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Analysis

Wetlands, Flood Control and Ecosystem Services in the Smith Creek Drainage Basin: A Case Study in Saskatchewan, Canada

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ABSTRACT

This paper applies a social return on investment (SROI) analysis to the issue of flood control and wetland conservation in the Smith Creek basin of southeastern Saskatchewan, Canada. Basin hydrological modeling applied to wetland loss and restoration scenarios in the study area provides local estimates of the ecosystem service (ES) provision related to flood control and nutrient removal. Locally appropriate monetary values are applied to these services to gauge the cost effectiveness of wetland conservation funding at two levels: flood control capacity alone and then incorporating a suite of ES. SROI ratios for flood control alone provide ratios between 3.17 (retention) and 0.80 (full restoration) over 30 years; when other ES are included, the ratios increase, ranging from 7.70 (retention) to 2.98 (full restoration) over 30 years. Retention of existing wetlands provides the highest SROI and therefore we argue that government policy should focus on preventing further loss of wetlands as a strategic investment opportunity. Overall, these results indicate that wetland retention is an economically viable solution to limit the financial, social and environmental damages of flooding in Saskatchewan specifically and the Prairie Pothole Region (PPR) generally.

1. Introduction

The Canadian Prairies are characterized by level to rolling landscapes interspersed with small post-glacial topographic depressions known as potholes, resulting in the label of Prairie Pothole Region (PPR). The deep, nutrient rich soils resulting from these glacial and post-glacial deposition processes created land suitable for agricultural production and human settlement and form the agriculturally productive southern regions of the Canadian Prairie Provinces of Manitoba, Saskatchewan and Alberta. A continental climate characterized by low temperatures, development of a seasonal snow cover and frozen soils in winter and rainfall when there is high infiltrability to unfrozen soils in summer results in highly seasonal surface-water runoff that is primarily driven by spring snowmelt (Gray, 1970). Lakes, rivers and pothole wetlands are recharged by the annual snowmelt, and spring flood events are a natural and expected annual occurrence (Buttle et al., 2016; Dumanski et al., 2015; Gray, 1970; Pomeroy et al., 2007; Wheater and Gober, 2013). While sparsely populated, the Canadian Prairies are an iconic part of the Canadian landscape and agriculture industry.

The low topographical relief and poorly developed surface drainage system that characterizes much of Saskatchewan has meant the southern regions of this province are particularly susceptible to flood events (Government of Canada, 2016a; Gray, 1970; Dumanski et al., 2015). The frequency distributions of extreme runoff events are not controlled by the frequency of precipitation but by the transformation of precipitation from snowfall to snowpack, to runoff and after wetland storage to streamflow (Shook et al., 2013). In recent years, the frequency and severity of floods has increased due to the extreme weather events associated with climate change (Pomeroy et al., 2009) and 2010 through 2014 have been some of the wettest years on record (Buttle et al., 2016; Chun and Wheater, 2012). There has been a dramatic shift in the sources of runoff in Smith Creek, SK since the 1990s. Before the late 1990s about 85% of streamflow volume was derived from snowmelt runoff and all streamflow peaks occurred in the March–May period; the stream normally dried up in late May. Since 2009 however rainfall is involved in 55% of streamflow volume and for the first time in any record, was involved in generating peak flows in 2012 and 2014 (Dumanski et al., 2015). Runoff efficiency in the basin has increased 12-fold over this period, but there are no trends or changes to annual

Abbreviations: ES, Ecosystem Services; SROI, social return on investment; NPV, Net Present Value; TN, total nitrogen; TP, total phosphorous; PPR, Prairie Pothole Region; CRHM, cold region hydrological modeling platform

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precipitation volumes despite increasing temporal concentration of precipitation in multiple day springtime events and a shift to less snowfall and more rainfall as temperatures increase.

Excess surface water on the landscape has a substantial negative impact on the agriculture industry and local private and public infrastructure (Ahmari et al., 2016; Szeto et al., 2015). In 2010 there was a record number of acres un-seeded (eight million) and drowned (four million) (Government of Saskatchewan, 2014a) in Saskatchewan due to excessive soil moisture conditions.[1] Infrastructure damage to roads, households and communities caused by flooding has been significant, and many urban and small-town homeowners faced extensive damage and associated insurance costs (Ahmari et al., 2016; Szeto et al., 2015). Due to these collective occurrences, provincial policy-makers and stakeholders have identified extensive coverage of the landscape by water – from either snowmelt or extreme rainfall – as one of the most serious environmental challenges in the province (Saskatchewan Water Security Agency, 2016a).

Significant financial resources have been required to compensate for these damages (Saskatchewan Water Security Agency, 2016b). These resources have come from private insurance, provincial and federal governments, or a combination of both (Ahmari et al., 2016). In addition, public and private expenditures on water control structures – such as dykes and dams – and rebuilding roads and buildings are significant. Further, surface drainage networks have been expanded to remove water from the landscape at significant cost (Saskatchewan Water Security Agency, 2016c). The extreme rainfall and flood events led to federal government disaster payouts to Saskatchewan of CAD$245 million in 2011 and CAD$160 million in 2014 (Government of Canada, 2016b) and the probability of these events and the use of the federal government disaster assistance program in the prairie provinces is expected to increase in future years more than in other regions of Canada (Government of Canada, 2016b).

Exacerbating these water quantity impacts is the associated transport of significant levels of nutrients such as phosphorous and nitrogen within these floodwaters. Algae blooms and water quality concerns in Lake Diefenbaker have prompted research into the water quality of the lake and sources of the nutrient loading (Abirhire et al., 2015). Further, as much of southern Saskatchewan is within the Lake Winnipeg basin, surface water loaded with phosphorous and nitrogen from Saskatchewan has negative implications for downstream residents of Manitoba (Water Innovation Centre, 2010).

Research initiatives to understand the scientific processes of flooding and natural control mechanisms from wetlands have been improving over the last several decades internationally (Brander et al., 2013; Golden et al., 2017; Kadykalo and Findlay, 2016; Watson et al., 2016), nationally (Fang et al., 2010; Pomeroy et al., 2016; Yang et al., 2016) and provincially in Saskatchewan (Fang et al., 2010; Pomeroy et al., 2009; Shook, 2016; Shook et al., 2013). Results from these studies indicate that the pothole wetlands of the prairie landscape act as a natural flood control mechanism (Pomeroy et al., 2014; Shook et al., 2013) and result in a significant value in terms of ES. These wetlands act as storage on the landscape, controlling the severity of the release of water and minimizing the damage from floods (Dumanski et al., 2015). In what may seem contradictory, the drainage networks promoted by provincial prairie governments in the 1960–80s to expand and enhance agricultural production are likely increasing the flood damages to downstream users (Government of Canada, 2016b; Pomeroy et al., 2014; Saskatchewan Water Security Agency, 2016c). Wetland drainage in basins allowed swift removal of excess water from the local landscape, but came with a cost to downstream producers and communities, and placed increased pressure on both water control structures, roads and homes. The very projects designed to reduce the impact of high water levels has contributed to the problem.

ES provision from wetlands was recognized by the government of Saskatchewan in 1995 when a provincial wetland policy was drafted and legislated (Government of Saskatchewan, 1995). Unfortunately, this policy has not been effectively implemented (SWSA, 2012) and despite their importance as a natural flood control mechanism, the loss of pothole wetlands continues relatively unabated; Ducks Unlimited Canada estimated that 250,000 ha of wetlands have been lost in southern Saskatchewan between 1950 and 2010, and that 11.3 ha of wetlands continue to be lost each day (Yang et al., 2012). In 2014 the province of Saskatchewan released the Saskatchewan Plan for Growth, an ambitious roadmap for focussed and disciplined economic growth within the province that builds[2] upon its natural resource and agricultural advantage and recognizes that natural ecosystems provide indirect benefits to society and environment – and the importance of protecting these natural environments and water resources for future generations (Government of Saskatchewan, 2014b). Despite recent scientific advances of wetland function and government interest in wetland protection, economic studies exploring wetlands as a flood mitigation tool in Saskatchewan are scarce.

We attempt to address this limitation by exploring the possibility of investment in prairie pothole wetland conservation as a natural alternative to physical infrastructure solutions to flooding, and incorporate an expanded suite of ES associated with wetlands of the Prairie Pothole Region. Using locally specific biophysical data on annual basin discharge and nutrient reduction by wetlands, conduct a social return on investment (SROI)[3] analysis – a conceptual and quantitative approach that incorporates social and environmental values into a traditional benefit cost analysis – that is conceptually familiar to policy makers and the general public. Using a case study from the Smith Creek basin in southeastern Saskatchewan, we pose two research questions:

1) *Do wetland ecosystems in this area present a viable financial option to mitigate the impact of flood events in Saskatchewan specifically, and the Canadian PPR in general?*
2) *Is wetland conservation an economically viable solution to address a suite of environmental issues in Saskatchewan specifically, and the Canadian PPR in general?*

We contribute to the existing literature on the subject of wetland conservation by linking the costs and benefits of wetland conservation in a traditional business case format. While economic analyses of wetland drainage in prairie Canada (Cortus et al., 2011; Packman, 2010) and benefit analysis (Pattison et al., 2011) do exist, to our knowledge few studies have taken this approach for wetland conservation (Pattison-Williams et al., 2017) and no studies have taken this approach in Saskatchewan. We intend to link the local biophysical benefits and cost data in a way that will both contribute to the academic knowledge and be a useful decision-making tool for government policy-makers.

The paper will describe the case study area from southern Saskatchewan and the Smith Creek basin; provide an overview of SROI and basin hydrological modeling methods; and present results from a "flood control" return on investment and then SROI. These results will be further discussed in the context of wetland conservation policy in Saskatchewan specifically and Canada generally.

2. Background

2.1. Ecosystem Services and Wetland Loss

Natural ecosystems provide the foundation of a functioning human

[1] Although 2011 had more significant flooding, the provincial average of seeded acres was higher than in 2010.

[2] The Plan for Growth identifies six core growth activities: infrastructure growth, education, economic competitiveness, increased international trade, advancing natural resource strengths, and fiscal responsibility (Government of Saskatchewan, 2014b).

[3] SROI is a principles-based method for measuring environmental and social values not currently incorporated in conventional financial accounting. This approach has been used effectively by various organizations, including the New Economics Foundation in the UK and the Canadian Evaluation Society.