I first heard about [the program] I was expecting it to be more of a book thing. What I learnt about it is we're able to combine the culture, with the kids, and it was activities and it was a little bit of [the children's] own activities and culture involved... so in that way, [I was] a little bit hesitant when I first heard about it, to really overwhelmed with how well it went with both the culture and the university.

Doug, another community member who acted as a facilitator of many of the cultural activities in the program, stated:

> [At first] I assumed it was going to be more of an information session, based on the lungs, you know how the lungs operate and, you know, the deterrents, the pros and the cons, you know, but ultimately it became a lot more than that... that was the good thing about it because like Betty said, we had the dance, we had the games, we had our culture, all those components, you know, condensed into one.

Grace and Sharon both stated that the best feature of the program was the fact that it incorporated hands-on, interactive activities into lessons about respiratory health because the youth were more likely to remember the lessons if they were having fun. Ian, who played a role in the development of HLHE indicated that the program went "above and beyond" his expectations for the project. These responses indicate that some of the community partners had concerns about program content that were alleviated once the program started, but Betty and Doug's comments also suggest that the researchers could have worked more closely with the community in the lead up to the project to ensure that everyone had a clear idea of what the HLHE program would entail or, at minimum, express the fact that in CBPR, flexibility in design is a key hallmark of its success.

Community participation

Prior to the implementation of the HLHE program, an agreement was made between the community partners and university researchers that members of the community would be responsible for recruiting youth for the program and ensuring that consent was received from parents. This approach was effective due to the familiarity of the community partners with the children in the community and their established relationships. Betty, Doug and Cameron all described their own involvement in the recruiting process, explaining that they made an effort to make the community aware of the program and actively encouraged youth to participate. While they agreed that everyone was probably not aware of the program, they stated that almost all of the family groups in the community were represented by the youth that attended the HLHE program. This is indicative of not only the considerable effort made by the community partners but also the widespread support of the project by Dakota Tipi as a whole.

Doug explained that having a university-based research team implementing the program might have generated resistance or disinterest among some community members due to their lack of experience or familiarity with academic institutions. He suggested that parents who had been to university themselves would be more interested in exposing their children to such a project as they see it as a way to provide their children with a "better future". Similarly, Cameron described how they are working as a community to move past the residential school experience and motivate parents to prioritize their children's education:

> If you ask [parents in our community] what their top ten priorities are, because of the [residential school] experience, that

> negative impact, they will rate [education] in either 8th or 9th... today we've tried to ask them to move that, education, into their top three because we feel that education and learning... we have to change, whether we like it or not... we've got [parents] to this stage now, where we have the parents participating in parent teacher interviews, we have them participating in the initiatives that happen at school.

These responses from the community suggest that while a great effort was made to engage the community as a whole, the involvement of an academic institution in the project may have dissuaded some community members from participating or sending their children to the program. Cameron's point about the legacy and continuing influence of colonialism and the residential school experience in the community speaks to the importance for university researchers to be sensitive to how their presence could be affecting community dynamics.

The university research team worked closely with a small group of community members, including members of the band council, in the lead up and implementation of HLHE. As all meetings and activities took place in the band council office, there were few opportunities to interact with members of the community who were not involved in the project. In her field journal, the lead author expressed some discomfort about the uncertainty of how the project was perceived by the wider community:

> This is probably the most difficult aspect of the research for me – having an awareness about how our actions may unintentionally offend or anger people in the community and constantly questioning what might be appropriate.

Although all of her interactions with people in the community were positive, the lead author did have a sense that some members of the community were not interested in being involved with the project, which was their right. Broadening the community presence of the team was further challenged by internal politics and divisions within the small community. The short length of the HLHE program as well as the distance to the community limited the ability of the research team to gain a full appreciation of these local dynamics and to respond to them. By the end of the project, the formal leadership had changed, after which attempts to communicate with the new council went unanswered. We can only assume that our status as research partners was somehow connected to local politics of the community.

Incorporation of culture

Community partners also identified the active incorporation of their culture into program activities as an important aspect of its success. The university researchers made an explicit effort to help create a culturally relevant program for the community by suggesting that community members deliver cultural teachings related to health and traditional practices, such as dance, medicine and traditional ceremonies. This was done not only for the benefit of the youth but also the researchers, so that they could begin to gain an understanding of what kind of programming was relevant to the community. As Betty mentioned above, this showed the community that the research team had a genuine interest in learning about their culture, which helped to foster a relationship of trust, respect, and reciprocity. Additionally, she explained how the incorporation of cultural programming into the health oriented project provided an identity affirming experience for youth, as they were able to see the value of their cultural practices in relation to health and well being. During the traditional dancing demonstration in the fourth week of HLHE, the first author noted in her field notes that this activity was not only effective at connecting the themes of the program (healthy living and cultural integration) but noticeably contributed to the process of building relationships. She noted that some of the youth helped to lead the workshop, which gave them an opportunity to share something of importance to them while demonstrating their increasing level of comfort amongst their peers and the university researchers.

Doug, who led some of the cultural teachings, described how framing the program from a more traditional perspective allowed him to educate the youth about the cultural significance of items such as tobacco (a sacred traditional medicine in many First Nations cultures in Canada), which might be excluded from health and asthma education delivered from a western, or mainstream, perspective:

> In a sense you look at the tobacco and say, well, it's bad for all you kids, you know, this is detrimental to your lungs, the asthma, it can trigger all that. But in the same instance you want to say to them, it's not, because you're Dakota, it's traditional. You pray with it, it's an offering, you know, so teaching them that, the difference about it. And part of [HLHE] was that. And it did that, you know, to differentiate... the good and bad of smoke and the tobacco.

In this way, youth were allowed to see the important and positive role of tobacco in their culture, rather than only receiving information about how it was harmful to their health. This was an aspect of the program that was understood to be important by all of the community partners and the research team.

The theme of cultural exchange and maintaining a reciprocal research relationship throughout the process appeared to be important to the community. Community stakeholders in the program seemed to appreciate the fact that the research team had a genuine interest in learning about their culture and actively incorporating it into the HLHE program:

> The way we do things may be a little different than the way the university does things; we start off with a prayer, a smudge, and the children understood that. And it showed them that the [research team] was just as interested in learning and taking part in that... it wasn't something like ""Oh no we just want to do the interviews and that's it"... it was important for them to bring in the cultural side of it so that the kids can experience both (Betty).

The community stakeholders considered the university researchers as mentors and role models for the youth involved in the program regarding respiratory health. By the same token, the research team was able to demonstrate to the youth a willingness to learn from the youth about their culture by integrating activities such as traditional dancing and medicines in which the youth and other community members took a lead role. Thus, community stakeholders suggested that the research team was able to make the youth comfortable with the intervention and instil in them the confidence to one day pursue academic studies if they wanted to go down that path.

Building trust

The community of Dakota Tipi was accustomed to partnering and working with non-Indigenous groups and individuals from outside the community in the past and this relatively positive history (unlike other stories that form part of the collective Indigenous memory of wrong-doings on the part of non-Indigenous researchers, government agencies, and others in Indigenous contexts) was somewhat responsible for the willingness of community partners to trust the university researchers without being concerned about the risks that might result from such a partnership. However, the community stakeholders emphasized that it was important for the researchers to clearly communicate their intentions and not take advantage of the community's trust. Parents were able to decide for themselves whether their children could participate, giving them the autonomy to say yes or no to being involved. Betty also suggested that the process of gaining the trust of the youth participants was facilitated by delivering the program within the community in a space that they considered to be "their safe place".

Toward the end of HLHE, the lead author reflected in her field journal on the time required to build relationships based on trust. She noted in particular that sharing meals and joining youth in activities and games were "a really critical component of relationship building" noting that these things were essential to the project despite not necessarily being explicitly linked to the formal objectives of the project as a health intervention. Ultimately she felt that as a research team they had honoured their commitment to "delivering a culturally appropriate and community driven program" but at the same time it did not feel as though sufficient time was spent in the community to build the kind of relationships required for a CBPR project. This left the university research team with the feeling that more time and community consultation would have strengthened the project and resulted in a more successful outcome. However, with the change in leadership and the loss of key community contacts who had moved from the community, our own ability to sustain the partnership and continue the research gradually subsided.

To summarize, the feedback from the community partners indicated that they were impressed with the project overall and had a favourable opinion of working with members of the university. They each described an appreciation for the university researchers as partners and believed that the project, and the continuation of the partnership, could provide some tangible benefits to the community. The words of the community partners indicated a sense of ownership over the project, particularly in the way that the activities were delivered and in their ability to transmit cultural teachings to the youth through the project. But one important lesson learned as a consequence of the subsequent waning of the partnership was the importance of transcending the research moment to ensure that the lessons learned would be sustained in the longer term. The limited uptake of the project learnings in longer term community programming were at least in part a function of the lack of longer term research funds to support continued knowledge mobilization as an integral part of the project.

Discussion

There is an abundance of literature focused on the topic of building research relationships between Indigenous communities and (largely non-Indigenous) academic researchers, which commonly describes these relationships as being characterized by mutual trust, respect, communication and a balance of power (Louis 2007; Christopher *et al.* 2008; Bull 2010; Maar *et al.* 2011; Grimwood *et al.* 2012). These principles are of particular importance to CBPR projects, which depend on a high level of collaboration and cooperation to be successful. The centrality of relationships in research points to the need for researches to be attentive to how partnerships are established and maintained as their relationships with communities develop and evolve.

This paper is an analysis of the feedback provided by First Nations community partners about the process of building a relationship between the community and a research team (which represented one of many teams that do/do not take a CBPR approach from within an academic institution). A key outcome of this research was the ability to provide community partners with a forum in which they could evaluate and provide meaningful feedback about a project that took place in their community. Analysis of the data has also revealed that community partners considered the project a success and had some important insights into the process of building a respectful research relationship with university-based research teams that related to the need for trust, open communication, transparency, reciprocity, cultural relevance and tangible benefits for the community within the research project. While these findings are important, it is necessary to acknowledge that a university researcher facilitated the focus groups and as a result, community partners may have felt compelled to talk about only the positive aspects of the HLHE project and their partnership with the university. Further, the fact that this project had an economic benefit within the community is another dimension to consider with respect to the responses provided by community partners. There is certainly value in reflecting on this aspect of the research methodology and exploring alternative ways to collect feedback in the future that might be more comfortable for community partners to share critical perspectives.

This research provides useful insights for health practitioners and academics who are implementing health promotion interventions for youth living in Indigenous communities in Can-

ada as well as Indigenous communities elsewhere in the world. In addition to the well-understood necessity of developing relationships grounded in trust and reciprocity, this study has revealed some important factors that can act as both encouraging and inhibiting agents in the process of building a relationship. In terms of encouragement, the way that the HLHE program incorporated the First Nation's culture and traditional knowledge showed the community partners that the research team not only recognized the value of programming that is culturally relevant but also that the researchers wanted to learn from the community. The symbolic as well as the tangible significance of this aspect of the project cannot be overstated. Indigenous methodologies in research seek to preserve, maintain and restore traditions and cultural practices (Louis 2007). The HLHE project became oriented toward this goal as it helped to facilitate an environment in which the community of Dakota Tipi could transmit traditional teachings about health to their youth.

With respect to inhibiting aspects of the study, the involvement of a university-based research team in this (or any) project was identified as a factor that may have generated resistance among some members of the community. The legacy of colonization continues to pervade the lives of indigenous peoples and the historical and intergenerational trauma of the residential school system has entrenched feelings of distrust or anger toward education systems and other institutions of power among many members of Indigenous communities in Canada (Silver *et al.* 2002). As described by some of the community partners, this distrust can act as a barrier to participation in university-led research for some people in the community. Grimwood and colleagues (2012), among others, suggest that academics need to adopt a reflexive perspective and recognize their role as affiliates of an institution that has historically abused its power and caused harm within indigenous communities. Considering this will not only prompt reflection about how and why a research relationship is established, but it will also aid researchers in understanding why they might encounter resistance from individuals or struggle to establish relationships within Indigenous communities. Even when there is broad support for a research project, as was the case in Dakota Tipi, academic researchers must be sensitive to how their presence in communities might have an impact on underlying community dynamics, which may not be immediately apparent to them as outsiders in the community.

Our findings are not intended to account for the effectiveness of our asthma intervention, nor to provide a list of best practices or guidelines in building research relationships with all Aboriginal communities. Rather we have demonstrated the value of receiving feedback from community partners during and at the conclusion of a project as well as to highlight some of the factors that contributed to a relatively successful partnership with Dakota Tipi. Our results are context specific, and the researchers recognize that much of the success of the project can be attributed to the initial openness and comfort level of Dakota Tipi leadership with the presence of a university-based research team in their community. There are several possible explanations for the receptiveness of the community to the project. As mentioned earlier, conversations with community members revealed that at least some of them were accustomed to cooperating and working with outsiders to the reserve, likely due to the proximity of the reserve to the city of Portage la Prairie as well as its relative closeness to Winnipeg. The community partners had a positive perspective of working with the research team from the outset and perceived the research as a tool for improving the well-being and increasing the capacity of the community. This may not be the case for other communities; therefore, the results of this research are only meant to advance some new perspectives for consideration prior to establishing research partnerships and developing health interventions in Indigenous communities as well as monitoring the process during the research and evaluating the process and outcomes after the project has concluded.

Limitations

There are several key limitations within this study that must be acknowledged, which relate to funding, time, and physical location. First, funding for the HLHE program came from a Network Centre of Excellence (AllerGen), an outside source, which imposed certain financial limitations and time restrictions on the research activities. Second, the considerable amount of time that it took to establish a partnership with the community vis-à-vis the Assembly of Manitoba Chiefs and subsequent ethics approval (at least one year in total from the initation of the project) meant that there was less time to establish meaningful relationships and work on the development of the program alongside Dakota Tipi community members. Third, the distance of the reserve from the university also imposed limitations on the frequency and number of visits that researchers could make to the community. This point is not meant to lay blame, but simply to state the widely recognized reality, and challenge, of conducting community based participatory research according to the frameworks and timelines set out by institutions and funders. As the third author recently reported with respect to CBPR in general, many such researchers "spen[d] the first year drinking tea" (Castleden *et al.* 2012).

A fourth limitation of this study relates to the small-scale, exploratory and participatory nature of the HLHE project. The small size of the focus groups as well as the overrepresentation of the voices of Cameron, Betty and Doug is in part due to the small size of the Dakota Tipi community as well as the fact that these three participants were the most directly involved in all aspects of the development of the research partnership and delivery of the HLHE project. Two one-hour focus groups allowed for community stakeholders to provide feedback on all aspects of the research process; however, more follow-up visits to the community would have certainly added depth and detail to the results, and perhaps could have allowed community partners to assist in the analysis of the data and further cemented growing trust relationships (see limitations 1-3). Cameron, Betty and Doug's perspectives were nonetheless incredibly valuable given their multiple roles within the project, as community leaders, research liaisons, project facilitators and parents of youth participants. For this reason, the fact that they provided the most

feedback within the community can be seen as an advantage more so than a limitation.

Finally, the larger project's research team, representing multiple institutions, conceived of the project and sought funding for it in advance of approaching communities for partnership to participate in the project. The implications of this scenario are clear: a power imbalance was immediately imposed with the research team being in control of conceptual design and the project funding; thus, the conceptual and methodological approach were not initially designed with the needs or concerns of the community in mind. That said, efforts were made following the establishment of the partnership with Dakota Tipi to include community members in designing and implementing the activities of the program (as well as with the other sites in Nova Scotia and Alberta); however, it might still be argued that such an approach is not completely aligned with the methods of CBPR as they are commonly understood. This limitation exposes a widely debated "Catch 22" in CBPR – whether to seek community support first and burden them with the many hurdles of grant applications when the probability of securing funding is tenuous at best, or to take on this initial burden and approach potential partners when the project is certain (Castleden *et al.* 2012).

Conclusion

According to Shnarch (2004), "the problems with research stem from who is in control" (83). Health researchers working within Indigenous communities must be cognizant of the dangers of reproducing colonial relations or deepening power imbalances between researchers and communities through their work (de Leeuw *et al.* 2012). The motivations for this study emerged from the first author's interest in achieving a deeper understanding of the many ways that academic research can unintentionally cause harm to Indigenous communities and, alternately, the ways by which it can become a useful and meaningful tool. Through critical observations of the project and an analysis of the feedback provided by community members, we were encouraged by hearing that a relationship cultivated between the research team and Dakota Tipi was grounded in mutual respect, trust and reciprocity. It became clear that, while it was not without faults and limitations, the HLHE program had succeeded in producing a meaningful health intervention for community partners, it laid the foundation for potential mutually-beneficial research partnerships in the future, and perhaps most important (at least to the research team), a set of new relationships from which to grow in mutual understanding and respect.

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Intensification and neoliberalization: A case study of planning policy in Winnipeg, Canada, 1990-2013

Trevor James Wideman
Department of Geography, Queen's University

Jeffrey Masuda
School of Kinesiology and Health Studies, Queen's University

The City of Winnipeg, in its most recent planning document, OurWinnipeg*, has adopted a policy of urban intensification, a process that creates higher-density development in existing neighborhoods as an alternative to low-density suburban sprawl. This strategy is said to provide both socioeconomic and environmental benefits to communities, but it is unclear whether* OurWinnipeg *represents an effort to improve social conditions, or if it reflects a neoliberal philosophy of capital generation. This study set out to explore this tension through a combination of literature review, policy comparison, and key informant interviews. The results revealed that Winnipeg's planning structure has moved toward a neoliberal model over the past twenty years, and that 1)* OurWinnipeg's *policies fail to protect low income residents from gentrification-driven displacement; 2) ambiguous planning goals downplay infrastructure deficits in impoverished neighborhoods in favour of vague commitments to infill development; and 3) social supports are being reduced as responsibilities are offloaded to volunteers and community organizations. This research provides a basis for further investigation of the neoliberalizing consequences of intensification in Winnipeg, including a critical assessment of financial versus social capital driven planning and the concomitant subordination of the needs of the poorest citizens to the interests of market imperatives.*

Keywords: Winnipeg, city planning, intensification, neoliberalism, policy change

Introduction

Over the past decades, cities across the globe have begun to explore strategies for improving and revitalizing urban space as a response to the decline of inner cities in the face of rapid and expansive suburban sprawl (Isin 1996; Karlenzig 2012). At the same time, many cities have observed a growing social polarization and shifts in the political and economic climate as a result of globalization and increased competition between urban agglomerations (see Harvey 2009, 2012; Robinson 2011; Peck 2012). The City of Winnipeg, Canada, is no exception to these trends, and over the past few decades it has grappled with an exceptionally high level of inner city poverty, a decline in the quality of available housing stock, and a large infrastructure deficit that has been exacerbated by continued development pressures on the urban fringe (see Silver and Toews 2009; Cooper 2011; Social Planning Council of Winnipeg 2012).

To respond to these mounting issues, city planning has been mobilized to generate creative solutions, even as the city's population and economy have exhibited a marked pattern of "slow growth" over the past thirty years (City of Winnipeg 2000, 2011; Leo & Brown 2000). Indeed, this absence of rapid growth has historically been a cause for panic among both planners and policymakers in the city, though evidence suggests that growth may be increasing due to a continuing influx of international migrants and a newfound faith in the downtown core as a centre of economic revitalization (Leo & Brown 2000; Milgrom 2011; Suzuki 2013; Syvixay & McCullough 2014). Winnipeg's post-

1990 planning responses can be divided into two overlapping eras. The first era used a socially conscious, community-based model that was concerned with neighbourhood well-being and maintenance of essential services (see City of Winnipeg 1993, 2000), while the second prioritized large scale economic growth as a key to community revitalization (City of Winnipeg 2011). These eras reflect Winnipeg's changing political climate through three distinct mayorships, while also revealing a city that is becoming increasingly indebted to neoliberal modes of governance that privilege free-market competition and growth in day to day government operations (see City of Winnipeg 1993, 2000, 2011; Cooper 2011; Manitoba Historical Society 2012).

A key focus of this most recent era of planning in Winnipeg, as outlined in the 2012 plan *OurWinnipeg*, is the promotion of *intensification* as a key component of neighbourhood renewal (City of Winnipeg 2011, 2012a). This process has been utilized in cities as diverse as London (Davison 2012), Auckland (Carroll et al. 2011), and Toronto (Curic and Bunting 2006) to promote higher-density development in both existing residential neighbourhoods and on unused industrial lands as an alternative to low-density urban sprawl (Canadian Urban Institute 1991; Tomalty 1997; Filion et al. 2010). Advocates and scholars have identified many socioeconomic and environmental benefits that can accrue to cities that adopt intensification, such as closer communities, increased commercial activity and reduced reliance on cars (Daly and Milgrom 1998; Karlenzig 2012). On the other hand, researchers have criticized the ambiguity of many intensification policies (Campsie 1995), and identified their potential for exacerbating social inequalities and promotion of market-rate housing over affordable properties (England 1996; Leinberger 2008).

This article interrogates the City of Winnipeg's adoption of intensification as a revitalization strategy through a critical empirical examination of the discursive policy transformations inherent in the two eras of planning identified above. By examining the city's current plan (*OurWinnipeg*) and comparing it with two previous city plans from 1993 and 2000, we put forward a case study that demonstrates these policy changes. We also link Winnipeg's recent adoption of intensification to the broader process of *urban neoliberalization*, which we define as a variegated and hybrid process of market-based socio-spatial urban transformation based in intercity competition, privatization, and quick-fix policy regimes (Brenner and Theodore 2002; Peck and Tickell 2002; Wilson 2004). Furthermore, we draw on findings from a series of informal key informant interviews that reveal key insights into policy changes, development strategies, and intensification in Winnipeg. By using these strategies, this article will contribute to existing theoretical and empirical scholarship on urban neoliberalism (for example Boudreau et al. 2009; Peck and Tickell 2002; Peck et al. 2009) by revealing a case of neoliberalism in the making and illuminating the possible effects of intensification under a neoliberalizing policy climate.

Background

Research Context

This article is the result of a mixed-method study conducted from May 2012 through April 2013 that involved an examination of Winnipeg's city planning documents. We contrasted the current city plan, known as *OurWinnipeg*[1] (City of Winnipeg 2011) with earlier city plans, namely *PlanWinnipeg… Toward 2010* (City of Winnipeg 1993) and *PlanWinnipeg 2020 Vision* (City of Winnipeg 2000) to identify key changes in planning priorities over the past twenty years. We chose these three documents because: 1) Winnipeg planning documents written prior to 1993 proved difficult to obtain; 2) the time constraints of the project did not allow for the review of more than three plans; and finally 3) the literature review revealed that the use of intensification as a planning and development strategy became much more widespread in the early 1990's, around the time that *PlanWinnipeg… Toward 2010* (City of Winnipeg 1993) was written, making it the ideal starting point for this study.

To augment the document analysis, the first author engaged several key informants (N=10) in informal interviews to gain insight into how Winnipeg's planning strategies have changed over time, and reveal why the city is now adopting intensification as a tool for urban growth. Participants (city planners (N=2), property developers (N=1), non-profit employees (N=4), and academics (N=3)) were contacted using a snowball sampling technique, and they provided a diverse range of opinions on how intensification is currently being used as a development technique in Winnipeg, as well as valuable background information on the *OurWinnipeg* document. The informants identified a variety of economic, environmental, and social concerns faced by the city, and were able to contrast these issues with the ambitions of the *OurWinnipeg* city plan. Two of the samples had to be excluded due to the fact that city employees were unwilling to have their interviews used for analysis, however, academics and NGO employees were willing to go on record and have their interviews used as research material. These 30-60 minute interviews were unstructured and were not recorded, and key points were written down immediately following the interview.

There were two significant limitations to this interview program. The first was the small sample size, which was unavoidable due to the time constraints of the project. Interviews with architects, realtors, and business people would have lent weight to the findings and allowed a more holistic analysis to emerge. However, we believe that the key informant sample was useful because interviewees possessed a significant longitudinal knowledge of planning and policy in Winnipeg over the past thirty years, as well as a deep understanding of the current planning and development context. Second, while the fact that city employees were only willing to speak off the record is problem-

[1]Note: throughout this study, the term *OurWinnipeg* is used to refer to the policy document of the same name, and all sub-documents under the *OurWinnipeg* planning banner (i.e. *Complete Communities and Report to the Community 2012*).

atic, we chose to highlight the secrecy of these participants because we believe it represents a general concern among planners that personal opinion might unwittingly come into conflict with city hall agendas, leading to possible issues around job security. We also believe it highlights how the transformation of planning and policy in Winnipeg is a contested, uneven, and incomplete process, even among its facilitators.

We used the interviews and document analysis to create a case study that demonstrates how Winnipeg is using intensification as a tool on a local scale, while also identifying a growing neoliberalization of the city's broader planning goals and policies. We then used a geographic information system (ArcGIS) to map the locations that the City of Winnipeg has specifically targeted for revitalization to provide a visual commentary on the city's investment priorities and contextualize the development narrative that has been advanced in the *OurWinnipeg* document. Importantly, the techniques employed in this study allowed us to compare Winnipeg's planning goals with the physical effects of planning policy, both historically and currently.

History of intensification planning

Since the 1980s, much research has been done into the process of urban intensification, a city planning practice that saw its genesis in reactionary movements opposed to suburban sprawl (Isin 1996). Early scholarship on intensification (pre-2000) can be divided into two distinct waves that demonstrate significant differences in how the process was conceptualized, mobilized, and critiqued.

The first wave of research focused primarily on defining intensification and hypothesized the effects that the process would have on the urban structure. This literature promoted the development of unused (or underused) lands within city limits using techniques such as infill housing, building conversions, and redevelopment to create higher population densities (Canadian Urban Institute 1991). When implemented in this manner, intensification was posited to have environmental benefits in the form of reducing vehicle trips to and from the suburbs, social benefits in terms of closely-knit communities, and economic spinoffs like increased commercial activity and redevelopment of derelict areas (Emeneau 1996; Greenbelt Alliance 1996). In this early era, many cities were still pondering whether to promote density, and intensification talk had a primarily positive spin (see Canadian Urban Institute 1991; Metropolitan Toronto 1991; Filion et al. 2010).

Unsurprisingly, this early era of boosterism ushered in a second wave of scholarship that was highly conflicted over the stated benefits of the process. As intensification swiftly became an indispensable part of the planning lexicon, academics began to investigate the unproven benefits and imprecise goals of many proposed schemes (see Campsie 1995; Breheny 1997; Tomalty 1997; Jenks 2000). What this literature discovered is that the theorized environmental, economic, and social benefits of intensification came up against some severe structural constraints when implemented on the ground. For example, early assertions of sustainability were offered with little supporting evidence (Jenks 2000), and though intensified areas supported increased transit use and fewer car trips (Daly and Milgrom 1998), increases in density were often accompanied by increased environmental health risks such as site contamination and decreased air quality, a situation that counteracted some of the beneficial environmental claims of intensification advocates (Tomalty 1997). In addition, researchers challenged the claim that intensification would have economic benefits (such as decreased infrastructure costs, increased employment, and higher property values, see Daly and Milgrom 1998), claiming that the process undermined market demand for low-density suburban housing (Gordon and Richardson 1997). Finally, theorized social improvements like decreased segregation, improved access to facilities, and community cohesion (Daly and Milgrom 1998; Burton 2000) were often negated by a lack of affordable housing (England 1996), higher crime rates (Naismith 1996), and increased neighbourhood conflict over infill development (Tomalty 1997). Indeed, many intensification projects attracted young, middle to high income professional residents to exclusive market-rate properties like condos or gated communities, further undermining the claim that density could generate social balance (Campsie 1995; Gordon and Richardson 1997; Tomalty 1997; Daly and Milgrom 1998). Though these critical responses revealed significant drawbacks to intensification planning as it was originally conceptualized, high-density infill development remained an important aspect of urban revitalization in many cities across the globe, continuing into the present day (see Davison et al. 2012).

Intensification and planning in the neoliberal city

Though the use of intensification as a city planning strategy has been highly criticized, it continues to be widely used. This sustained use can be partially explained by the development of intensification planning under global neoliberalism, which is a theory that applies market logic to all sectors of society, including government operations (see McCann and Ward 2011). However, neoliberalism is more than just an ideological project. It is, as Brenner and Theodore (2002) assert, "a historically specific, ongoing, and internally contradictory process of market-driven sociospatial transformation" (p. 353) that facilitates material changes in the urban fabric. Under neoliberalization, the reality of place competition between cities has exerted enormous pressure on urban areas to attract investment, marketize space, maximize their corporate value, and increase tax revenues (Brenner and Theodore, 2002; Wilson 2004; McCann and Ward 2011). Therefore, local government becomes "a facilitative, rather than regulatory, apparatus, behaving like a business to attract and support capital, rather than to promote welfare" (McCann and Ward 2011, xviii). This prioritization of economic competitiveness requires long-term planning policies and strategies that mobilize government power to improve efficiencies allow for the free flow of capital (Purcell 2009; Wilson 2004). Under a neoliberalizing urban policy regime, planning documents begin

to prioritize the language of change, growth, and competition, reflecting an urgency of the part of local governments to present themselves as dynamic investment opportunities (see Brenner and Theodore, 2002; McGuirk 2005; Peck 2012). Using this logic, intensification appears to be an ideal strategy for transforming underused, neglected, and vacant properties into economically productive urban assets. However, the densification of urban space is often at odds with community interests and needs (see Davison et al. 2012). On one hand, wealthier neighbourhoods often oppose this type of development due to fears over loss of green space, higher crime rates, decreasing property values, and the unspoken social change that happens when new people move into a neighbourhood (Curic and Bunting 2006). On the other hand, lower-income areas have voiced concerns over lack of affordable housing, removal of supports for families with children, and the incompatibility of new developments with the physical and social fabric of the existing community (Nelson 2010; Carroll et al. 2011; Davison 2011).

For development schemes to become acceptable to the public, neighbourhood opposition has to be contained, and city planners have to facilitate development in a way that lends credence to resident concerns (Daly and Milgrom 1998; Davison 2011; Davison et al. 2012). As a result, planning efforts have become more organized, and community needs are now frequently assessed through comprehensive community consultation strategies that are tailor made for specific jurisdictions (Curic and Bunting 2006; Davison 2011). Furthermore, these consultations are often accompanied by project evaluations, reports, and supplementary exercises that allow for public feedback before, after, and during each planning stage (Davison 2011; Davison et al. 2012; Parker 2012), allowing planners to exchange knowledge on proposed developments with the public (Purcell 2009; Gunder 2010). Gunder (2010) identifies these "communicative planning" (303) processes as playing a key role in how cities govern space through land use policy: though they appear to be participatory and democratic, they fail to challenge authority while embedding neoliberalized policies into planning initiatives. In theory, citizens have the freedom to exercise their democratic right to oppose planning, yet in many cases, planners are implementing unquestioned and normative forms of planning without allowing for alternative viewpoints to emerge (Winkler 2012). In a case such as this, planning appears to enable community empowerment (Gunder 2010); while in fact, public consultations often serve to legitimate the adoption of preapproved planning policies (Purcell 2009; Parker 2012; see also Barnett and Scott, 2007).

While neoliberal policies are designed to facilitate the accumulation of capital, they often do so in a flexible manner, and as a consequence, planning policy often relies on a series of suggestions for urban development, rather than relying on explicit goals (see McLennan 2004; Peck 2012). As McGuirk (2005) demonstrates, urban planning documents frame this policy flexibility as beneficial, since it allows cities to respond to changing needs while facilitating "local capacity building" (64) and encouraging social, environmental, and economic sustainability. On the other hand, this lack of a clear policy direction potentially allows for the social needs of a population to be circumvented at the expense of increased capital accumulation (McCann and Ward 2011).

This study suggests that the concept of intensification is being co-opted and mobilized by planning processes to marketize and redevelop urban space in the City of Winnipeg at the expense of resident needs. In addition, the use of intensification as a development tactic has evolved in tandem with an increased neoliberalization of policy that is reflected through repeated changes in Winnipeg's planning goals over time. However, it is not my intent to place Winnipeg's neoliberal transformation in a vacuum. Winnipeg, as with other cities in Canada, is greatly affected by political transformations that occur at the provincial and federal levels, and its governance structures and policies are circumscribed by these shifts (see Boudreau et al. 2009). As Boudreau et al. (2009) note:

> What happens in cities regarding their economic growth, social and environmental sustainability, and human security is governed by processes that combine dynamics at different scales of socio-spatial activity. This seems to be particularly true for the case of Canada with its complex system of federalism, which necessitates multi-level cooperation between governments and social institutions. (20)

Cooper (2011) highlights how the progressive neoliberalization of federal and provincial policies over the past 30 years have resulted in an abrogation of state responsibility for social welfare and housing, a situation that has had drastic effects on Winnipeg's municipal priorities and on the state of the inner city. The rolling back of state support has forced cities like Winnipeg to prioritize homeownership and gentrifying development processes as market solutions to problems once addressed by upper levels of government (Cooper 2011). With multiscalar processes such as these in mind, this article critically examines Winnipeg's implementation of intensification policy while more fully elucidating the potential effects of neoliberal planning techniques on Winnipeg's urban space in an effort to encourage positive future change at the neighbourhood scale.

Results

Planning policy in Winnipeg: Then and now

The City of Winnipeg updates its planning documents approximately every ten years to keep policies current and attempt to ensure they reflect the changing needs of the city, and in 2011 a new city plan known as *OurWinnipeg* was implemented upon the expiration of the previous city plan, *PlanWinnipeg 2020 Vision* (2000). These ten-year planning reevaluations often coincided with changes in municipal government: *PlanWinnipeg… Toward 2010* (1993) reflects the city's priorities under Mayor Susan Thompson, while *PlanWinnipeg 2020 Vision* (2000) and *OurWinnipeg* (2011) were implemented under Mayors Glen Murray and Sam Katz respectively (see City of Winnipeg 1993; Manitoba Historical Society 2012). Robinson (2011) notes that

this is a typical situation for many cities: though most update their planning policies at regular intervals, large-scale reevaluations often occur during changes in civic governance, shifts in the balance of political power. However, as previously noted, civic decision making is always constrained by policy decisions at upper jurisdictions (see also Boudreau et al, 2009), which makes it impossible to point the finger at any one Mayor as the 'cause' of a particular political transformation.

OurWinnipeg (2011) is now the current master-planning document for the City of Winnipeg, and it has been created to guide the city's long-term development while serving as a reference for city planners, government officials, and citizens alike. Moreover, it is the first Winnipeg city plan to be developed as a collaborative document, taking into account the advice of professional city planners while including the voices of ordinary citizens through the *SpeakUpWinnipeg* program, a public consultation initiative that asked the citizens of Winnipeg for recommendations during the planning process (City of Winnipeg 2011). Although *OurWinnipeg* states that the *SpeakUpWinnipeg* consultation was an unprecedented and novel process (City of Winnipeg 2011, 21), popular participation in decision-making is a hallmark of current city planning strategies, and it frequently occurs at times of change in order for city governments to understand what the general populace is thinking about urban planning issues (Purcell 2009; Robinson 2011). *OurWinnipeg* (2011) bases many of its land use and development recommendations on the feedback provided at consultation meetings, as well as on a population projection that states that the city will need to house approximately 180,000 new residents in the next 25 years. As a consequence of this stated need for housing, the plan encourages higher-density development as a means to create neighbourhoods that allow for economic and demographic growth while remaining socially and environmentally sustainable (City of Winnipeg 2012a). However, the new planning policies touted in the *OurWinnipeg* plan raise significant concerns related to social equity, especially when comparing the document to the previous two plans (see Table 1 for a summary of the key differences).

The earliest plan examined in this study is *PlanWinnipeg… Toward 2010* (1993), which clearly states its intentions in terms of social equity and the built environment:

> The prosperity of a city is reflected in the opportunities afforded to its residents. In most major urban centres, including Winnipeg, opportunities are not being shared equally. These inequities are rooted in certain attitudes and practices which restrict the participation and inclusion of large numbers of people. *PlanWinnipeg* must influence these attitudes and practices because of their social consequences. As such, the document can guide not only the city's development but it's social development as well. (55)

This general sentiment is followed by specific statements that show how the city will actively respond to demographic changes, provide shelter to the neediest residents, reduce intolerance, develop community services and facilities, ensure educational needs are met, deliver employment opportunities, provide essential services, and improve personal safety (City of Winnipeg 1993). Along with these detailed goals, the document explicitly proposes to provide support for the growing Aboriginal population, ensure accessibility for disabled residents, and help immigrants to transition to life in Winnipeg (City of

Table 1
Summary of key differences between Winnipeg city plans.

	Plan Winnipeg… Toward 2010 (1993)	Plan Winnipeg 2020 Vision (2000)	OurWinnipeg (2011-2012)
1. Population Expectations	- Slow Growth - Declining Housing Demand - Low Household Formations	- Flat Growth - Positive Migration Projections - Future Population Growth	- Increased Growth - Very Positive Forecasts - Current Population Growth
2. Key Goals	- Good Management - Quality Customer Service - Sustainable Development - Healthy Community	- Sustainability - Social Consciousness - Thoughtful Development - Partnership and Collaboration - Healthy Living - Local Empowerment	- High Quality of Life - Sustainability - Access to Opportunity - Healthy Neighbourhoods - Creative City
3. Economy	- Support Innovation and Technology - Attract New Industry - Strong Commitment to Local Business	- Sustainable Growth - Attract New Industry - Prioritize Local Business - Long-Term Planning	- Sustain Prosperity - Build Confidence - Improve Global Economic Image - Strong Economy = High Quality of Life
4. Environment	- Sustainable Development - Preventative Measures - Positive Action - Long-Term Planning	- Individual Stewardship - Holistic Environment - Link Between Natural & Built	- Value & Respect for Environment - Sustainability Good for Business - City as "Green" Corporate Role Model
5. Social Equity	- Equitable Access to Services - Ensure Public Safety - Ensure Freedom from Intolerance	- Promote Equitable Access - Remove Barriers - Accommodate Cultural Needs	- Foster Inclusion - Support Diversity - Engage Newcomers - More Opportunity = More Competive
6. Urban Development	- Support Neighbourhoods - Recognize the Role of Downtown - Maintain Infrastructure	- Prioritize Transport Infrastructure - New Approaches to Land Use - Maintain Infrastructure - Encourage Diversity	- Urban Design - Variety of Housing Styles - Transportation Options - Suburban and Urban Balance
7. Urban Image	- Project Positive Image - Celebrate Environment - Positive Lifestyle - Diversity - Quality of Life	- Good Opportunities - Diversity - High Quality Environment	- Create Attractive & Competitive City - Enhance Infrastructure - Build Complete Communities - Improve Image

Winnipeg 1993). The plan is equally inclusive when describing development strategies, encouraging a policy of neighbourhood management that recognizes the diversity and uniqueness of communities by encouraging resident pride and commitment to support gradual change (City of Winnipeg 1993).

> The City seeks to manage urban development and change in a manner that supports its neighbourhoods, that recognizes the vital role of its Downtown, and that promotes the efficient, effective, and appropriate use of regional and local services and facilities. (73)

The concept of mixed-use is promoted in this document, but in a balanced context, supporting revitalization and intensification only if desired and deemed appropriate to the community (City of Winnipeg 1993), and as one informant revealed, many of these progressive ideals did not come to pass due to lack of financial resources and political will on the part of government (A007[2]).

Seven years later, *PlanWinnipeg… Toward 2010* was replaced by the document *Plan Winnipeg 2020 Vision* (City of Winnipeg 2000), which displayed several subtle differences. Here, the city is still providing the residents with specific goals that need to be achieved, but now the language of economic growth and change has begun to seep into the city's plan, as opposed to simply promoting maintenance and stability (City of Winnipeg 2000).

> Pursuing economic opportunity is a cornerstone of responsible government, and while attracting new business investment to Winnipeg is important… the primary source of economic growth will be our own local economy. Sustainable economic development reflects the belief that economic growth and environmental protection should be complementary objectives. This also conveys the sense that long-term growth is a higher goal than short-term growth. (24)

Much of the plan's overall message stays the same from 1993, as does the city's vision statement, however, neighbourhoods now have an even greater significance than they did in the previous document, and revitalization of downtown is seen as paramount (City of Winnipeg 2000). Significantly, inclusivity and equity are prioritized, and the city sets specific objectives for itself in its quest to achieve improved conditions for impoverished residents:

> The City shall provide leadership in addressing social concerns by: striving to eliminate all forms of discrimination; addressing illiteracy through public library services and encouraging literacy programs in partnership with other stakeholders; and encouraging initiatives aimed at eliminating child poverty including working with the senior levels of government. (21)

The discourse of intensification in *2020 Vision* is much more prominent than in 2010: here, the City of Winnipeg (2000) begins to prioritize density in its planning doctrine, asserting that it will promote "orderly development" (30), "compact urban form" (22), and "regional consistency" (31). The plan continues to be highly goal-oriented, stating that activities will be monitored through reports, and the plan's progress will be measured by evaluating key indicators (City of Winnipeg 2000). In contrast to these two documents, the current document (*OurWinnipeg*, City of Winnipeg 2011) contains planning policies that use more ambiguous language and display a lack of clearly defined goals (see Table 1).

OurWinnipeg's planning policies: Potential effects

The commodification of urban space. OurWinnipeg (2012a) identifies certain sites within the city that have a great capacity for change and can be altered into complete communities through intensification (City of Winnipeg 2012a). Known as "*transformative areas*" (10), these locations are prioritized for development in the current plan due to a large projected influx of population and the need to maintain growth within city limits, whereas population growth in previous years had been slow or stagnant (see City of Winnipeg 2011, 7-8). Transformative areas are depicted as requiring reinvestment, revitalization, and promotion, language that reflects their value in the property market and frames them as commodities with profit making potential (City of Winnipeg 2012a). Particularly telling is the language surrounding neighbourhood redevelopment, which seeks to create stable communities through "predictability" and investment (City of Winnipeg 2012a, 16), suggesting that increased commercial and residential activity will make for better neighbourhoods. While the plan recognizes that each neighbourhood is different ("fostering complete communities requires unique policies for different parts of the city", 33), the plan's vision for the future city appears to be more homogeneous than heterogeneous (City of Winnipeg 2011). This is demonstrated visually through the graphics accompanying the *Complete Communities* subdocument (City of Winnipeg 2012a), which depict a variety of derelict or underdeveloped neighbourhoods being transformed into mixed-use neighbourhoods filled with cafes, restaurants, shops, and high-end department stores replacing warehouses, strip malls, gas stations, and cheque cashing businesses. Existing communities are now revealed to be inadequate, and their incompleteness is stated to be a barrier to Winnipeg's becoming globally competitive (see also Hugill and Toews, 2014).

> A key to making our city attractive and competitive will be to create 'complete communities' and to ***complete existing communities*** by enhancing existing infrastructure and assets… To accomplish this, growth will be focused on areas that will best respond to city-building objectives, including social, economic, and environmental sustainability. (33, emphasis mine)

[2]References in this format refer to key interview testimony. Individual identities have been protected using a series of codes.

In addition to this increased marketization of space, the city is now described as a "corporate role model" (City of Winnipeg, 2011, 3) rather than a representative governing body, and the ultimate implementation of planning initiatives is stated to be subject to market based incentives and an ill-defined community of stakeholders (see City of Winnipeg 2012a, 136-141). Increased economic activity also depends upon attracting a "skilled workforce" which desires a certain "quality of life" (City of Winnipeg 2011, 24), rather than supporting the needs of existing residents. From these quotes, it appears that the economic development of transformative areas may be prioritized at the expense of equitable community development, ignoring the need for improved social infrastructure in existing neighbourhoods and doing little to ensure that current resident needs are met. While these interventions are meant to apply at the local scale, they are derived from a much broader neoliberal policy script. As Brenner and Theodore (2002) note, neoliberalized spatial interventions require a "retreat from community-oriented planning initiatives" to move toward the "creation of new privatized spaces of elite/corporate consumption" and the implementation of projects that might "attract corporate investment and reconfigure local land-use patterns" (371). These economic and spatial readjustments are integrally linked to *gentrification*, a process where existing residents of a community are squeezed out to make room for higher-income demographics (Smith 1996; 2002; Slater 2007). Significantly, Quastel (2009) illustrates how gentrification often goes hand in hand with intensification, an observation that further exposes the problematic nature of Winnipeg's proposed planning framework. Indeed, the intensification proposed by *OurWinnipeg* appears to rationalize gentrification processes that are already occurring in several Winnipeg neighbourhoods. Two of the key informant interviews revealed that lower income residents are being forced out of affordable areas of the city (A007; A010). Indeed, new-build condos, condo conversions, and higher-end businesses are fast replacing rental units and community-oriented services in many neighbourhoods (A007; A010, see also Social Planning Council of Winnipeg 2012). As Smirl et al. (2012) empirically demonstrate, these gentrifying processes are occurring in inner city communities like Spence, West Broadway, and Daniel MacIntyre, slowly shifting the demographics of these primarily low-income neighbourhoods and lowering the stock of affordable housing in the city.

Balanced growth is undermined by imprecise goals. The new city plan states that intensification will allow for economic and demographic growth while keeping the city socially inclusive and environmentally sustainable (City of Winnipeg 2012a), but there are no clear objectives (Salakoh 2012). In fact, as one key interviewee stated, it is difficult to understand what the plan's main focus is, because the language describing the complete community is nebulous and most of the goals have soft-targets (A009).

> Complete communities are places that both offer and support a variety of lifestyle choices, providing opportunities for people of all ages and abilities to live, work, shop, learn, and play in close proximity to each other. *OurWinnipeg* (City of Winnipeg 2012a, 4)

This noble, yet elusive sentiment is complemented by the city's statement that complete communities (which may or may not be intensified neighbourhoods), must have the necessities of life "within reach" (4), however, *OurWinnipeg* declines to comment on actual distances to amenities, or acknowledge the challenges faced by disadvantaged groups such as the elderly or the disabled (City of Winnipeg 2012a). As Cardona's (2014) research has revealed, Winnipeg's neoliberal policy climate has delegitimized the needs of the differently abled, the aging and the impoverished, while prioritizing individual bodies constituted as "productive members of society." Crumbling urban infrastructure and the commodification of public space, combined with an increasingly auto-oriented suburban monoculture, has created an built environment that is highly difficult to navigate for anyone other than "able-bodied, working age, career-oriented, middle-class" citizens (Cardona, 2014). Even though the city is committed to creating vibrant, mixed use neighbourhoods (24) that might help alleviate some of these issues, it also states that both new communities (suburbs) and existing ones are needed, creating a confusing mix of both sprawl and intensification that makes the reader wonder which one is the true priority (City of Winnipeg 2011, 25).

> A successful strategy for sustainable city growth needs to be balanced, using a variety of approaches. We need to strike a balance between 'growing out' and 'growing up', offering choices from traditional, single-family neighbourhoods to more dense forms of urban housing and new neighbourhoods designed around a rapid transit system. (24)

These inconsistent policies are meant to continually evolve, as shown in the progress report document *OurWinnipeg: Report to the Community 2012*, which notes that *OurWinnipeg* has a "clear, yet flexible vision for the future" (City of Winnipeg 2012b, 3). Furthermore, since policies are not static, any inclusive intensification policies that were identified by residents during the *SpeakUpWinnipeg* consultation (and subsequently outlined in *OurWinnipeg*) have serious potential to be circumvented, since the "flexible tools for implementation" (12) can be modified to align with political priorities (City of Winnipeg 2012a; 2012b). Two respondents had the perspective that even if developers were inclined to create inclusive neighbourhoods, *OurWinnipeg* does not provide them with the proper tools for implementation, because imprecise goals (even if they are well-intentioned), are difficult to operationalize on the ground (A008; A005).

Unrealistic housing plan. Key informants revealed that intensification strategies may affect community well-being by simply creating market-rate housing while ignoring the urgent need for affordable housing in Winnipeg (A010; Cooper 2011). Winnipeg's rental vacancy rate in 2012 was 1.2%, and one key informant noted that this low number makes it incredibly difficult

for both newcomers and existing residents to find adequate and affordable housing (A005; Canada Mortgage and Housing Corporation 2012). As it stands, the *OurWinnipeg* plan (specifically the *Complete Communities* document) does not provide any remedies for the inequitable housing situation in the city, because it declines to give details on how affordable housing will be implemented for people with marginal incomes or specialized needs, and it fails to reconcile gentrification processes with an affordable housing component (A004; see City of Winnipeg 2012a; Bartmanovich 2013). Indeed, the creation of housing is addressed in two primary ways. First, the plan supports housing within a design context, stating that housing in a range of styles is desirable, but leaves it up to the reader to decide how these different styles of housing will allow for affordability for needy residents (City of Winnipeg, 2012a).

> …a city that works also recognizes that attractiveness and vibrancy are integral to a high quality of life. There ***needs to be*** a variety of housing styles for residents to choose from and transportation choices for residents and businesses alike. This requires the city to make land available for development and to support the creation of an attractive variety and mix of housing that appeals to various affordability ranges. (24, emphasis mine)

Second, the city's role in residential development is one of support, collaboration, and partnership with private interests (see City of Winnipeg 2012b, 17) that, in one informant's perspective, ignores social concerns in favour of the continued promotion of market-driven development (A005). This can be seen in *OurWinnipeg*'s description of the downtown area (i.e. the primary transformative area) which, according to the plan, is slowly being transformed into a complete community through strategic investments in art, sports, and entertainment, as well as the reinforcement of the area's traditional role as a centre for business and commerce (City of Winnipeg 2011). Another respondent noted that these initiatives are meant to attract a different demographic to downtown, and through this process, low-income people are being displaced, because new/existing housing is being transformed and marketed to the upper middle classes (A006; see also City of Winnipeg 2012a, 18-21). A different key informant noted that *OurWinnipeg* reflects Winnipeg's unwillingness to address housing and other social issues within city limits, preferring to pass that responsibility to the Province of Manitoba or the Government of Canada (A009; see also City of Winnipeg 2011), an argument that finds some evidence in the document:

> Three important aspects of quality of life are access to opportunity, the maintenance of vital, healthy neighbourhoods, and being a creative city with a vibrant arts and culture. All of these areas include social aspects that are critical to the overall well-being of our city. ***Senior levels of government hold much of the responsibility for these areas.*** However, the City of Winnipeg acknowledges their critical importance to the overall competitiveness of the city and to the personal well-being of our citizens. (3, emphasis mine)

The city has not always denied responsibility for housing issues: it had previously provided coordinated discretionary funding to Neighbourhood Renewal Corporations (NRCs) through its Housing Improvement Zone program, supporting targeted interventions that would alleviate poor housing conditions in the inner city (Bartmanovich, 2013). Instead, the city is now able to use the logic of Complete Communities to spread funding thinly across reinvestment areas and encourage home ownership, instead of helping to improve affordable rental stock in low-income areas (Bartmanovich, 2013) Furthermore, the city is unwilling to combat strong Not In My Backyard (NIMBY) sentiments in established neighbourhoods that would allow for the implementation of more affordable rentals for citizens in need (A009). Indeed, planning language attempts to alleviate resident fears by stating that development must always be suitable to the context and enhance the "unique character" of the neighbourhood (City of Winnipeg 2012a, 78).

OurWinnipeg also displays an inability to reject sprawling suburban development, because the document continues to promote the creation of new communities on the urban periphery, reflecting the city's unwillingness to deny the demand for single-family suburban tract homes while simultaneously endorsing intensification, resulting in a cobbled-together solution that theoretically allows the market to be satiated (see City of Winnipeg 2012a, 70-77). Milgrom (2011) frames this trend as problematic, demonstrating how rapid suburban development is continuing in Winnipeg despite slow population growth, leaving the city with a large infrastructure deficit and a reliance on funding from upper levels of government to cover its unmanageable costs. This has resulted in a situation where inner-city renewal projects are viable *only* if growth and market demand allow for it, rather than being implemented *despite* growth rates, as is currently happening in the suburbs (Milgrom 2011). Milgrom (2011) specifically cites the recent development of the massive Waverley West suburb as a case where public policy and city spending has allowed for yet another socially and economically segregated community to be established on Winnipeg's periphery, a situation that has exacerbated the hollowing out of the inner city and prioritized new-build development at the expense of neighbourhoods in need. With these points in mind, *OurWinnipeg*'s idea of community development remains inconsistent in its goals, and it does not appear to foster inclusion since it does not include any affordable component or contingency plan for the residents who will be displaced or ignored as a result of major economic development.

Prioritizing developable land over community needs. According to the *OurWinnipeg* plan, complete communities will be primarily implemented through the development and improvement of transformative areas, which are areas of the city that have potential for infill development (City of Winnipeg 2012a). While the plan identifies a variety of locations in the city that are appropriate for intensification (there is a major focus on

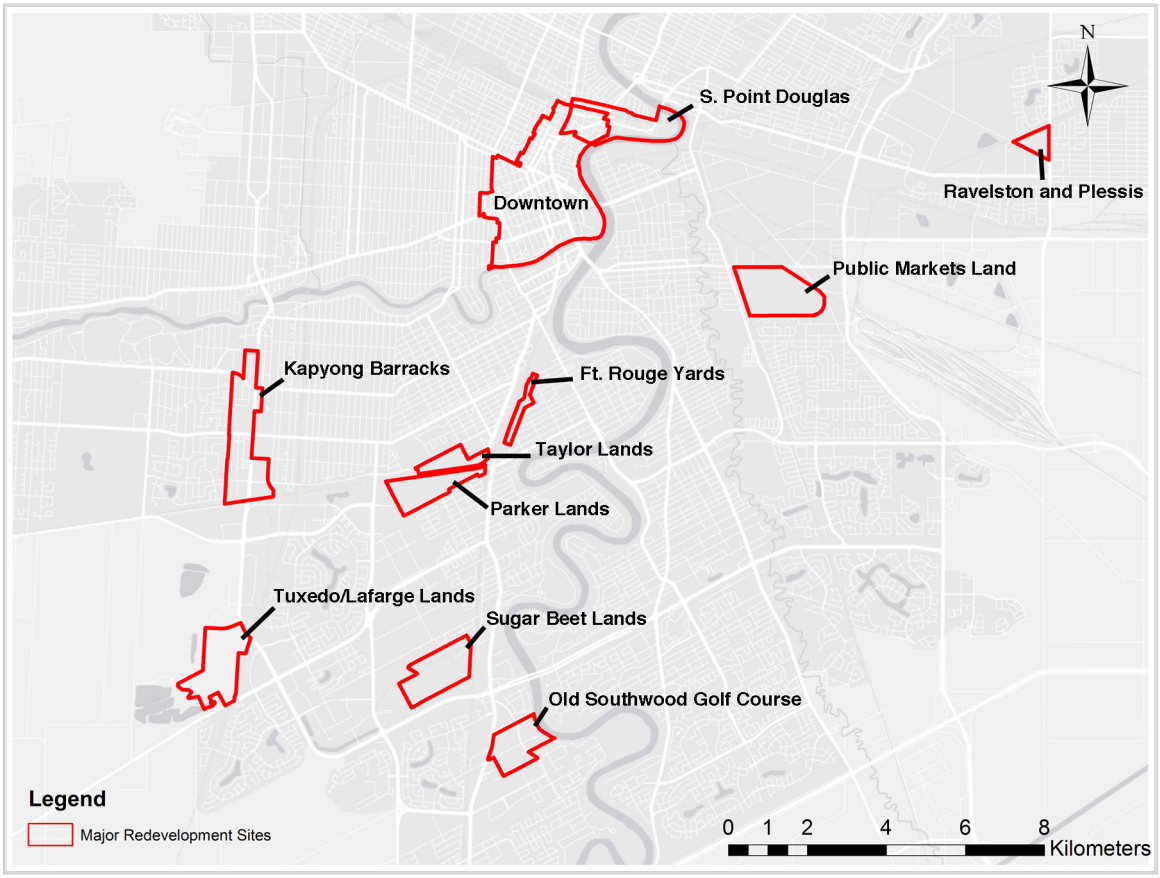

Figure 1
Transformative areas that the City of Winnipeg has slated for intensification.
(data courtesy City of Winnipeg 2012)

downtown), significantly, most development sites are unused or derelict lands scattered throughout the city (known as *major redevelopment sites*) or *new communities*, which are suburban developments on the edge of the city, as shown in Figure 1 (City of Winnipeg 2012a). Major Redevelopment Sites are defined as new infill neighbourhoods that easily connect to existing urban infrastructure, while new communities will be planned as complete at their outset in order to ensure their sustainability and accessibility (City of Winnipeg 2012a).

In contrast to these areas are *areas of stability* (medium to low density neighbourhoods that are well established), which will accommodate low to moderate levels of intensification and infill that is suitable to community context, enhances the unique character of the neighbourhood, and is developed in a sensitive way (see City of Winnipeg 2012a, 78-84). Accordingly, transformative areas can more easily be subjected to high-density infill than areas of stability, which have to be treated more delicately. In fact, the only type of existing community that may be appropriate for infill is known as a *reinvestment area* (a mature neighbourhood in decline, see City of Winnipeg 2012a, 84), however, the document is opaque about how reinvestment areas should be defined and where such areas should exist. This ambiguity is justified in the plan by stating that the city does not currently have the tools to identify these neighbourhoods, and that these communities may continue to change on their own, regardless of civic intervention or planning (City of Winnipeg 2012a).

> *OurWinnipeg* does not identify specific neighbourhoods as reinvestment areas. This is because neighbourhoods are not static and their characteristics may change dramatically over the life of the plan. In the future, indicators will be developed which will provide criteria for identifying reinvestment areas. (84)

The ongoing development of transformative areas may potentially divert resources away from communities that are in need of assistance. Key informant perspectives (in addition to literature) revealed that neighbourhoods such as Winnipeg's North End and West End (both of which fit the definition of a reinvestment area) require both social and economic investment, yet they have not been targeted for assistance in the *OurWinnipeg* plan, potentially allowing the policy to ignore community needs (A008; Cooper 2011). In another informant's judgement, these areas of disinvestment certainly desire the amenities that have been promised by the *OurWinnipeg* plan (A010), however, investment is prioritized in spaces where there are few to no residents, promising very few improvements in impoverished areas. Furthermore, some interview participants were concerned that investment in neighbourhoods would be primarily dependent on

developer interest, and since there is nothing in the plan that specifically addresses social equity concerns in low-income areas, developers will likely use its flexibility to suit their needs at the expense of community (A004; A008). As Hugill and Toews (2014) highlight, these logics can be dangerous, revealing how developer-driven "improvements" in vulnerable disinvested areas such as the North End have raised concerns over social justice under Winnipeg's flexible planning and policy regime. Interrogating the new Youth For Christ "Centre for Youth Excellence," they demonstrate how the city, in conjunction with Centre Venture (its arm's-length downtown development corporation), was able to leverage funding from multiple levels of government to encourage the Christian group to develop on a site proximal to many Aboriginal community resources, despite the objections of neighbourhood activists (Hugill and Toews, 2014). While on the surface this development appears to be a socioeconomic investment that improves the community by repurposing 'empty space,' it reinforces hegemonic logics of 'highest and best use' of property and ignores community needs at the expense of economic development strategies (Hugill and Toews, 2014).

Offloading of social programs without support. *OurWinnipeg* leaves open the possibility of planning policy trumping resident needs in communities with meager financial and community resources. When it comes to issues such as poverty and disinvestment, the plan not only fails to identify specific communities, but it states that poverty reduction strategies will be "community-led" (City of Winnipeg 2011, 73). City government, according to *OurWinnipeg* and key informants, will operate at arm's length of poverty-reduction strategies, but may be willing to partner with community groups if requested, stating that neighbourhood vitality is dependent on volunteerism (A009; City of Winnipeg 2011). Therefore, in the views of one interviewee, impoverished neighbourhoods are left to create grassroots solutions to neighbourhood problems (or concentrate fundraising efforts toward higher levels of government), since the city offers them little support unless there is a market-driven impetus to do so (A007). According to *OurWinnipeg*, creating a city with a better quality of life is dependent on the actions of senior levels of government, as well as the enactment of public-private partnerships, resulting in a strategy of passive management that the city proclaims will improve liveability (City of Winnipeg 2011, 72-78). The creation of equity is now the responsibility of all Winnipeggers, and though the city states that it has been doing its part to promote social equity, it declines to state how (City of Winnipeg 2011):

> As Winnipeg grows we do not want anyone to be left behind. Our success as a city depends on the well-being and contribution of all Winnipeggers. Working together, we can ensure that Winnipeg is a place where people – whether born in the city or having adopted it as their new home – want to stay for life and where people of all ages, abilities, and cultures can find opportunity. (73)

Most tellingly, the city is now merely a "collaborator" (City of Winnipeg 2011, 73), instead of the "leader" that it wanted to be a decade previous (City of Winnipeg 2000, 21). This shift from leadership role to background role allows the city to simply encourage the work of community-based groups and avoid directly addressing poverty issues through city planning policy. Furthermore, the city's unwillingness to take an active policy role in social improvement suggests that this municipal government has absolved itself from taking any sort of real responsibility for the alleviation of poverty issues, and it reflects a lack of political will to initiate a plan that will have real and positive effects in low-income communities. In fact, as the city more openly embraces a neoliberal governance agenda, this type of hands-off approach is not only allowed to happen, it is encouraged, because the removal of government support from social programs is increasingly seen as a way to encourage the market to create wealth (Cooper 2011). However, these cuts have the effect of removing support from low-income individuals and community groups who are already struggling to survive (Cooper 2011).

Discussion and Conclusion

The preceding summary and critique suggests that Winnipeg's planning priorities over the last 20 years have shifted from a model that prioritizes neighbourhood well-being to one that views communities as a vehicle for capital accumulation. Furthermore, the rise of intensification as a tool for community revitalization in Winnipeg is concomitant with a shift in policy language that reflects an increasing neoliberalism on the part of the city's government that is being mobilized in response to policy adjustments at the global, federal, and provincial scales. The imprecise goals of the plan, combined with the city's unwillingness to directly address systemic issues such as inadequate housing, poverty, and decline in the same manner as it did in previous years, means that there are no mechanisms in place to ensure that people can stay in place as communities are intensified. The plan also has the potential effect of diverting funds toward development of unused land at the expense of communities that are in need of both social and economic capital.

Neoliberalization, in its quest to reconstitute space using the logic of the free market, coopts prescriptive strategies such as intensification (which began as a grassroots reactionary movement against rampant urban sprawl, see Isin 1996), and mobilizes them using cultural projects, policy transformations, shifts in governance, and discursive tactics (Wilson 2004; Lees 2011; McCann and Ward 2011; Peck and Theodore 2012). Ephemeral concepts at the core of the "neoliberal doxa" (Bourdieu 2003, 23) such as sustainability and creativity (which are used throughout the *OurWinnipeg* plan) have entered planning vocabularies as catch-all frameworks that can be adopted by localities with the purpose of facilitating approved modes of economic development (Peck 2011; Temenos and McCann 2012). Furthermore, these efforts implicate the public in their results by soliciting their participation in communicative consultation processes like the *SpeakUpWinnipeg* program (Purcell 2009; City of Winnipeg

2011) in which planners introduce planning and policy ideas to the populace, who then become implicated in an "insulated and practically self-fulfilling decision-making cycle" (Peck 2011, 778). In this way, the opinions of the public are molded and shaped to fit into policy frameworks that have the potential to contravene *OurWinnipeg*'s supposed goal of creating a socially, economically, and economically balanced city.

Mobilized through communicative planning, these neoliberalizing shifts can simply result in further gentrification of the city; however, more radical, citizen-initiated planning interventions can be effective at maintaining and enhancing existing communities (Monno and Khakee 2012). Theoretically, this is backed up by the arguments of Harvey (2009) who suggests a complete transformation of the dominant discourse through activism and political movement, stating that the neoliberalizing context in which cities operate presently requires a reconfiguration of processes in order to create social change, with the eventual goal of creating a more equitable city. However, the definition of equity becomes ambiguous at the urban level, where the ever-shifting nature of political power and capital (mobilized by planning regimes and laws) makes the concept murky at best (Harvey 2009). Therefore, Harvey states, equity can only exist when marginalized groups envisage the city that they desire, and then organize themselves to form powerful collectives that mobilize to change the dominant social process. Harvey's empowerment of the disenfranchised is an inspiration to Soja (2011), who called for "spatial justice" (5) to be enacted in the city from the bottom up, through grassroots campaigns that reclaim urban spaces for the marginalized instead of maintaining them for the powerful. Soja suggests that city spaces have historically been produced by the forces of capital accumulation, and that decision-making processes weighted in favour of the wealthy have created an unequal distribution of amenities (Soja 2011). This situation, in Soja's (2011) view, can potentially lead to radical action by the oppressed, with the intent of reconfiguring space in a more equitable way. However, Robinson (2011) cautions that movements such as these will always be threatened by the subtle strategy adjustments of the neoliberalizing city, therefore, effective community empowerment and mobilization requires an increased understanding of how global shifts in governance are locally mobilized through planning policy.

If neoliberal planning trends and strategies are to be resisted, then careful analyses of shifts in governance and policy adoption are needed in order to understand how people can be mobilized at the local level to create grassroots change (Robinson 2011). However, to effectively enact change, neoliberal policy directions must be reversed in order to build strong communities that address the inequalities inherent within them (Robinson 2011). This will require sufficient community involvement combined with a sense of injustice in order to challenge the dominant social process and create a new type of urban dynamic, one based on fairness, not just capital accumulation (Harvey 2009). The fact that Winnipeg has been comparatively late to the neoliberal game means that there is space for resistance. We hope that studies such as this one can help individuals and community advocates to better understand the urban policy frameworks that facilitate unbalanced development in order to subvert these processes and promote inclusive and viable neighbourhoods through problem solving, not problem dispersion.

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